MINERAL REPORT 15

CANADIAN MINERALS YEARBOOK 1966

MINERAL RESOURCES DIVISION
DEPARTMENT OF ENERGY, MINES AND RESOURCES
OTTAWA

1968

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Foreword

This issue of the Canadian Minerals Yearbook is a report of developments in the industry during 1966. As usual, the chapters dealing with specific commodities were issued as separate pamphlets during 1967 to provide advance information to the public. The General Review, specially written for this volume, deals with the overall position of the industry in 1966 in its national and international perspectives.

The Yearbook is the official annual record of the growth of the mineral industry in Canada and is preceded by similar reports under various titles dating back to 1907 and earlier. Those wishing to refer to previous reports should consult departmental catalogues.

Most of the basic statistics on Canada production, trade and consumption were collected for the Department by the Dominion Bureau of Statistics. Company data were obtained directly from company officials or from corporate annual reports, combined with information obtained by authors on systematic field trips. Market quotations were mainly from standard marketing reports issued in Montreal, London or New York.

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

W. Keith Buck
Chief
Mineral Resources Division

November 1967

Editor: G.E. Thompson

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Readers wishing more recent information than that contained in the present volume should obtain the 1966 series of preprints: complete set available from the Queen's Printer, $5. Individual copies are available from the Distribution Office, Mineral Resources Division, Department of Energy, Mines and Resources, Ottawa, at 25¢ each.

All photographs by George Hunter, Toronto.

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Mineral map 900A, Principal Mineral Areas of Canada, 16 edition. Map pocket

General Review

Canadian minerals are playing an increasingly important part in the world mineral resource industry. To place the domestic industry in perspective this general review summarizes the statistical highlights of 1966, and relates them to the Canadian economy as a whole.* Aspects of the world industry of special interest to Canadians are also considered. The review contains an appraisal of development in mining technology and in new exploration techniques. The more important events that took place in 1966 in production and development are summarized on a provincial basis. The review concludes with a description of how the mineral industry has developed in Canada since Confederation.

A BRIEF REVIEW OF THE CANADIAN ECONOMY

Expansion continued to be the keynote of the Canadian economy in 1966. Gross National Product (GNP) reached $57.8 billion, 10.9 per cent above 1965, as the economic expansion, which started in 1961, continued. However, high levels of resource utilization were responsible for a 4.6 per cent increase in prices, which reduced the real growth in GNP to 5.9 per cent. In 1965 a 2.8 per cent increase in prices had reduced a 9.9 per cent growth in GNP to a real gain of 6.9 per cent. The history of the rise of Canada's GNP, in current dollars, and in real, or deflated dollars, is shown in Figure 1.

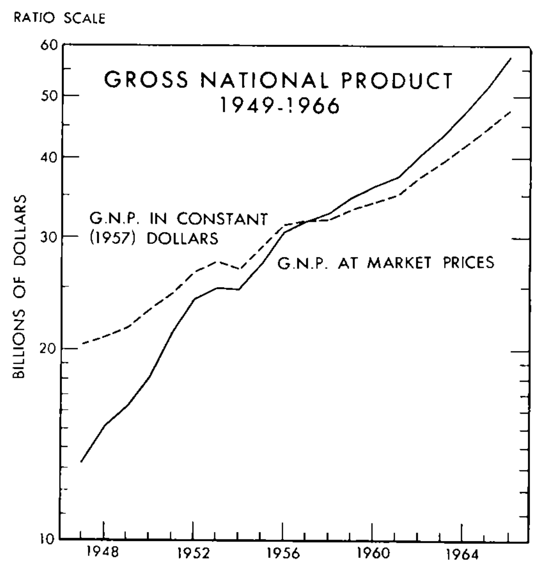

Figure 1

Business gross fixed capital formation in the field of new non-residential construction, and new machinery and equipment exceeded $10 billion in 1966, an increase of $1.5 billion, over 17.5 per cent, compared with a 12 per cent growth rate from 1961 to 1965. The very rapid growth in these capital goods is shown in Figure 2.

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

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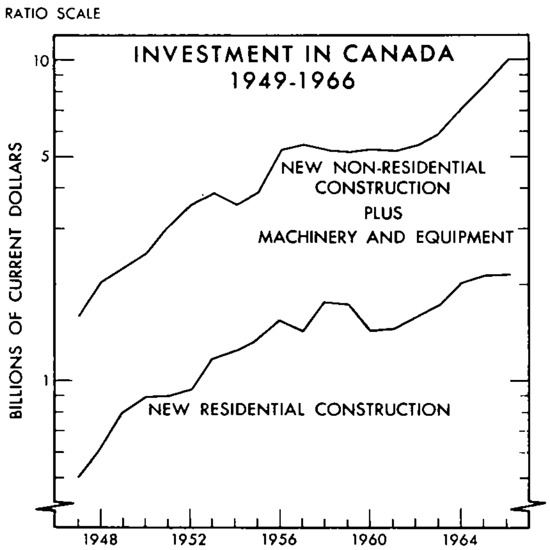

Figure 2

The personal expenditure section of the Gross National Expenditure (GNE) continued to expand, but at a less rapid rate than business capital formation. From $32.0 billion in 1965, personal expenditure rose to $34.8 billion in 1966, an 8.7 per cent increase. At the same time, labour income (wages, salaries and supplementary labour income) increased from $26.0 billion to $29.3 billion, i.e., 12.6 per cent. The labour force rose from 7,141 million to 7,420 million, while the number of persons unemployed fell from 280,000 to 267,000, that is from 3.9 per cent to 3.6 per cent of the labour force.

Exports of goods and services expanded sharply in 1966, the increase of 15.3 per cent was more than twice the advance of 1965. The main factor behind this rapid growth was an increase of 17.4 per cent in commodity exports, chiefly wheat and automobile parts. The value of all other exports was up by 5 per cent over 1965, in real terms. The positive balance on merchandise trade, of $380 million, was offset by a deficit of $1,363 million on non-merchandise trade, Figure 3.

A REVIEW OF THE MINERAL ECONOMY

The Canadian mineral industry had another year of outstanding achievement in 1966. A record was established for value of output. Exploration for new deposits and development of properties for production continued at high levels, and announcements were made of major projects that will increase appreciably the existing productive capacities for several commodities. Exploration and development was extensive and widespread in all producing provinces and territories.

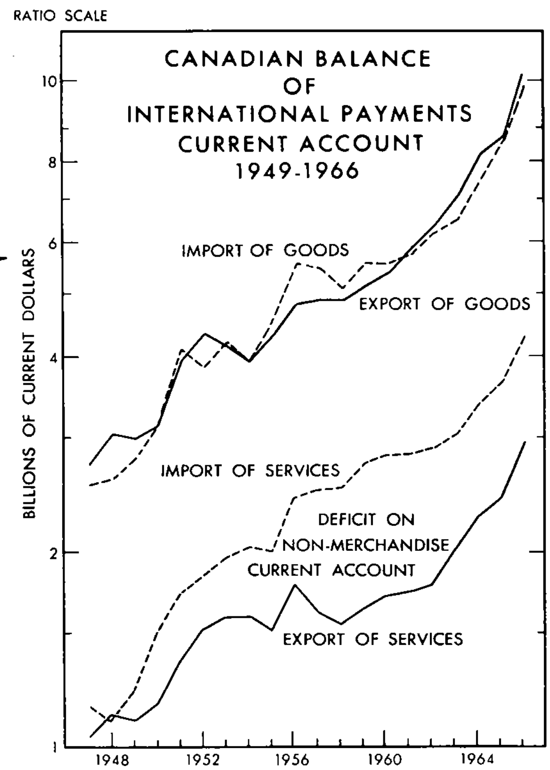

Figure 3

Canadian mineral production increased by 7.7 per cent, to $4,032 million from $3,745 million in 1965, Figure 4. Each of the three sectors registered new highs in the value of production: metallics increased from $1,908 million to $1,994 million, non-metallic minerals and structural materials increased from $761 million to $845 million, and the value of fuel production increased from $1,076 million to $1,193 million (Table 1).*

*Table numbers refer to the statistical tables at the end of the volume.

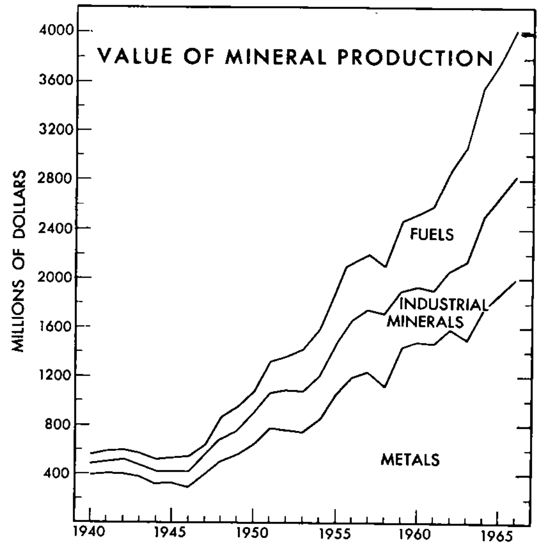

Figure 4

The index of physical volume of mineral production rose to over 393 (1949 = 100) from 366 in 1965; the respective indices for total industrial production in Canada in the two years were 275 and 255 (Table 3).

Contributing to this increase the value of copper produced was up by $70 million, although there was little change in the volume of metal produced; the output of zinc rose 130,000 tons, which represented an increase in value of $40 million. In the fuels sector, the production of crude petroleum was up $90 million and more than 30 million barrels. The output of gold and uranium continued to decline.

Canada's ten leading minerals, in terms of output were worth $3,177 million, 78.9 per cent of the total. The table below shows their value and their proportion to total output.

Ontario was again Canada's leading mineral-producing province with output valued at $959.5 million, 23.8 per cent of the total, Figure 5. It was followed in order by Alberta with 22.1 per cent, Quebec with 19.0 per cent, Saskatchewan with 9.1 per cent and British Columbia with 7.9 per cent. All provinces and territories increased their mineral output in 1966 with the exception of Ontario where the value of production fell from $993 million to $959.5 million, and the Yukon Territory, where the decline was from $13.4 million to $11.4 million. The provinces recording the greatest increases in value were Alberta, Quebec, British Columbia and Saskatchewan. Although Ontario is still the leading mineral-producing province its share of total output value has declined from 37.6 per cent in 1958 to 23.8 per cent in 1966. Production of petroleum, natural gas and elemental sulphur in British Columbia, Alberta and Saskatchewan and of potash in Saskatchewan has led to a rapid rise in value of output. Greatly increased diversification in mineral production has occurred in all four western provinces since 1960.

Canada's Ten Leading Minerals in 1965 and 1966

	Value in millions of dollars		Per Cent of total mineral production	
	1965	1966	1965	1966
Petroleum	722	813	19.3	20.2
Copper	381	458	10.2	11.4
Iron Ore	413	419	11.0	10.4
Nickel	430	400	11.5	9.9
Zinc	248	290	6.6	7.2
Natural gas	187	199	5.0	4.9
Asbestos	146	167	3.9	4.1
Cement	142	158	3.8	3.9
Sand and Gravel	134	148	3.6	3.7
Gold	136	125	3.6	3.1
Total	2,939	3,177	78.5	78.9
All others	706	855	21.5	21.1
Total	3,745	4,032	100.0	100.0

There were many developments of significance in Canada and throughout the world that were of importance in bringing value of output in the metallics sector of the mineral industry to a record high. There were also many large projects still in the development stage at the year-end, others were in the planning and engineering stages and others of significant proportions were being considered for production in the years ahead. These developments, notwithstanding increasingly severe market conditions, particularly in western Europe and Japan, indicate continuing growth in metallics output. Also of great significance to the mineral industry was the accelerated pace and scope of exploration and development in widely scattered locations.

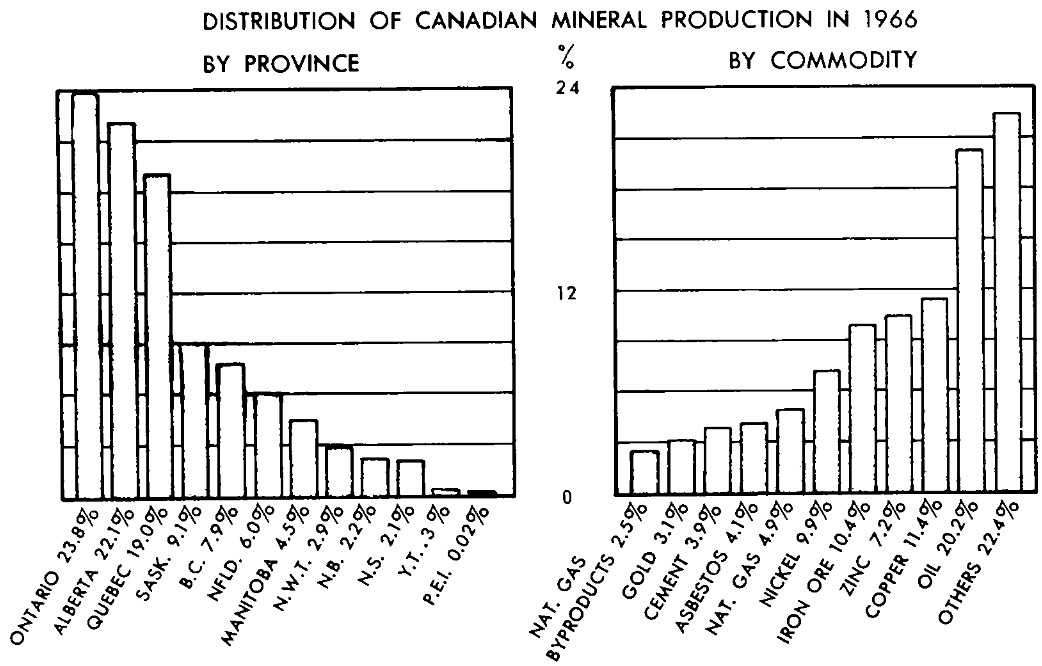

Figure 5

Figure 6 shows the extent of capital investment that has been made in the mineral industry since World War II, with estimates for 1967. The very rapid advance in investment in petroleum and natural gas, especially since 1963, is clearly shown. Mid-year estimates for 1967 indicate that investment in both sectors may rise very little over the totals of 1966.

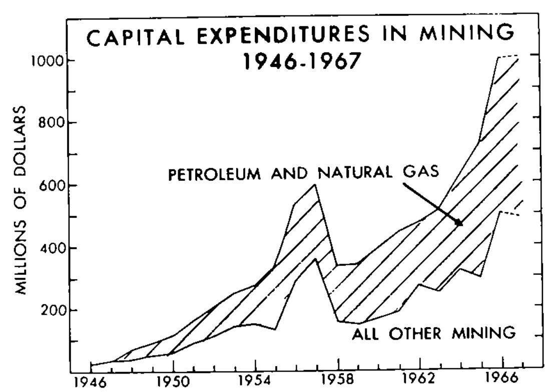

Figure 6

The faster rate of growth of the mineral industry, on a per capita basis, compared with the rate of growth of the Canadian Gross National Product (GNP) since 1947 is clearly seen on the ratio scale of Figure 7. The average compound rates of growth in current dollars are 7.4 per cent for mineral production and 5.5 per cent for GNP. For comparison the same series for the United States are also shown, the growth rates for these series are 3.0 per cent for mineral production and 4.7 per cent for GNP. The dollar values in this diagram are in the domestic currency of each country.

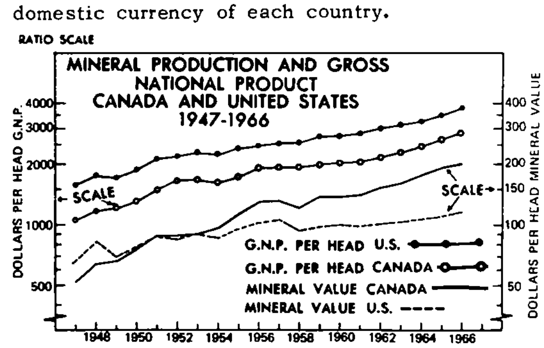

Figure 7

Growth in the Canadian industrial economy and its major sectors is shown in Figure 8.

The composite Index of Industrial Production has an annual average growth of 6.1 per cent from 1949 to 1966. The growth rates for Electric Power and Gas Utilities, and for Mining, are 10.0 per cent and 8.4 per cent respectively. The rate of growth of the manufacturing index is 5.5 per cent.

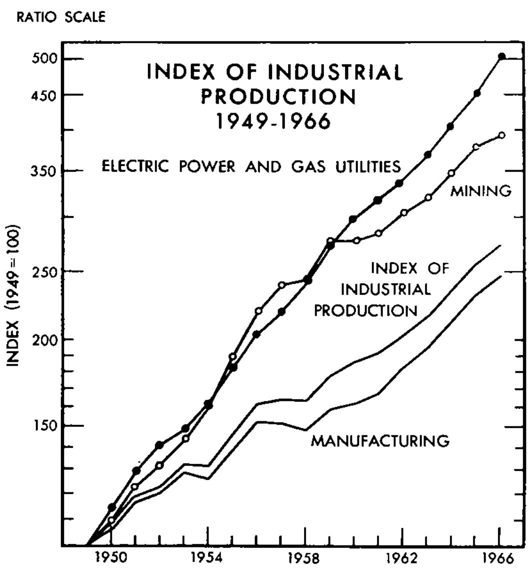

Figure 8

Figure 9 provides a comparison between production and employment indexes in mining and in manufacturing in both Canada and the United States. Each graph represents the ratio:

$$\frac{\text{Index of Industrial Production, by Sector*}}{\text{Index of Employment, by Sector}}$$

The much stronger growth in the Canadian mining series, compared with United States mining, and the similarity in the manufacturing growth rates in both countries is clearly illustrated, despite the hiatus caused by the change in industrial classification carried out by the Dominion Bureau of Statistics in 1961.

Minerals and Metal Prices

Continued growth in the economies of the developed nations kept most metal prices firm, although the almost universal bullish condition of 1965 did not hold across the whole mineral industry in 1966. Price changes in the major mineral commodities are summarized below; for details of price behaviour the individual commodity reviews should be consulted.

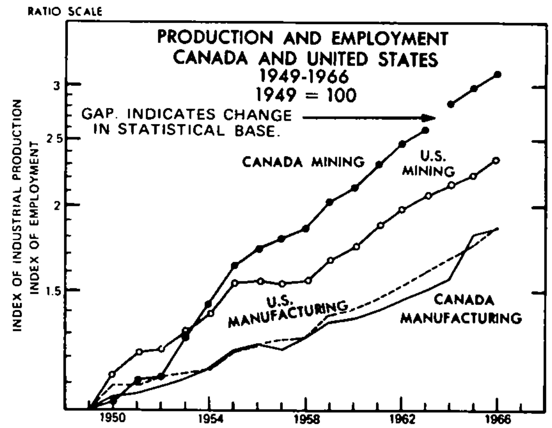

Figure 9

Nonferrous metal prices were mixed. Canadian domestic price of copper remained steady at 45 cents a pound, although some United States producers raised their prices from 36 cents to 38 cents (US) a pound. Prices on the London Metal Exchange (LME) fluctuated between a high of about £780 to a low of £396 a ton, (97.5 cents to 49.5 cents a pound, US). Producers' European prices also fluctuated widely. The price of nickel, which had been stable since 1962, rose 7½ cents to 91½ cents a pound in Canada and to 85¼ cents a pound in the United States. Zinc prices were unchanged in Canada and the United States at 14½ cents a pound. Canadian sales of zinc outside North America continued to be made on the "overseas producer basis price". This price declined from 14.7 cents to 13.7 cents a pound during the year. Zinc prices on the LME fluctuated between £115 and £92 a long ton (14.4 cents to 11.5 cents a pound US). The domestic price of lead, f.o.b. Toronto and Montreal, fell from 15½ cents a pound, the price it had held since December 1964, to 15 cents in May and 14 cents in October. The US price for common lead, f.o.b. New York, fell from 16 cents to 15 cents and again to 14 cents, paralleling the Canadian changes. Lead prices on the LME fell fairly steadily during the year from £111.75 to £80 a long ton, (13.9 cents a pound to 10 cents, US).

*United States data are from the Federal Reserve Board, and The Department of Labor, Bureau of Labor Statistics.

The price of aluminum remained unchanged during the year, at 26 cents a pound. The Canadian price of silver fluctuated marginally with the exchange rate on the Canadian dollar, as the US price remained at $1.2929 a troy ounce. Molybdenum, cobalt, magnesium, and bismuth prices remained unchanged. The price paid for Canadian exports of antimony to the United States declined about 4 cents in 1966, to about 42 cents (US) a pound. Tungsten and cadmium prices rose slightly.

Iron ore and pellet prices were unchanged in the North American market. However, there was some softening in the price of iron ore sold to Japan.

There were no significant changes in the price of Canadian crude oil in 1966. The stockpile price of uranium remained at a basic $4.90 a pound.

Posted prices for potash fell, and for sulphur rose, during 1966.

The behaviour of the wholesale and retail price indexes, between 1945 and 1966, is compared with the behaviour of the indexes for products of the mineral industry in Figure 10. The iron product price index has generally been above the others, while the price indexes of the nonferrous metal and the nonmetallic mineral sectors have remained below the wholesale price index. The non-metallic mineral industry, in particular, has suffered rising factor cost, as represented by the wholesale price index, on the one hand, while the prices that the industry received for its products have remained steady, as exemplified by the curve showing the price index of its products.

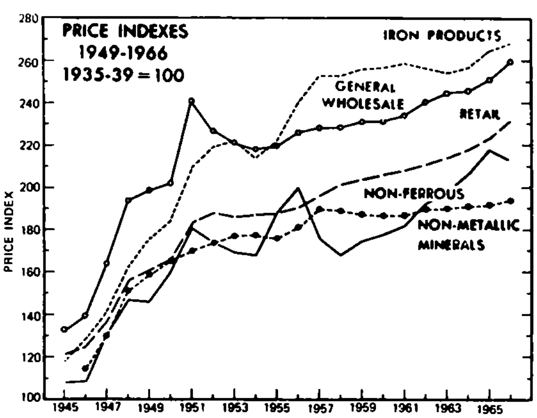

Figure 10

Mineral Trade

The value of mineral exports rose $340 million, or 12 per cent compared with 1965. All major commodity groups showed increases (Table 12). Fabricated non-metal exports showed the largest increase, $83 million, which was the result of including about $76 million worth of potash (KCl) exports in this sector. Previously, potash trade statistics had not been included in the mineral sector.

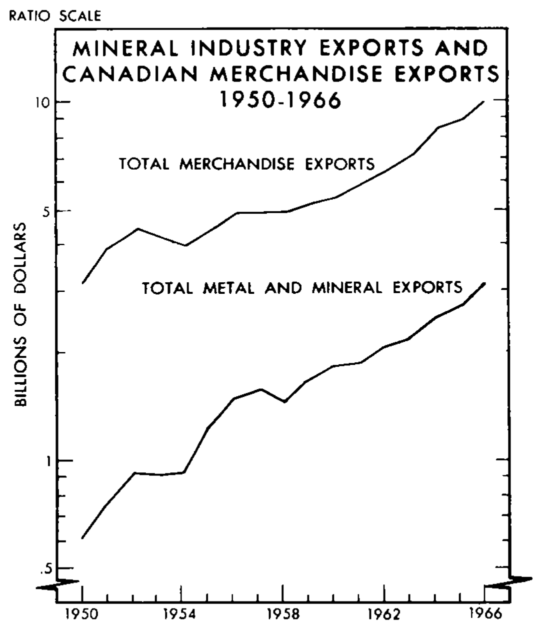

Figure 11

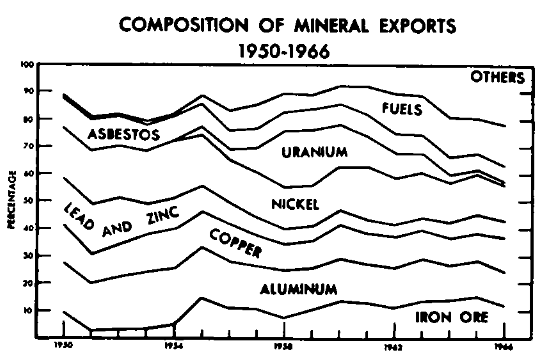

Figure 12

Value of mineral imports was up slightly from 1965 (Table 13). A drop in value of ferrous materials was compensated by a nearly equal-sized increase in nonferrous imports.

Although mineral exports increased in absolute value, they decreased as a proportion of total merchandise exports from 32.6 per cent to 31.0 per cent (Table 14). This is a reflection of increased sales abroad of wheat and motor vehicles and parts.

Of the $340 million increase in mineral exports, $270 million went to the United States, which increased its share of Canadian mineral exports from 58.3 per cent in 1965 to 60.7 per cent in 1966, Figure 13. Commodity exports to the US that increased were copper, up nearly $90 million; iron ore, up $16 million; aluminum up about $15 million, and fuels $50 million. Despite the repeal of quotas in October 1965, sales of lead rose only $2 million to $21.8 million and sales of zinc rose only $15 million to $72.3 million. Nickel and uranium were both down slightly.

Mineral exports to Britain fell by $20 million to $470 million in 1966, which represents 15.0 per cent of the total, compared with 17.6 per cent in 1965. All commodity groups fell, with the exception of copper and asbestos, the value of which rose, and nickel, which remained unchanged.

The share of mineral exports to other EFTA nations* rose from 3.5 per cent to 4.1 per cent. The value of mineral exports to EEC countries** remained almost unchanged from 1965, at $209 million; as a proportion of trade this represents a fall from 7.5 per cent to 6.7 per cent. Trade to Japan increased $40 million over the 1965 total, to 4.6 per cent. The chief changes were a large increase in copper shipments, from $22 million to $56 million, and in the "other minerals" category.

The value of exports of most leading mineral commodities was up from 1965 (Table 18). Copper showed the largest absolute and relative increase at $396 million, 145 per cent of the 1965 figure. Other mineral exports showing an increase were asbestos, up from $160 million to $182 million, and mineral fuels, up from $419 million to $472 million. The "other minerals" category exports rose from $459 million to $605 million: this includes potash statistics previously referred to. There was a decline in the value of lead and uranium exported.

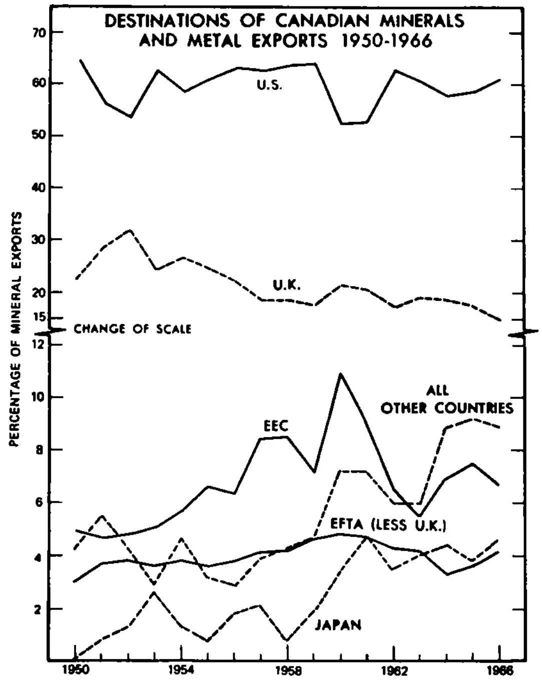

Figure 13

MINING TECHNOLOGY, 1966

Advances in mining technology that took place in Canada during 1966 are reviewed in this section. In addition to those mentioned, many improvements of an operating nature are continuously being incorporated in any mining plant. They generally do not gain the prominence given to entirely new changes in technique but they contribute largely to cutting costs, improving safety and speeding operations.

Production and Mining Method

The tonnage of ore mined and rock quarried rose from 87.7 million tons* in 1950 to 289 million tons in 1964. In metal mining operations in 1965, 74.5 million tons** came from open

*Other European Free Trade Association countries: Norway, Sweden, Denmark, Switzerland, Austria and Portugal. **European Economic Community (Common Market) countries: Belgium, France, Italy, Luxembourg, Netherlands, West Germany.

*Net tons of 2,000 pounds. **Includes stone quarried for manufacture of cement and lime; does not include sand and gravel.

Tonnage* of Ore Mined and Rock Quarried in Canada,
Selected Years, 1950 to 1964

(millions of tons)

Ore Source	1950	1960	1961	1962	1963	1964
Metal Mines	45.9	101.6	99.4	114.3	123.9	141.3
Non-metal Mines	17.7	42.0	47.0	52.2	58.1	64.9
Stone Quarries**	34.1	55.8	59.7	62.5	74.1	82.8
Total (other than coal)	87.7	199.4	206.1	229.0	256.7	289.0

Source: Rounded from DBS data.

*Net tons of 2,000 pounds. **Includes stone quarried for manufacture of cement and lime; does not include sand and gravel.

Ore Production* from Metal Mines, 1960-1965

(millions of net tons)

Year	Underground** Tons	Open Pit** Tons	Total Tons	Ratio Underground to Open Pit
1950	39.6	6.3	45.9	6.3
1960	74.8	26.8	101.6	2.8
1961	68.2	31.2	99.4	2.2
1962	74.7	39.6	114.3	1.9
1963	63.4	60.5	123.9	1.1
1964	66.0	75.3	141.3	0.9
1965	70.5†	74.5†	145.0†	0.9†

* Revised to reconcile information from DBS and other sources.
** Excludes waste. † Preliminary estimate.

pits and 70.5 million tons came from underground. This is the second successive year that tonnage from open pits exceeded the tonnage from underground and the trend is expected to continue.

Mining method changes are related to use of large scale front-end loaders in conventional cut-and-fill stopes. Increases in productivity were noted in the Sudbury area mines. Considerable interest in the use of large scale mobile equipment in stoping and development appears elsewhere in Canada.

Improved pillar recovery methods have been developed in the Sullivan mine of Cominco Ltd. In essence, the method is two-stage. A core is stoped out of the pillar then the remainder is blasted in a single shot to fill the opening.

Assembly of two large bucket wheel excavators for mining of 100,000 tons of tar sands daily in Alberta was undertaken during the year. This will be the first Canadian application of bucket wheel excavators and is expected to be fully operative in 1967.

Exploration*

All of the provinces and territories of Canada benefited from the continued high level of exploration activity which was maintained through 1966. Notable large scale programs were under way in the Atlantic provinces, in provinces partly in the Precambrian Shield and in the Cordilleran.

Impetus towards prospecting was provided by release by the Federal Government of a large number of aeromagnetic maps, many resulting from co-operative federal-provincial programs.

An integrated program of geological — geophysical — geochemical investigation has been launched by the Manitoba Department of Mines

*The reader is referred to a paper by Hood (CMJ, Feb. 1967) from which these comments were extracted.

and Natural Resources in co-operation with the Department of Geology, University of Manitoba. Known as "Project Pioneer", a portion of the Precambrian Shield within the province will be explored and geologically mapped at a scale of 4 inches to one mile.

A measure of the intensity of geophysical exploration that has been carried out in Canada in the past was reported recently. The article* infers that 113 mineral deposits have been found throughout the world directly, or indirectly by geophysical methods. Of these, 66 were in Canada.

Advances were made in design and improvement of all types of geophysical equipment. Further, new applications of proven principles were developed. Existing geophysical equipment was made more compact and durable by wider use of transistors.

Drilling and Blasting

Most of the advances in drilling noted in Canada during 1966 dealt with the introduction of foreign equipment, often of outstanding design. The trend from air-leg drills to larger drill units appeared to continue.

A Canadian company that mines by blast hole open stoping, reported a substantial improvement in drilling performance by substituting button-type tungsten-carbide bits for conventional 4-wing types. In western Canada, another mining company has developed a stepped bit to eliminate separate drilling and reaming cut holes.

Mining companies and explosives manufacturers pursued vigorous research and development programs which resulted in significant cumulative improvements in blasting practice. One explosives manufacturer has developed a 4,000-shot portable blasting machine, a cable cutter, and a miniature circuit tester. Several new bulk-handling AN-FO trucks have been adopted in open pits. Wider varieties of metallized and slurry explosives and a new detonating fuse are being taken into use. A technique of blasting a complete access ramp was successfully applied in an asbestos open pit. Approximately 90,000 tons of broken material resulted from the blast which was loaded to a factor of 0.75 pound water-gel per ton broken.

*R.H. Pemberton, Engineering and Mining Journal, Volume 167, No. 4, pp. 85-88, 1966

Drifting and Tunnelling

A sliding steel floor has been adopted for driving the Granduc tunnel, Tide Lake, British Columbia. The 3-segment unit provides a portable switching yard, designed to expedite cleanout at the face.

An advance of 3 feet per man shift was achieved in a 14 ft. by 14 ft. heading, driven at a 12 per cent decline in a western Canadian mine. The equipment used in this heading was a 3-drill jumbo and a front-end loader-hauler. In another location, a tracked, front-end, side-dumping loader was applied to clearing out development openings. Evidence from these and other sources indicates that the trend to larger, arm-mounted drills and large loaders in development openings, appears to be accelerating.

Raising and Shaft Sinking

There were further applications of raise boring techniques in Ontario, Manitoba and British Columbia mines during 1966. Diameters of bored raises were 3 and 4 feet. No change of the basic 2-stage method was noted, but some unusually favourable rates of advance were reported. In a British Columbia mine, over 700 feet of 4-foot diameter raise were completed in 17 days.

A new Canadian shaft sinking record of 570 feet in a month was established early in 1966 for a 16-ft. diameter circular shaft at the Alwinsal Potash Mine. This record was broken later in the year when 627 feet were driven at the Duval Corporation property, also in the potash area. A new type of circular shaft lining was installed through the Blairmore formation in the Alwinsal shaft. The lining consists of concentric welded steel cylinders, each about an inch thick with high strength concrete filling the annulus between them. Total combined thickness of the steel and concrete wall is 28 inches.

Increases in rates of shaft sinking appear to result from experience with circular shafts and development of more efficient techniques as more shafts are driven through essentially the same rock formations.

Materials Handling

As noted in the section devoted to drifting and tunnelling and stoping, application of large loader-transporters occurred during the year. Application of small capacity equipment for loading-transporting in sublevel headings eliminated, in some instances, the need for multiple scraping. A Canadian-developed boltless scraper with a reversible blade has found an area of application in Canadian and foreign mines.

Several mining companies have re-examined the suitability of timbered mill holes in stopes filled with hydraulically-placed fill. Circular segments of steel and treated plywood have in some instances been advantageously adapted. Methods of joining the segments gained some attention.

The trend to larger loaders is matched by larger cars and pneumatic dumps for development and stoping. Aluminum car bodies have made some advance against steel. One mining company reports a 30 per cent payload increase with aluminum cars, protected by rubber-lined bottoms. Rubber lining has been applied to several hoisting skips as a protection against wear.

Urethene plastic liners have in some instances been substituted for wood and leather liners on new hoist sheaves. Application to some old hoist sheaves has also been made.

In open pits, three mining companies are known to have converted to 100-ton capacity haulage units as part of a general attack on materials handling costs. Other mining companies have added vehicles in the 35- to 85-ton capacity sizes, often as replacements for smaller units.

Conveyors and skipways appeared to have lost ground to trucks for run-of-mine ore handling in established mines. New mobile haulage units, with improved power plants, are able to negotiate steeper grades than formerly. However, the tar sand mining development will be equipped with large conveyors to provide a continuous transport system for the uniform mine product.

Support

Use of epoxy-grouted steel bars has made some progress in Canadian mines, and more gunnite is being employed in shaft stations and other permanent locations.

A salt mining company has fitted a crane with controls which can be operated from within a basket at the top of the crane boom. The device is used for methodical rock bolting, and placement of up to 100, 5-foot bolts per shift has been achieved.

HIGHLIGHTS OF THE MINING INDUSTRY IN 1966

Mineral output from most regions of Canada increased in 1966. A number of new mines were brought into production, and some of the large, open-pit operations that had started in 1965 reached capacity.

The value of output in Labrador-Newfoundland was up by nearly 20 per cent, chiefly because of increased shipments of iron ore. Direct shipping ore from the Schefferville area amounted to about 4 million long tons and shipments from the Carol Lake Project, mainly pellets, increased to 7 million long tons. Shipments from the Wabush area mines were more than 5 million long tons despite destruction by fire of the concentrator and time lost in its subsequent rebuilding. The Wabana Mines Division of Dosco Industries Limited stopped operating its Bell Island mine, after nearly 70 years of continuous operation. The Gullbridge copper mine of First Maritime Mining Corporation Limited, started operations during the year.

The report by Dr. J.R. Donald, Special Consultant on Coal to the federal government was published. The adoption of its findings will lead to the planned phasing out of the coal mines in Nova Scotia.

Brunswick Mining and Smelting Corporation Limited began tune-up operations on its No. 6 mine late in the year. Output is expected to be about 2,250 tons a day, and will be treated in a mill adjacent to the one at the No. 12 mine.

Probably the most active mineral area in Quebec was in Gaspé Park, where Wexford Mines Limited conducted an extensive exploration program and outlined substantial reserves of copper-bearing material. Copper producers in the Noranda, Chibougamau and Matagami areas of the northwestern part of the province continued to operate near capacity, and discoveries of additional ore were reported from several mines.

The decline in value of production from Ontario was the result of reduced output from the Sudbury area where The International Nickel Company of Canada, Limited (Inco) was closed by strikes in August and September. Both Inco and Falconbridge Nickel Mines, Limited continued with expansion plans to existing facilities; Inco is scheduled to bring three new mines into production shortly. Steep Rock Iron Mines Limited started shipping pellets from its new concentrator. Development work continued at the Sherman mine at Timagami and the Griffith mine near Red Lake. One of the three 3,000-ton units of the Texas Gulf Sulphur Company's concentrator near Timmins started tune-up operations late in 1966.

In Manitoba, Inco prepared three new mines for production in the nickel belt in the vicinity of Thompson. Sherritt Gordon Mines, Limited started shaft sinking on its Fox Lake zinc-copper property.

Ten shafts and six refineries were under construction in the potash producing area of Saskatchewan in 1966. Annual production capacity is anticipated to be in the order of 7 million tons of K_2O equivalent in 1970.

In Alberta, development of the newly discovered Rainbow Lake oil and gas area continued. This find may become the largest single oil-producing area in Canada. Construction continued on the plant of Great Canadian Oil Sands Limited at McMurray, with first production from the Athabasca oil sands scheduled for late 1967.

Production value of metallic minerals in the Northwest Territories was up nearly 70 per cent in the first full year of shipments from the lead-zinc deposits at Pine Point. Production in the Yukon Territory was down as United Keno Hill Mines Limited curtailed production.

Red Mountain Mines Limited, near Rossland, British Columbia, started production of molybdenum in 1966. This plant is to handle 400 tons of ore a day. This production, coupled with the output from large operations started since 1964 has established Canada as the world's second largest molybdenum producer. Several large-tonnage copper producers are under development as a result of the attention being given to copper properties in the active base metals exploration program in British Columbia.

MINERAL INDUSTRY HIGHLIGHTS, 1867-1966

One hundred years after Confederation Canada's mineral industry is the most dynamic sector of the economy, and on the international scene puts Canada in third place among the world's diversified mineral producers.

While much of the production growth has taken place since the mid-1940's, the record of the past 100 years is filled with many events which have played a major role in determining the size and importance of the mineral industry of 1967. This brief review of Canadian mineral industry history sets out some of the highlights and measures the progress, decade by decade and province by province, since Confederation. Brief reference to some pre-Confederation events is made as a reminder that the industry was already well established in 1867 and, in fact, had its earliest beginnings in the voyages of discovery of the 15th and 16th centuries.

The growth in the value of Canada's mineral production and GNP over the past 100 years is indicated in the accompanying tabulation.

Value of Mineral Production and of Gross National Product

Year	Mineral Industry $ Million	GNP $ Million	% GNP
1867	6.9e	n.a.	—
1870	6.9e	459	1.5
1880	8.0e	597	1.3
1890	16.8	809	2.1
1900	64.4	1,044	6.1
1910	106.8	2,186	4.9
1920	227.9	5,536	4.1
1930	279.9	5,546	5.1
1940	529.8	6,743	7.8
1950	1,045.5	18,006	5.7
1960	2,492.5	36,254	6.9
1966	4,032.0	57,781	7.0

n.a. Not available; e Estimate.

Canada's population in 1867 was 3,499,000 and in 1870, the first year for which the GNP is available, it was 3,673,000. Since 1870, the population has increased by a factor of 5.4; the GNP has increased by a factor of 12.3, and the value of mineral production increase has been 58-fold. During this period, mineral production value at the primary level has advanced from 1.5 per cent of the GNP to 7.0 per cent. Capital investment in mining rose from 3.0 per cent of the Canadian total in 1929 to 6.4 per cent in 1966. Exports of all commodities had only reached $67 million in 1870 and mineral exports were less than 5 per cent of this amount; in 1966 total exports were more than $10,000 million and mineral commodities, including aluminum, accounted for almost one third of the total. The value added in mining production, as computed for the national income, increased by 35 times from 1870 to 1920 while the value added in agriculture increased by only 7 times, fishing and trapping by 9 times, and forest operations by 5 times. The national income rose by 12 times during this period. This particular comparison is of significance in that it shows that the dynamic growth characteristic of the mineral industry, so apparent during the past 20 years, was also a key factor in the country's economic growth during the first 50 years of Confederation. From 1926 to 1963, the net value of mining production increased from 15.2 per cent of the primary resource sector and 6.5 per cent of all primary and secondary production in Canada to 29.2 per cent and 8.1 per cent of the respective net values.

These key indicators point to the outstanding rate of growth of the mineral economy in the past 100 years of Canada's economic advance. However, the mineral industry historical record is much more than a measurement of production growth. It is a record of an industry that led the way in opening up vast new territories and in colonization and settlement. It is an account of the pioneering activities of a young nation, of the country's great expansion after the turn of the century, of the supply of vital materials made available to the country and the allied nations in two world wars, of the support to the economy in times of recession, and of the stimulus to economic activity in times of great industrial expansion. Thus, the mineral industry record is an integral part of the history of Canada. A survey of mineral industry development is one of the paths of Canadian history which may be retraced in this Centennial year to gain a greater appreciation of the country's accomplishments during its first 100 years.

In commencing this 100-year journey, the reader may first wish to picture the mineral industry of 1867. In that year, metals accounted for 57 per cent of the industry's mineral output; industrial minerals accounted for 23 per cent, and fuels, 20 per cent. The 1966 percentages were rather similar: 52 per cent, 19 per cent and 29 per cent. These percentage shares of the three sectors have been quite representative throughout the 100 years but the components of each sector have changed considerably. In 1867, gold accounted for 77 per cent of the metals output and silver, 13 per cent; in 1966 these two metals only accounted for 9 per cent of the value of the metals. Structural materials accounted for two thirds of the value of industrial minerals in 1867 and barely one half in 1966. In 1867, coal value was more than four fifths of the fuels output; in 1966 it was only 6 per cent. The most significant difference in the two years, aside from the great value increase, is the contrast in the numbers of mineral commodities produced: 25 in 1867; 65 in 1966. Even so, the 1867 record remains interesting and impressive in relation to the early stage of the country's economic development in the year of Confederation.

Added perspective to an historical review of mineral industry progress is gained by brief reference to some milestones in the nation's history since 1867.

In reviewing the past, mineral developments can be seen in relation to such national events as the following. The British North America Act of 1867 brought together four provinces: Nova Scotia, New Brunswick, Quebec and Ontario. In 1870 Manitoba entered Confederation and the Northwest Territories were transferred to Canada; British Columbia entered in 1871; Prince Edward Island in 1873; Alberta and Saskatchewan, as provinces in 1905 and Newfoundland in 1949. Each province came into Confederation with some background of mineral development interest and each province's mineral development was expedited by events associated with and following Confederation. These included progress in transportation, in the work of the Geological Survey of Canada, and in the evolution of fairly uniform sets of mining laws

Mineral Production of Canada — Ten Leading Minerals 1890-1966

1890	$000	%	1900	$000	%	1910	$000	%
Coal	5,676	34.0	Gold	27,908	43.3	Coal	30,910	28.9
Clay products	2,041	12.2	Coal	13,742	21.3	Silver	17,580	16.5
Asbestos	1,260	7.6	Nickel	3,327	5.1	Nickel	11,181	10.5
Stone	1,162	7.0	Clay products	3,195	5.0	Gold	10,206	9.6
Gold	1,150	6.9	Copper	3,066	4.8	Clay products	7,630	7.1
Copper	947	5.7	Lead	2,761	4.3	Copper	7,094	6.6
Nickel	933	5.6	Silver	2,740	4.3	Cement	6,412	6.0
Petroleum	903	5.4	Stone	1,657	2.6	Stone	3,669	3.4
Silver	419	2.5	Petroleum	1,151	1.8	Asbestos	2,574	2.4
Lime	412	2.5	Lime	800	1.2	Natural gas	1,346	1.3
Total	14,903	89.4	Total	60,347	93.7	Total	98,602	92.3
Other minerals	1,860	10.6	Other minerals	4,074	6.3	Other minerals	8,222	7.7
Total all minerals	16,763	100.0	Total all minerals	64,421	100.0	Total all minerals	106,824	100.0

1920	$000	%	1930	$000	%	1940	$000	%
Coal	82,497	36.2	Coal	52,850	18.9	Gold	204,479	38.6
Nickel	24,534	10.8	Gold	43,454	15.5	Copper	65,773	12.4
Gold	15,814	6.9	Copper	37,948	13.6	Nickel	59,823	11.3
Cement	14,798	6.5	Nickel	24,455	8.7	Coal	54,677	10.3
Asbestos	14,792	6.5	Cement	17,713	6.3	Lead	15,864	3.0
Copper	14,244	6.3	Lead	13,103	4.7	Asbestos	15,620	2.9
Silver	13,450	5.9	Clay products	10,594	3.8	Zinc	14,464	2.7
Clay products	10,665	4.6	Natural gas	10,290	3.7	Natural gas	13,000	2.5
Stone	7,594	3.3	Silver	10,089	3.6	Cement	11,775	2.2
Natural gas	4,233	1.9	Zinc	9,635	3.4	Sand & Gravel	11,759	2.2
Total	202,621	88.9	Total	230,131	82.2	Total	467,234	88.1
Other minerals	25,239	11.1	Other minerals	49,743	17.8	Other minerals	62,591	11.9
Total all minerals	227,860	100.0	Total all minerals	279,874	100.0	Total all minerals	529,825	100.0

1950	$000	%	1960	$000	%	1966	$000	%
Gold	168,989	16.2	Petroleum	422,926	17.0	Petroleum	812,699	20.2
Copper	123,211	11.8	Nickel	295,640	11.9	Copper	457,790	11.4
Nickel	112,105	10.7	Uranium	269,938	10.8	Iron ore	419,108	10.4
Coal	110,140	10.5	Copper	264,847	10.6	Nickel	399,736	9.9
Zinc	98,040	9.4	Iron ore	175,083	7.0	Zinc	289,707	7.2
Petroleum	84,619	8.1	Gold	157,152	6.3	Natural gas	198,818	4.9
Asbestos	65,855	6.3	Asbestos	121,400	4.9	Asbestos	166,937	4.1
Lead	47,886	4.6	Sand & Gravel	111,164	4.5	Cement	157,901	3.9
Sand & Gravel	36,435	3.5	Zinc	108,635	4.4	Sand & Gravel	147,625	3.7
Cement	35,894	3.4	Cement	93,261	3.7	Gold	125,102	3.1
Total	883,174	84.5	Total	2,020,046	81.1	Total	3,175,432	78.8
Other minerals	162,276	15.5	Other minerals	472,464	18.9	Other minerals	856,558	21.2
Total all minerals	1,045,450	100.0	Total all minerals	2,492,510	100.0	Total all minerals	4,031,981	100.0

of high standard in all provinces. Each province pursued actively the development of its own mineral resources, a responsibility initiated by the BNA Act for the eastern provinces and approved by the federal government for Manitoba and Alberta in 1929, and British Columbia and Saskatchewan in 1930.

Other earlier events of significance included the surrender to the Crown of the Hudson's Bay Company's territorial rights in the northwest in 1869. The Intercolonial Railway was completed in 1876 to connect Ontario and Quebec to the Maritimes. The Canadian Pacific Railway was completed in 1885 to link British Columbia to eastern Canada and to provide transportation for the settlers of western Canada. The first wheat was exported from Manitoba to Britain in 1877. The "National Policy" with its protective tariff was adopted in 1879 with the objective of promoting domestic production in a wide range of goods and of diverting trade from international to interprovincial channels. The protective principle was extended to primary iron and steel by the introduction of bounties in 1883 and higher duties in 1887. In 1897 Canada established preferential tariffs, thus inaugurating Imperial Preference. Although the economic policy based on railways, immigration, and tariffs of the post-Confederation period created stresses and strains for the other resource industries, and the young manufacturing sector, the mineral industry was not adversely affected and did benefit greatly from the transportation links established by a great transcontinental railway building program.

In the pre-World War I years there was a major inflow of immigrants to western Canada, encouraged by mining activity in British Columbia and by the agricultural potential of the Prairies. Large-scale settlement of the Prairies was made possible by the extensive railway construction program that had followed completion of the CPR link to the Pacific in 1885. This project, in turn, had come about as the result of conditions laid down by British Columbia when it entered Confederation in 1871. Going farther back, the gold rushes in British Columbia of the 1850's and 1860's had attracted so many people to the area that colony status was no longer adequate and a link with eastern Canada was urgently needed if sovereignty north of the 49th parallel was to be maintained. Thus can the chain of events of railway building and Prairie settlement from 1900 to 1914 be traced back to colonization generated by mining activity.

In the Maritime provinces, there were complaints of little benefit from Confederation and demands were made in 1910 for lower tariffs. The Reciprocity Treaty signed with the United States in 1911, however, led to Laurier's defeat on an issue concerning Canada's identity in the face of increasing dependence on the United States. While this was a period of considerable uncertainty, with the reciprocity issue being of great importance to agriculture, fishing and the forest industries, mining development proceeded rapidly following the Sudbury nickel-copper discovery in 1884, the base metal discoveries of southern British Columbia in the 1890's, and the Cobalt silver and Porcupine-Kirkland Lake gold discoveries of the first decade of the 20th century.

World War I came at a time when Canada's mineral potential was gaining recognition and the part the country played in vital mineral supply led to increasing mineral interest in the 1920's during a period of rapid economic development. Organization of the Canadian National Railways in 1919 provided for improved transportation, particularly to northern areas. Air transportation began to develop and was an important factor in mineral exploration for the first time in the 1920's. In this period of economic expansion, American capital played a major role and in 1930 United States ownership of Canadian manufacturing and mining was at least one third. While ties with the United States were being increased, the Imperial Conference of 1926 and the Statute of Westminster of 1931 recognized the autonomy of Canada and of other Dominions.

Canada suffered extensively in the depression of the early 1930's because of its extensive dependence on foreign markets. Foreign markets were cut in half, and agriculture, forestry and fishing were badly hit. As is customary in a depression, gold mining activity served as a stabilizer for the mining industry. This was a time of difficulty in federal-provincial relations because of the increased responsibilities of provincial governments relative to education, highways, social security, public welfare, etc., not foreseen when respective spheres of responsibility and revenue sources were established in 1867. The Rowell-Sirois Commission reported in 1939 on federal-provincial financial relationships but World War II prevented implementation of the Commission's recommendations. In the economic life of the country, the mineral industry led the way out of the depression of the early 1930's. Fortunately, mineral markets had recovered sufficiently by the mid-1930's which, along with the increase in the price of gold, had stimulated new mineral development and Canada entered World War II with a mineral output twice the value of a decade earlier. As in World War I, her mineral economy played a key role in strategic mineral supply.

World War II had brought increased economic prosperity and political prestige to Canada. The Canadian Citizenship Act of 1947 created a new Canadian citizenship. Appeals to the British Privy Council were abolished in 1949. The Massey Commission, established in 1951, made important recommendations relative to the cultural life of the country. Public welfare measures and more sophisticated economic policies brought government more and more actively into national life. All these new trends, together with an almost unbroken period of economic expansion, have given Canada a new sense of identity and greater responsibilities, both national and international. The country is, therefore, more than ever dependent on a dynamic mineral economy. The mineral industry record of the last 100 years indicates that the industry can continue to give the support and economic leadership that has been forthcoming in the past.

Atlantic Provinces

The history of mining in Canada dates from the days of the earliest explorers, some of whom set the stage for later mineral development, particularly in the Atlantic Provinces and Quebec. John Cabot claimed Newfoundland in the name of England in 1497. There was little interest other than in fisheries, however, in this area during the following century. At the beginning of the 17th century, Samuel de Champlain arrived on the scene. In 1603 he sailed up the St. Lawrence and on his second voyage from France to North America the next year, he was accompanied by a mining engineer. Discoveries of silver were made at St. Mary's Bay and native copper at Cap d'Or in what is now Nova Scotia. No doubt these discoveries encouraged Champlain to return and he established permanent settlements at Port Royal in 1605 and at Quebec in 1608. Although Cabot had discovered Cape Breton in 1498, and there were subsequent numerous voyages by other explorers, it was not until 1672 that the first reference was made to the coal seams of Cape Breton. Nicholas Denys, who had been appointed Governor of the eastern part of Acadia in 1637, referred to it in a book published in Paris 1672. The first attempt at systematic coal mining was made in 1720 when fuel was needed for the fortress of Louisbourg. Later, English interests carried on the mining of coal in Cape Breton to supply the needs of the militia at Halifax. In these early times, mining operations remained in the hands of a few large companies, mainly the General Mining Corporation which was given a monopoly of mining rights in Nova Scotia.

In 1856, the monopoly of the General Mining Company in Nova Scotia was broken and coal exports increased from Cape Breton mines, especially to American seaports. During the decade of the 1860's, over 5 million tons of coal were produced in Nova Scotia.

A lead-mining venture at La Manche got under way in 1857 and continued for about 16 years. A copper mine was opened up at Tilt Cove in 1864; the Betts Cove Copper deposit was discovered in 1874, and the Little Bay copper mine in 1878. These and other developments enabled Newfoundland to obtain a position of prominence in world copper production in the 1870's. Copper output in 1879 was 1,200 tons. The record shows that the value of nickel produced in Newfoundland from 1860 to 1876 was $32,740.

In Nova Scotia, 58 small mines were producing gold in the 1880's. Iron ore production was limited to Acadia Mines at Londonderry. Copper was being produced in Albert County, New Brunswick. Oil occurrences had been found in both New Brunswick and Nova Scotia.

Nova Scotia

Five Leading Minerals, 1890-1966, Selected Years

	1890		1920		1950		1966	
	$ million	%	$ million	%	$ million	%	$ million	%
Coal	3.41	80.2	32.24	94.5	50.3	84.5	51.5	59.9
Gypsum	0.16	3.6	0.57	1.7	3.8	6.4	8.6	10.0
Sand and Gravel	—	—	—	—	1.5	2.5	7.9	9.2
Salt	—	—	—	—	1.1	1.8	4.8	5.6
Cement	—	—	—	—	—	—	3.5	4.1
Clay	—	—	0.54	1.6	1.1	1.9	—	—
Stone	0.10	2.4	0.42	1.2	—	—	—	—
Lime	—	—	0.04	0.1	—	—	—	—
Gold	0.47	11.2	—	—	—	—	—	—
Iron Ore	0.10	2.4	—	—	—	—	—	—
Others	0.01	0.2	0.32	0.9	1.7	2.9	9.7	11.2
Total	4.25	100.0	34.13	100.0	59.5	100.0	86.0	100.0

— Indicates minerals not among the leading five.

New Brunswick

Leading Minerals, Selected Years, 1890-1966

	1890*		1920		1950		1966	
	$ million	%	$ million	%	$ million	%	$ million	%
Zinc			—	—	—	—	44.2	49.5
Lead			—	—	—	—	14.3	16.0
Coal			1.10	—	4.4	34.3	7.9	8.9
Copper			—	—	—	—	5.9	6.7
Silver			—	—	—	—	4.2	4.7
Stone			—	—	3.5	27.7	—	—
Sand and Gravel			—	—	3.0	23.5	—	—
Clay			—	—	0.7	5.3	—	—
Lime			—	—	0.4	3.0	—	—
Natural gas			0.13	—	—	—	—	—
Gypsum and Structural Materials			1.27	—	—	—	—	—
Others			—	—	0.8	6.2	13.0	14.5
Total	0.36	100.0	2.5	100.0	12.8	100.0	89.5	100.0

— Indicates minerals not among leading five. * Lime, stone, clay products, grindstones and gypsum.

The 1930's and 1940's were years of growth in the coal mining industry of Nova Scotia. Gypsum continued as the second mineral commodity. There was some activity in gold mining, and shipments of silver, lead and zinc were made in the 1930's from the Stirling mine. Coal was the leading mineral in New Brunswick and a number of deposits of clay, stone and structural materials were also worked.

The Newfoundland mineral production record prior to Confederation in 1949 is not complete but the Island of Newfoundland has had an active mineral industry since the mid-19th century. In the 1870's it ranked fourteenth among copper-producing countries of the world. Mining of iron ore started at Wabana on Bell Island in 1895. The Rambler copper-zinc deposits at Baie Verte, Newfoundland, were discovered in 1905; after many years of intermittent development, production got under way in 1964. The exploitation of base metal deposits at Buchans, beginning in 1928 after intermittent development dating from 1905, marked the

Newfoundland

Five Leading Minerals

	Cumulative Production 1854-1935	1950		1966	
	$ million	$ million	%	$ million	%
Iron ore	46.98	5.8	22.7	186.7	77.2
Copper	18.33	1.5	5.8	16.8	6.9
Zinc	10.38	9.6	37.0	10.4	4.3
Asbestos	—	—	—	10.3	4.3
Lead	8.94	5.2	20.1	6.3	2.6
Fluorspar	—	1.3	5.0	—	—
Pyrite	3.42	—	—	—	—
Gold	.13	—	—	—	—
Other	not available	2.4	9.4	11.4	4.7
Total	(88.17)	25.8	100.0	241.9	100.0

— Indicates minerals not among leading five.

start of mining expansion in this century, although exploration practically ceased in the early 1930's. Newfoundland's mineral production value rose from $1.2 million in 1901 to $6.2 million in 1936 and $8.7 million in 1939. A steady increase in value followed but the dramatic expansion started in 1954 with the beginning of Labrador iron ore production. Production rose from $27.6 million in 1949 to $42.9 million in 1954; from then on, except for a setback in 1958, the advance was rapid to $241.9 million in 1966.

The nonferrous sector has been a source of major expansion for the mineral economy of the Atlantic Provinces, particularly the lead-zinc mines of the Bathurst area of New Brunswick. There has also been a reactivation of copper mines in the Notre Dame Bay region of Newfoundland. A new asbestos mine was put into production in 1964 in the Burlington Peninsula area of Newfoundland. Iron ore from Labrador has accounted for by far the largest part of the increase in mineral production value in the Atlantic Provinces in recent years.

The value of mineral production from the Atlantic Provinces has risen from $98 million in 1950 to $417 million in 1966. A large proportion of this increase has come from iron ore production in Newfoundland, which more than compensated for the decline in coal output.

The Atlantic Provinces' long mining history was dominated by coal until the 1940's. Since then the iron ore of Newfoundland and the nonferrous minerals of New Brunswick have been providing much-needed growth and diversification. The long-established nonmetals sector is now expanding, due chiefly to the Newfoundland asbestos development. The relatively small structural materials sector, accounting for less than 10 per cent of the combined mineral output of Nova Scotia and New Brunswick and about 2 per cent of Newfoundland's output, reflects the lower level of industrial activity of the region compared with Ontario and Quebec where this sector accounts for 17 or 18 per cent of mineral value totals. With the coal industry in decline, the hope for a thriving mineral fuels sector may lie in the offshore exploration for oil and gas now under way.

Quebec

The first reference to Canada's mineral wealth was made by Jacques Cartier on return to France from his first voyage in 1534 with stories told by Indians of a legendary Kingdom of the Saguenay with its gold and precious stones. In two subsequent voyages he sought unsuccessfully to find this wealth. The first examination of bog iron deposits at Baie St. Paul and in the St. Maurice Valley was made by Sieur de la Portardiere who came from France in 1667. La Compagnie des Forges started the first smelting of bog iron in this area in 1737 and forges operated at St. Maurice until the

1880's. Iron smelting operations in Bagot, Nicolet and Drummond counties were all of some importance in Quebec's early history. The first portland cement made in Canada was produced in 1840 at Hull. The Montreal Mining Company, established in 1845, was the main mining operator in Quebec at this time.

Discovery of quartz gold in the Eastern Townships, near Sherbrooke, was made in 1861, shortly after the placer gold discoveries in British Columbia. There was a small gold rush in the Chaudiere River area in 1864 and during the succeeding 20 years nearly $3,000,000 worth of gold was to come from mines there. Asbestos was discovered in 1877 in the Eastern Townships during the building of the Quebec Central Railway. Within ten years production exceeded 4,500 tons of fibre annually. Copper was also discovered in the Eastern Townships; the most important producer was the Eustis mine which had a history of production from 1865 to 1939.

Asbestos was generally the leading mineral in Quebec in this early period although the clay products industry was also thriving. Other operations included the production of phosphates in Ottawa County and the quarrying of construction materials.

Following the opening up of the northern Ontario gold mining areas, prospecting activity spread into northwestern Quebec and in 1921 the discovery of gold and copper in the Rouyn district marked the start of the Noranda mine development. The mine and smelter went into production in 1927.

In 1936 one of the richest gold mining strikes ever made in Canadian mining occurred at the O'Brien mine. This was a very active period for the gold mining industry, and gold moved into first place with the opening of the Sullivan Consolidated mine in 1934, Lamaque and Canadian Malartic in 1935, Sigma in 1937, Barnat and East Malartic in 1938, Malartic in 1939, and several others – all in the general Rouyn district.

During the war Quebec mines and plants supplied most of the Allied Nations requirements of asbestos, and two fifths of the aluminum came from its smelters. Noranda and Montreal East copper processing facilities operated at capacity.

Development of Quebec-Labrador iron ore resources began in the early 1950's, resulting in the establishment of the mining towns of Schefferville, Gagnon and Pointe Noire, a new railway and dock facilities, and many service industries. Iron ore quickly rose to a position of prominence in Quebec's mineral output. Nonferrous mineral production also advanced

Quebec

Five Leading Minerals, 1890–1966, Selected Years

	1890		1920		1950		1966	
	$ million	%	$ million	%	$ million	%	$ million	%
Copper	0.74	22.5	–	–	34.1	15.5	155.1	20.2
Asbestos	1.26	38.3	14.8	51.2	64.4	29.3	141.6	18.4
Iron ore	–	–	–	–	–	–	128.7	16.8
Zinc	–	–	–	–	26.9	12.2	87.7	11.4
Stone	–	–	2.2	7.6	–	–	55.1	7.2
Gold	–	–	–	–	41,7	18.9	–	–
Cement	–	–	6.5	22.6	14.5	6.6	–	–
Clay products	0.46	13.9	2.4	8.2	–	–	–	–
Lime	–	–	0.8	2.9	–	–	–	–
Phosphates	0.31	9.4	–	–	–	–	–	–
Pyrite	0.22	6.7	–	–	–	–	–	–
Others	0.30	9.2	2.2	7.5	38.6	17.5	199.5	26.0
Total	3.29	100.0	28.9	100.0	220.2	100.0	767.7	100.0

– Indicates minerals not among leading five.

rapidly as a result of the opening of copper mines from 1955 to 1959 in the Chibougamau area, 200 miles northeast of Noranda; the Gaspe copper mine in 1955 at Murdochville; and the zinc-copper deposits of the Matagami Lake area in 1963. Quebec has expanded its molybdenum output in the 1960's through the opening of mines in the Lake Preissac area and at Lacorne.

The decreasing share of total production of the five leading minerals in recent years points to increasing diversification and also to the decline in importance of gold which had held a prominent position in the 1930's and 1940's. Its value in 1966 was only $35.8 million. Structural materials, such as clay products, cement, lime, sand and gravel and stone have increased in importance accounting for 18 per cent of Quebec's mineral output in 1966. The newer mineral operations such as columbium and nickel, are giving further diversification to Quebec's mineral industry.

Ontario

As settlement spread westward in the early 1800's, iron deposits were found in Upper Canada. A number of industrial mineral deposits were worked, one of the earliest being for gypsum near Paris in 1822. Various types of building stone and clays were mined for local construction purposes. In 1847, a substantial deposit of copper was discovered at Bruce Mines on the North Channel of Lake Huron and mining operations began the following year with the ore being shipped to England for refining. This operation continued to thrive and in the 1860's was employing nearly 400 men.

In 1858, the first oil well on the North American continent was dug at Oil Springs, Ontario. Drilling operations brought in Canada's first flowing well in 1862 in Black Creek Valley and by the end of the year 35 flowing wells and 200 wells using pumps were in production. During the remainder of the decade many wells were completed in this part of Ontario, a number of small refineries were constructed near Petrolia, and the completion of pipelines and large storage tanks permitted further expansion of the industry. In 1870, production reached about 5,000 barrels a week, much of which was exported to Europe. Salt was discovered at Goderich in 1865 during oil drilling operations.

A gold discovery at Madoc in 1866 was the first in the Canadian Shield. Silver veins on Silver Islet in Lake Superior were discovered in 1868 and up to 1884, when the mine was

Ontario

Five Leading Minerals, 1890–1966, Selected Years

	1890		1920		1950		1966	
	$ million	%	$ million	%	$ million	%	$ million	%
Nickel	0.93	24.2	24.5	30.0	112.1	30.6	291.2	30.4
Copper	0.20	5.3	5.6	6.9	54.4	14.8	181.8	18.9
Iron ore	—	—	—	—	17.6	4.8	83.0	8.7
Gold	—	—	11.7	14.3	94.4	25.7	62.3	6.5
Sand and Gravel	—	—	—	—	—	—	61.9	6.5
Platinum	—	—	—	—	17.8	4.9	—	—
Silver	—	—	10.0	12.2	—	—	—	—
Clay Products	1.35	34.9	5.6	6.9	—	—	—	—
Crude Oil	2.90	23.4	—	—	—	—	—	—
Lime	0.19	4.8	—	—	—	—	—	—
Others	0.29	7.4	24.3	29.7	70.5	19.2	279.2	29.0
Total	3.80	100.0	81.7	100.0	366.8	100.0	959.4	100.0

— Indicates minerals not in leading five. (In 1966 uranium output value was $40.5 million; in 1959 peak value was $268.5 million.)

flooded in a storm, over $3,000,000 worth of silver was produced. Apatite and mica were mined in a number of deposits as early as 1870. Stone quarries were opened up, and brick and tile plants based on clay products near Toronto were established. Iron ore mining was of increasing importance in the 1870's with much of the ore from eastern Ontario being exported to the United States.

Sudbury nickel-copper ore was discovered in 1883 during blasting operations for the Canadian Pacific Railway. Mining soon began and by 1900 two furnaces were in operation. Metallurgical research leading to the development in 1892 of processes for separating copper and nickel made the development of the Sudbury deposits possible on a large scale. The Sudbury and other discoveries of the 1880's led to great optimism concerning Canada's mineral resources and predictions were made that minerals would become one of the chief sources of wealth for the country. Notwithstanding this optimism, Canadian investors were hesitant and early development of the Sudbury deposits was based largely on United States capital.

During the construction in 1903 of a railway line north to the clay belt region surrounding Hudson Bay, blasting operations uncovered a very rich deposit of silver ore at Long Lake (later Cobalt Lake). This was the beginning of the Cobalt silver camp, itself a forerunner of the important mining camp discoveries of northern Ontario and northwestern Quebec. Gold was discovered at Larder Lake in 1906 and silver near Gowganda in 1907. In 1909 ground was staked leading to the development of three famous gold mines – Dome, Hollinger and McIntyre – in the Porcupine mining camp, the country's leading gold-producing area. Kirkland Lake which became Canada's second largest gold mining camp, got under way in 1911. These gold discoveries had been preceded by the development of the cyanide process for treating gold ores and this metallurgical advance, plus the technical improvements in mining and ore concentrating, prepared the way for the rapid growth of a great gold industry. With these gold and silver discoveries of the first decade of the century, Ontario assumed mineral production leadership and by 1910 was accounting for two fifths of Canada's mineral output. It has remained the leading province since that time.

In 1916 the Falconbridge nickel deposit in the Sudbury district was found. Two years later the production of refined nickel was started at Port Colborne, Ontario.

While the Noranda district was under active exploration in the 1920's prospecting spread westward to the Red Lake District of northwestern Ontario. The Sudbury nickel-copper operations were expanded greatly during World War I and nickel again became the leading mineral after being second to silver in the pre-war years.

Only the gold mining industry remained under active development in the depression period of the early 1930's. With the increase in the gold price to $35 (US) in 1934, many gold mines were brought into production in this province and also in Quebec, Manitoba and British Columbia. New gold production records were set with the opening in the 1930's of the Hollinger Ross mine, Macassa, Upper Canada, Kerr-Addison, Pickle Crow, Broulan Reef, Delnite, Hallnor, Pamour Porcupine, Preston, Leitch, MacLeod-Cockshutt, Cochenour Willans, Madsen Red Lake, and McKenzie Red Lake. Considerable progress was also made, following the depression, in the mining and refining of nickel and copper through the introduction of improved equipment and the construction of copper refineries at Copper Cliff and Montreal East.

In spite of the lack of manpower during World War II, and a shortage of mining machinery and equipment, Canada supplied over four fifths of the Allied Nations' nickel requirements, making up for the deficiencies from the loss of refining facilities in Norway and France. Large supplies of copper were also made available. At the same time, gold mining declined as workers were transferred to other industries. However, Ontario and the other gold producing provinces were able to produce $1.1 billion worth of gold from 1939 to 1945 despite severe manpower shortages.

In recent years, Ontario has established an important iron ore industry with mines at Wawa, in the Steep Rock Lake area, at Capreol, at Marmora, and in the Kirkland Lake area. There are also important byproduct operations in the Sudbury area.

The uranium industry was Ontario's most spectacular growth industry during the 1950's. Production reached a peak in 1959 with 15 mines in operation and then swiftly declined as a result of a decision made in November 1959 by the United States Atomic Energy Commission not to exercise its options to purchase additional quantities of Canadian uranium after the expiry dates of sales contracts. The decline in output from uranium mines in Ontario, from 25.5 million pounds in 1959 to 19.8 million in 1960 and 5.8 million in 1966, is a measure of the impact of this decision.

The province has experienced considerable growth in its nonferrous sector, with the opening in 1957 of the copper-zinc mines of the Manitouwadge area , 40 miles north of Lake Superior, the discovery of a very large zinc-silver-copper deposit near Timmins that is scheduled for production in 1967; and continuing expansion in the Sudbury nickel-copper district.

Unlike some of the other provinces where marked new diversification is indicated by the decline in relative importance of the five leading minerals, Ontario has had a fairly diversified mineral economy since the turn of the century. However, whereas nickel and copper have maintained about their same relative positions, gold has declined in importance, and iron ore and uranium appear as principal contenders for leading positions in the 1970's. As in Quebec, the structural materials have shown marked growth. They now account for about 18 per cent of Ontario's mineral output value.

Prairie Provinces and Northwest Territories

Canada's north attracted early explorers seeking a sea route to China. One of the earliest explorers, Martin Frobisher, made three voyages to Baffin Island between 1576 and 1578. Samples of rock taken back to England on the first voyage caused a great stir and led to much speculation in London as Canada's first gold mining boom got under way. The story of Frobisher's gold mine is one of intrigue and knavery by unscrupulous promotors including even the salting of ore samples. Soon the bubble burst and Frobisher and other great Elizabethans continued their voyages of adventure across the world searching for wealth in other new lands.

Until almost the end of the 19th century, the history of the Prairie Provinces and the Northwest Territories is primarily related to the activities of the early explorers, the fur traders, the Red River settlers and the railroad builders, although G.M. Dawson and other noted geologists of the Geological Survey of Canada were laying the groundwork for the mineral development that was to get under way after the turn of the century. Their work had begun to attract attention to the mineral potential of the region even before 1900. In the second half of the 19th century most of the country's coal output was obtained from Nova Scotia and British Columbia but large coal deposits had been discovered in the Northwest Territories (later Alberta). Oil seepages had been found as early as 1884 in the Waterton Lakes district of southwestern Alberta. Even at this time, the Athabasca oil sands were widely known, having been first noted by Alexander Mackenzie in 1789. They were considered in the 1880's to be "the most extensive petroleum field in America, if not in the world". A Senate committee report of 1887 observed that "it is probable that this great petroleum field will assume an enormous value in the near future, and will rank among the chief assets comprised in the Crown domain of the Dominion". Some 80 years later, these deposits are now being brought into production.

Shortly after the turn of the century, much interest was being taken in oil and gas drilling. Gas was first produced in the Medicine Hat area in 1904. The Bow Island field was discovered in 1909 and in 1912 a 170-mile gas pipeline was built to Calgary. The Turner Valley field, near Calgary, was discovered in 1913 and gas was soon available. The boom that followed quickly subsided and the next important well—Royalite No. 4 — was completed in 1924 as a prolific gas producer and between 1924 and 1929 it produced almost one million barrels of condensate. A number of other wells were drilled in the now-famous Turner Valley field but it was not until 1936 that oil was discovered. Subsequently, the field was fully developed by the drilling of 116 gas wells and 325 oil wells.

Manitoba

Five Leading Minerals, Selected Years

	1890*		1920		1950		1966	
	$ million	%	$ million	%	$ million	%	$ million	%
Nickel			—	—	—	—	98.3	54.0
Copper			0.53	12.6	9.8	29.8	27.7	15.2
Crude petroleum			—	—			13.0	7.1
Cement			—	—	4.0	12.1	11.0	6.0
Zinc			—	—	6.7	20.6	10.8	6.0
Gold			—	—	7.3	22.3	—	—
Gypsum			0.49	11.7	1.0	3.2	—	—
Stone			0.37	8.8	—	—	—	—
Lime			0.21	5.0	—	—	—	—
Clay			0.21	5.0	—	—	—	—
Others			2.39	56.9	3.9	12.0	21.4	11.7
Total	0.03		4.2	100.0	32.7	100.0	182.2	100.0

— Indicates minerals not in leading five. * Clay products, lime and stone were produced.

Saskatchewan

Five Leading Minerals, Selected Years

	1890*		1920***		1950		1966	
	$ million	%	$ million	%	$ million	%	$ million	%
Crude petroleum					—	—	212.9	58.0
Potash					—	—	76.7	20.9
Copper					13.6	37.7	17.4	4.7
Uranium					—	—	13.8**	3.8
Zinc					8.6	23.9	8.7	2.4
Coal			0.83		4.1	11.3	—	—
Gold					3.0	8.4	—	—
Sodium Sulphate					1.6	6.5	—	—
Others			0.91		5.1	14.2	37.6	10.2
Total	0.01	100.0	1.71	100.0	36.0	100.0	367.1	100.0

— Indicates minerals not in leading five. *Mainly clay products with some coal. **Uranium had a peak value of $54.5 million in 1959. ***Complete commodity distribution not available.

Alberta

Five Leading Minerals, Selected Years

	1890*		1920		1950		1966	
	$ million	%	$ million	%	$ million	%	$ million	%
Crude petroleum			0.08	0.2	82.2	60.6	545.2	61.2
Natural gas			1.2	3.5	2.9	2.2	170.5	19.1
Elemental sulphur			—	—	—	—	33.5	3.8
Cement			—	—	3.4	2.5	16.7	1.9
Sand and Gravel			—	—	2.6	1.9	12.6	1.4
Coal	0.198	98.0	29.8	88.9	41.7	30.7	—	—
Clay			0.8	2.4	—	—	—	—
Lime			0.07	0.2	—	—	—	—
Gold	.004	2.0	—	—	—	—	—	—
Others			1.63	4.8	3.0	2.1	122.7	12.7
Total	0.202	100.0	33.58	100.0	135.8	100.0	891.2	100.0

— Indicates minerals not in leading five. * Breakdown by commodity not available for the Territory that later became Alberta.

Northwest Territories

	1890		1920		1950		1966	
	$ million	%	$ million	%	$ million	%	$ million	%
Zinc					—		57.3	48.9
Lead					—		34.4	29.4
Gold					7.64	94.9	15.9	13.6
Silver					0.05	0.6	2.7	2.3
Copper					—		0.7	0.6
Crude Oil					.35	4.3	—	—
Natural gas					0.01	0.1	—	—
Coal								
Other					0.01	0.1	6.2	5.2
Total	Not available		Not available		8.05	100.0	117.2	

— Indicates minerals not in leading five.

In 1914 the Flin Flon copper-zinc deposit on the Saskatchewan-Manitoba border was discovered. However, this complex ore presented metallurgical problems and it was not until 1927 that the necessary financing could be arranged and the processing problems resolved. Arrangements were also completed for a railway to this northern location, for a large electric power development and for a copper smelter and zinc refinery. The first blister copper and refined zinc were produced in 1930, illustrative of the time involved in overcoming major financial, metallurgical and transportation problems in Canadian mining.

In the 1920's, while exploration activity was spreading throughout northwestern Quebec and northern Ontario, efforts in the Prairie Provinces were being concentrated on getting the Flin Flon deposit into production and also the Sherritt Gordon mine. The latter reached the production stage in 1931 but had to be closed until 1937 because of low copper prices. The use of the aeroplane in mineral exploration here, and in the Red Lake district of Ontario marked the start of a new era in mineral exploration in Canada.

In the 1930's the Flin Flon copper-gold-zinc mine was the largest mining operation in Manitoba. In 1936 a new gold producer, the Gunnar gold mine, came into production in the God's Lake area. In Saskatchewan, mineral production value was largely attributable to the Flin Flon operation on the Manitoba border although a new gold area was opened up in the mid-1930's at Lake Athabasca. The province also had an important lignite coal industry and some production of clay products and sodium sulphate. Coal continued to be the leading mineral product in Alberta but the province was beginning to achieve importance as a producer of petroleum and natural gas, principally from the Turner Valley field. There were also brick, cement and lime plants.

In the Northwest Territories, at the Eldorado gold mine, high-grade silver ore was found with pitchblende. In 1930 these ores were shipped to Port Hope, Ontario for the recovery of silver, radium and uranium products. Exploration was active throughout the Territories and the Yellowknife gold mining camp was opened during this period.

Saskatchewan, like Ontario, had felt the benefit of rapid growth in the uranium industry in the latter half of the 1950's. With the loss of new markets in the United States, the industry in the province declined from a peak output of 5.4 million pounds in 1959 to 4.6 million in 1960 and 1.8 million in 1966. The Prairie Provinces, however, have had a number of developments in the mineral economy that have more than compensated for this decline.

The Thompson nickel mine came into production in 1961 and this mining and metallurgical complex now employs over 2,000 workers. The composition of Manitoba's mineral output has changed dramatically as a result of this and related developments. In the Northwest Territories a new era for the mining industry began events associated with the Kimberley-Trail enterprises, leading to their full production, are illustrative of the progress made in the fields of chemistry and metallurgy in support of Canada's mineral resource development.

However, the 1890's achieved their greatest immediate fame with the discovery of placer gold in the Klondike area of the Yukon Territory in 1896. From 1898 to 1905 about $100 million worth of gold was mined from the gravels near Dawson. Like the Fraser River and Cariboo gold rushes of the 1850's and 1860's, this great epic of early mining history attracted attention to the mineral possibilities of British Columbia and the North and at the same time encouraged early settlement.

In 1914 the Anyox copper smelter in northern British Columbia was completed and began processing ores from copper deposits in the Portland Canal district. Preparations started in 1918 to bring the rich Premier silver-gold mine near Stewart into production.

The 1920's were active years of mine development in British Columbia and the Yukon Territory, as elsewhere in Canada. The centres of activity included the Premier gold mine near Stewart and the silver-lead properties in the Mayo district. The Britannia copper mine on Howe Sound near Vancouver was one of several mines that went into large-scale production at this time as a result of the progress made in the development of the flotation method in milling. The deposit had been discovered in the 1890's; continuous production began in 1923.

The early 1930's was a time of great activity in the gold mining industry, particularly beginning in 1934 with the increase in the price of gold. The Bridge River mining camp was the leading gold-producing area. By the mid-1930's British Columbia had become one of the world's greatest sources of lead and zinc. Copper and silver mining had also expanded.

There was little mine development during the war and, as elsewhere in Canada, a major draw-down on reserves took place. Trail smelting and refining facilities operated at capacity to meet wartime requirements.

An iron-ore industry has been developed in recent years, based on markets in Japan. There are six iron mining operations on Vancouver Island, one on Texada Island, and one on Queen Charlotte Islands as well as production from pyrrhotite flotation concentrates at Kimberley. Of even more importance have been the developments in the nonferrous sector including the opening of the Craigmont and Bethlehem copper mines near Merritt and a number of silver-lead-zinc operations including those at Salmo, Remac, and Riondel in the southeastern part of the province. A major mine development project is currently under way at the Granduc property north of Stewart; the Granisle mine is scheduled for production shortly, and there are a number of other copper deposits in this northern part of the province under development. British Columbia has also recently achieved prominence as a molybdenum producer; the province will have five mines in production in 1967 with an estimated annual capacity of over 20 million pounds of molybdenum. The province became an asbestos producer with the opening up of the Cassiar asbestos mine, about 50 miles south of the Yukon border, in 1953. Oil and gas exploration has done much to develop the northeastern part of the province where a thriving industry producing crude oil, natural gas and natural gas byproducts accounts for 17 per cent of the province's mineral output value.

The less dominant position of the five leading minerals in recent years is a result of increasing diversification in British Columbia's mineral industry brought about by the development of an oil and gas industry, the growth of the structural materials sector, and the opening up of other types of mineral operations such as iron ore, molybdenum and asbestos.

Abrasives

D.H. STONEHOUSE*

Canada produces a major portion of the crude fused alumina and the crude silicon carbide used in the world today. However, the Canadian requirements for most types of abrasive grains and secondary abrasive products are met by imports. The Canadian output of refined abrasive grains and of natural abrasives is extremely small.

Almost all minerals, mineral assemblages and many man-made materials may be used as abrasives. However, only those with the most suitable physical properties for each general type of use are normally in demand. In general, they may be classified by origin (natural or artificial) and by degree of abrasiveness. The high-grade type includes diamond, corundum and the principal artificial products, silicon carbide and fused alumina. Quartz and feldspar are examples of the low-grade type. Mild abrasives include lime and diatomite, which commonly have a small particle size and are used for polishing and scouring. Some ores perform the role of an abrasive during grinding but eventually become pulverized and utilized as an ore.

Practically all the natural abrasives produced in Canada are from operations established primarily to supply materials for non-abrasive purposes. It is estimated that output of these abrasives commodities is valued close to $100,000 per year, although supporting statistics are not available. Included in this group are silica and beach sand, iron oxide, feldspar, granite and sandstone.

Production of crude artificial abrasives has increased steadily during the past three years, establishing an upward trend. The 1965 production of 98,545 tons of crude silicon carbide, valued at $14 million, was 71 per cent of the total Canadian and United States output, and the 169,289 tons of crude fused alumina, valued at $19.6 million, represented 87 per cent of the two-country production of that commodity. Virtually all of the Canadian production of crude abrasives is exported to the United States to supply a generally increasing yet widely fluctuating demand. Metallic abrasives such as grit and iron and steel shot are also produced but are not reported separately in statistics.

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*Mineral Processing Division, Mines Branch.

96411—3½

TABLE 1

Abrasives – Production, Trade and Consumption, 1965–66

	1965		1966P	
	Short Tons	$	Short Tons	$
Production				
Artificial abrasives				
Crude silicon carbide[1]	98,545	13,966,574		
Crude fused alumina[1]	169,289	19,634,770		
Abrasive wheels and segments	..	11,377,296		
Other products[2]	..	14,173,851		
Total		59,152,491		
Imports				
Natural and artificial abrasives				
Diamonds, industrial	..	5,971,484	..	6,709,000
Diamond dust	..	565,862	..	657,000
Pumice, lava and volcanic dust, crude or ground	10,532	176,920	14,426	221,000
Abrasives, natural, n.e.s.	6,218	427,116	8,172	464,000
Abrasives, artificial, crude and grains, n.e.s.	10,543	3,534,818	10,614	3,661,000
Abrasive wheels	..	2 941,589	..	2,790,000
Abrasive stones and blocks	..	461,517	..	614,000
Abrasive paper and cloth	..	1,816,896	..	1,718,000
Metal shot	..	1,519,613	..	1,965,000
Abrasive basic products, n.e.s.	..	693,717	..	1,056,000
Total		18,109,532		19,855,000
Exports				
Natural and artificial abrasives				
Abrasives, natural, n.e.s.	143	10,502	30	3,000
Fused alumina, crude and grains	177,287	20,159,149	196,840	22,521,000
Silicon carbide, crude and grains	90,902	12,243,784	98,878	12,832,000
Abrasive paper and cloth		375,594		540,000
Abrasive wheels and stones		172,895	..	160,000
Abrasive basic products, n.e.s.		1,294,710	..	2,911,000
Total		34,256,634		38,967,000
Re-exports				
Abrasives, natural		1,710,594		2,008,000
Abrasive basic products		182,776		201,000
Total		1,893,370		2,209,000
Consumption				
Abrasives, natural and artificial, in the production of artificial–abrasive products				
Natural–abrasive grains:				
garnet	180	50,168		
emery	45	8,253		
quartz or flint	139	9,044		
other	12	1,670		
Total	376	69,135		
Artificial–abrasive grains for wheels, paper, etc.:				
fused alumina	3,319	1,062,184		
silicon carbide	4,491	1,436,301		
Total	7,810	2,498,485		

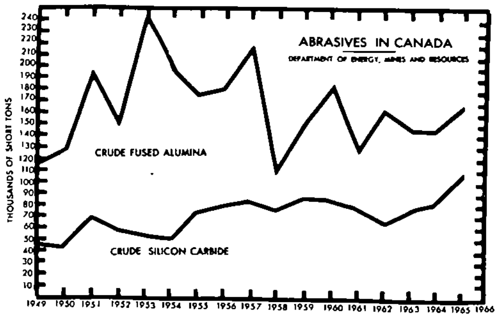
Source: Dominion Bureau of Statistics.

[1]Includes material for refractories and for other nonabrasive purposes.

[2]Includes abrasive cloth, paper and tile, sharpening stones and files, artificial pulpstone, boron carbide, fused magnesia and firesand.

PPreliminary, .. not available, n.e.s. Not elsewhere specified.

Manufactured abrasive products, also made in Canada, include abrasive wheels and segments valued at $11.4 million in 1965, and abrasive cloth and paper, abrasive tile and artificial pulpstone valued at $14.2 million in 1965. Total value of production from the Canadian abrasives industry during 1965 rose to $59.1 million from $50.9 million in 1964.



Imports of abrasives consist of both natural and artificial products. About 60 per cent of the total value consists of refined grains, abrasive wheels, stones, cloth, paper and metal shot. Many of these items came from crude silicon carbide and crude fused alumina that had been produced in Canada and exported to the United States for processing.

Imports, including natural abrasives, were valued at $80 million, of which industrial diamonds and diamond dust accounted for $7.5 million, practically all from the United States. A substantial proportion of the diamond imports is re-exported to the United States as finished products. Exports of abrasives included nearly all the crude artificial abrasives produced in Canada as well as some manufactured abrasive products. However, exports of natural abrasives remained insignificant.

PRODUCERS

Quartzite for sandblasting is produced by Industrial Minerals of Canada Limited at St. Donat de Montcalm, Quebec; by Nova Scotia Sand and Gravel Limited near Shubenacadie, Nova Scotia; and occasionally by Winnipeg Supply and Fuel Company Limited, Selkirk, Manitoba. Small quantities of feldspar are shipped by International Minerals & Chemical Corporation (Canada) Limited, Buckingham, Quebec, for use in soap and cleansers. Finely ground silica is sold for the same purpose by Industrial Minerals of Canada Limited, St. Canut, Quebec. Bog iron oxide is processed for use as crocus and jeweller's rouge by Red Mill Industries Limited at the plant formerly owned by The Sherwin-Williams Company of Canada, Limited, at Red Mill, Quebec. Grindstones are manufactured from sandstone at Sackville, New Brunswick, by H.C. Read.

Although not considered products of the abrasives industry, ores used in pebble and autogenous grinding temporarily perform as natural abrasives. Like most others, they result from materials required mainly for other purposes. However, they serve a twofold purpose, initially as grinding media and eventually as a semi-processed ore. In Canada, many ores are subjected to this type of comminution.

Canada's production value of crude artificial abrasives by far out-weighs that of the natural variety. Practically all shipments of artificial abrasives consist of crude fused alumina and crude silicon carbide. They are produced by six companies at four plants in Quebec and at four plants in Ontario. These plants, established under profitable operating conditions some years ago, are listed in Table 2 and have experienced no major changes in recent years. Their products go mainly to the United States but small quantities are exported to the United Kingdom and to a few other countries. Consequently, the output from these plants is dependent on the demand in these countries, particularly on the degree of metal fabrication taking place.

Significant amounts of abrasive wheels, segments, stones, paper and cloth are also produced in Canada. Most of these are produced in southern Ontario, although Quebec and British Columbia supply small amounts.

CONSUMPTION AND USES

Consumption statistics for natural and artificial abrasive grains are incomplete, but diamonds represent by far the largest part of the consumption value. For 1965, Table 1 gives the consumption value and amount of most natural and artificial abrasives used in the production of

TABLE 2

Canadian Producers of Crude Artificial Abrasives

Producer	Location of Plant	Product
Canadian Carborundum Company, Limited	Niagara Falls, Ont. Shawinigan, Que.	Fused alumina Silicon carbide
Electro Refractories & Abrasives Canada Ltd.	Cap de la Madeleine, Que.	Silicon carbide
The Exolon Company............................	Thorold, Ont.	Silicon carbide Fused alumina
Lionite Abrasives, Limited	Niagara Falls, Ont.	Silicon carbide Fused alumina
Norton Company	Chippawa, Ont.	Silicon carbide Fused alumina
	Cap de la Madeleine, Que.	Silicon carbide
Simonds Canada Abrasive Company Limited	Arvida, Que.	Fused alumina

abrasive products. This does not include the quantity consumed for final use as loose grains.

Abrasives are employed universally and in numerous applications. Although each abrasive product has many possible applications, its versatility normally is limited by cost and performance. As a result, the numerous grades of each type provide a preferred abrasive for every use.

All minerals and rocks can be used as natural abrasives but only a few are in demand. Natural and synthetic diamonds are employed in grinding, cutting and boring metallic and nonmetallic materials and in polishing glass. Emery is used in bonded and coated abrasives and in abrasive surfaces for floors of concrete, masonry and asphalt. Corundum may be employed in bonded shapes or loose grains for grinding and polishing. Silica and beach sand are used in sandblasting, silica flour in soaps and cleansers, and silica sand in coated abrasives. Garnet serves mainly in coated abrasives and as loose grains for sandblasting and polishing. Feldspar is used in soaps and cleansers, and iron oxide and diatomite are ingredients in polishes. Other industrial minerals are consumed for less common abrasive purposes

Fused alumina and silicon carbide are the most popular artificial abrasives. Because they are both high-grade types, they compete in many applications and are used for grinding, polishing, sandblasting and for providing 'nonslip' surfaces on concrete and masonry structures. When bonded, fused alumina is used in the metalworking, woodworking and leather industries. Silicon carbide is also bonded into wheels, sticks, stones, rubs, etc., and used to abrade metal, industrial mineral products, rubber, leather and wood. In coated abrasives, fused alumina and silicon carbide are used in the metalworking, woodworking and leather industries.

Non-abrasive uses for fused alumina and silicon carbide consumed about 5 per cent of the former and 41 per cent of the latter.

PRICES

Canada does not produce refined grains for the production of manufactured abrasive products. Consequently, in 1965 the following average prices per short ton were for imported abrasives used at abrasive products plants:

Fused alumina	$320.
Silicon carbide	320.
Garnet	279.
Emery	183.

Lightweight Aggregates

H.S. WILSON*

The total value of all lightweight aggregates used in Canada in 1966 amounted to almost $7.5 million, an increase of 8.1 per cent over the 1965 value of $6.9 million.

For the second consecutive year, pumice showed the greatest increase in value; 24.7 per cent. Expanded slag, also for the second consecutive year, showed the second greatest growth; 23.7 per cent in volume and 24.0 per cent in value. Expanded clay and shale increased 3.8 per cent in volume and 7.0 per cent in value. Exfoliated vermiculite increased 2.8 per cent in volume and 6.4 per cent in value. For the second consecutive year, the production of expanded perlite decreased; 15.7 per cent in volume and 4.8 per cent in value.

Table 1 shows the production and value of each of the lightweight aggregates for 1965 and 1966. The accompanying graph shows the production of the four principal lightweight aggregates for the period 1954-1966.

The construction industry continued to expand during 1966 as it has done for several years. The total value of construction amounted to $11.2 billion in 1966, an increase of 13.5 per cent over 1965. Because the costs of materials and labour continued to rise, the increase in the volume of construction amounted to only 6.9 per cent. Table 2 shows the year-to-year change in construction from 1957 to 1966 on a current dollar basis and on a constant 1957 dollar basis.

TABLE 1

Production of Lightweight Aggregates 1965-66

	1965		1966	
	Cubic Yards	$	Cubic Yards	$
From domestic raw materials				
Expanded clay and shale	510,868	2,739,846	530,244	2,931,706
Expanded slag	345,515	877,313	427,334	1,087,914
From imported raw materials				
Exfoliated vermiculite	306,280	2,438,113	314,916	2,594,819
Expanded perlite	98,086	724,898	82,720	690,277
Pumice		135,088		168,483
Total		6,915,285		7,473,199

Source: Statistics supplied to Mineral Processing Division by producers.

*Mineral Processing Division Mines Branch.

TABLE 2

Annual Variation in Construction

Year	Total Value ($x1000)	Per Cent Change from Previous Year: Current Dollar Value	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	6,974	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	9,806	14.3	8.0
1966P	11,199	13.5	6.9

Source: Dominion Bureau of Statistics.
P Preliminary.

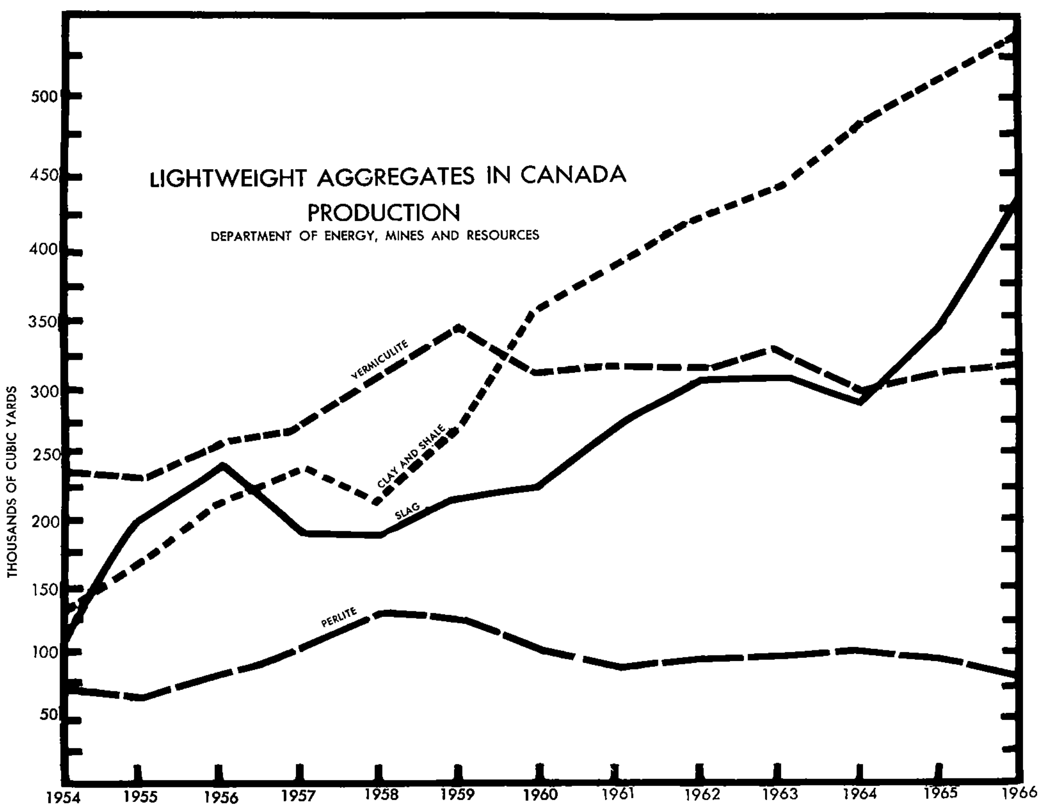
Table 3 shows the percentage changes of the various types of construction from 1965 to 1966 and the percentage of the total represented by each type, on a current dollar basis.

TABLE 3

Construction in Canada, 1965-66

Type of Construction	Percentage Change 1965-66	Percentage of Total Value 1965	1966P
Engineering	+15.0	40.1	40.7
Residential	+ 3.3	27.9	25.4
Commercial	+22.2	10.3	11.1
Institutional	+18.5	10.3	10.8
Industrial	+26.0	7.9	8.7
Other building	+ 8.4	3.5	3.3

Source: Dominion Bureau of Statistics.
P Preliminary.



DATA SOURCE: Mineral Processing Division

Lightweight aggregates are used in all these types of construction, but principally in the non-residential types. Consequently, consumption of the lightweight aggregates is affected most by variations in these types of construction.

RAW MATERIALS AND PRODUCERS

Shales and common clays are the most widespread of the raw materials used for the production of lightweight aggregate. All plants obtain their raw materials locally. Ten plants were in operation during 1966, as follows: Quebec – Lafleche and Laprairie; Ontario – Cooksville; Manitoba – St. Boniface (two); Saskatchewan – Regina (two); Alberta – Calgary and Edmonton; and British Columbia – Saturna Island. The plant at Lafleche was put into operation in 1966.

Expanded blast furnace slag is a processed byproduct from the production of pig iron. During 1966 it was produced at Hamilton and Port Colborne, Ontario and at Sydney, Nova Scotia. The processing operation at Port Colborne started again in 1966 after being shut down in 1962.

Vermiculite is similar to mica in appearance, but differs in that it exfoliates when heated to form a cellular material of low density and good insulating properties. Six companies produced exfoliated vermiculite at eleven locations, as follows: British Columbia – Vancouver (two); Alberta – Calgary; Saskatchewan – Regina; Manitoba – St. Boniface and Winnipeg; Ontario – Toronto, St. Thomas and Stanleyville; and Quebec – Lachine and Montreal. The plant at Stanleyville (near Perth) Ontario, the only one using a local Canadian raw material, was operated for a short period during 1966, but was shut down before the end of the year. The plant of Mid-West Expanded Ores Co. Ltd., was purchased by P & V Products in 1966, but vermiculite was processed only by the former company during the year. With the exception of one company, all plants processed raw vermiculite imported from the United States and Transvaal, South Africa.

Perlite is a volcanic rock that 'pops' when heated to form a white, cellular product of low density and with good insulating properties. Eight companies expanded perlite at nine locations during the year, as follows: British Columbia – Richmond and Vancouver; Alberta – Calgary and Edmonton; Manitoba – St. Boniface; Ontario – Caledonia and Hagersville; and Quebec – Ville St. Pierre and Charlesbourg West. All raw material is imported from the western United States, for processing. The plant of Perlite Products Ltd., St. Boniface, Man., was purchased by P & V Products, in 1966. Perlite was processed by both companies during the year.

Pumice, a highly vesicular material of volcanic origin is used in its natural state as a lightweight aggregate. All pumice used is imported from the United States, since known Canadian deposits are either too small or too far from transportation facilities.

Table 4 lists the lightweight aggregate processing plants in operation during 1966.

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	
Aggrite (1962) Inc.	Laprairie, Que.
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.
Expanded slag	
Dominion Iron & Steel Limited	Sydney, N.S.
National Slag Limited	Hamilton, Ont.
	Port Colborne, Ont.
Vermiculite	
Eddy Match Company, Limited (Grant Industries Division)	Vancouver, B.C.
	Calgary, Alta.
	Regina, Sask.
	Winnipeg, Man.
F. Hyde & Company, Limited	Montreal, Que.
	Toronto, Ont.
	St. Thomas, Ont.

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TABLE 4 (Cont'd)

Company	Location
Mid-West Expanded Ores Co. Ltd.*	St. Boniface, Man.
Olympus Mines Limited	Stanleyville, Ont.
Vermiculite Insulating Limited	Lachine, Que.
Western Gypsum Products Limited	Vancouver, B.C.
Perlite	
Canadian Gypsum Company, Limited	Hagersville, Ont.
Domtar Construction Materials Ltd.	Caledonia, Ont. Calgary, Alta.
Laurentide Perlite Inc.	Charlesbourg West, Que.
Perlite Industries Reg'd.	Ville St. Pierre, Que.
Perlite Products Ltd.*	St. Boniface, Man.
P & V Products	St. Boniface, Man.
Vantec Industries Ltd.	Richmond, B.C.
Western Gypsum Products Limited	Vancouver, B.C.
Western Insulation Products Ltd.	Edmonton, Alta.
Pumice	
Miron Company Ltd.	Montreal, Que.
Ocean Cement Limited	Vancouver, B.C.

* Purchased by P & V Products

CONSUMPTION

EXPANDED CLAY AND SHALE

Concrete blocks accounted for 76 per cent of sales in 1966 compared with 78 per cent in 1965 and 83 per cent in 1964. Precast concrete shapes and cast-in-place structural concrete accounted for 2 and 19 per cent respectively in 1966 compared with 4 and 16 per cent in 1965 and 5 and 11 per cent in 1964. Minor uses, such as aggregate for refractory concrete, roof fill, loose insulation, lightweight brick and soil conditioning, accounted for 3 per cent, 1 per cent more than in 1965 and 2 per cent more than 1964.

EXPANDED SLAG

As in the three previous years, 98 per cent of sales was used in concrete block. Precast concrete shapes and cast-in-place structural concrete consumed 1 per cent, unchanged from 1965, and 1 per cent less than in 1964. Minor uses, such as loose insulation, race track fill, etc., accounted for 1 per cent, unchanged from 1965.

EXFOLIATED VERMICULITE

Loose insulation consumed 72 per cent of sales during 1966, six per cent less than in 1965 and 1964. Plaster accounted for 14 per cent, compared with 11 per cent in 1965 and 12 per cent in 1964. Insulating concrete consumed 11 per cent in 1966, compared with 7 per cent in 1965 and 6 per cent in 1964. Three per cent was used for such purposes as soil and fertilizer conditioners, underground pipe insulation, barbecue base, etc. in 1966, one per cent less than in 1965 and 1964.

EXPANDED PERLITE

Plaster accounted for 71 per cent during 1966, compared with 74 per cent in 1965 and 81 per cent in 1964. Thirteen per cent was used as aggregate in refractory products. Insulating concrete consumed 7 per cent in 1966, unchanged from 1965, and 3 per cent less than in 1964. Minor uses, including loose insulation and horticultural applications, consumed 9 per cent in 1966.

PUMICE

All pumice was used as aggregate in concrete block.

PRICES

Expanded clay and shale	$4.50	to	$6.10/cu yd.
Expanded slag	2.50	to	3.85/cu yd.
Exfoliated vermiculite	0.25	to	0.35/cu ft.
Expanded perlite	0.30	to	0.40/cu ft.

All prices are f.o.b. plant.

Aluminum

W.H. JACKSON*

CANADIAN INDUSTRY

Smelter production of primary aluminum increased from 830,505 tons in 1965 to 907,659 tons in 1966. Shipments of primary forms to the domestic market increased 21.3 per cent to 196,318 tons and imports of ingot more than doubled to 16,923 tons. Production capability and inventory levels were factors limiting exports which increased only 1.2 per cent to 716,382 tons. While metal consumption was at a high level in many countries, the pattern of exports reflected the particularly strong demand in the United States where imports of primary forms from Canada represented 74 per cent of unwrought imports that totalled 523,000 tons. In contrast, although British import requirements have increased, metal of Canadian origin has decreased in both tonnage and in percentage share of the British market. In 1966, total British imports of primary forms were 381,866 tons of which 39 per cent was provided from Canadian suppliers.

Table 3 shows available data on Canadian aluminum consumption at the first processing stage. Metal consumed increased 14 per cent to 243,064 tons in 1966. Primary, secondary and scrap from all sources are included and the figures are more representative of consumption than domestic shipments. The growth element is overstated in that the category 'other castings' comprises mainly cast busbar for use in aluminum smelters in 1965 and 1966.

Die and permanent mould castings have shown considerable growth in the last five years, admittedly from a small base, largely because of demand by the automotive and appliance manufacturers. Extrusion and sheet products have benefited from building and construction, and from the transportation industries. As growth in these industries has levelled off, the substantial increase in consumption recorded for 1966 is not likely to be repeated in 1967. Semifabricated products, traditionally a minor item in Canadian exports, increased from 26,421 tons in 1965 to 34,126 tons in 1966, and imports of comparable items increased from 44,416 tons to 58,676 tons.

*Mineral Resources Division.

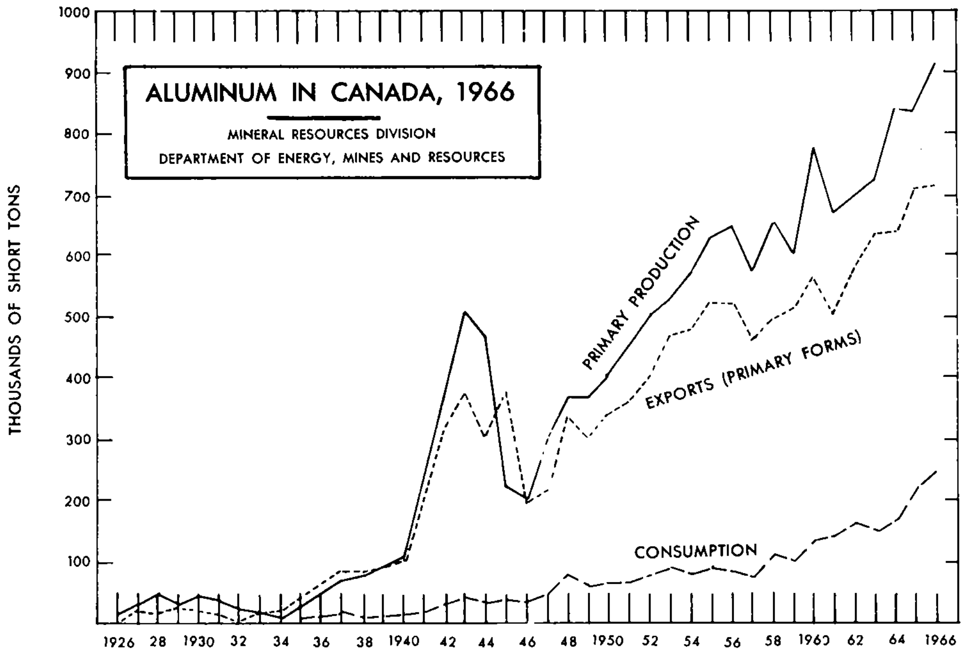


TABLE 1

Canadian Aluminum Production and Trade, 1965-66

	1965		1966[p]	
	Short Tons	$	Short Tons	$
Production				
Ingot	830,505[r]		907,659	
Imports				
Bauxite ore				
Guyana (formerly British Guiana)	898,922	6,968,377	1,457,258	13,005,000
Surinam	931,059	8,498,811	726,434	8,150,000
Malaysia and Singapore*	122,591	654,631	323,542	1,596,000
Australia	—	—	8,719	65,000
United States	8,789	248,127	8,327	203,000
Other countries	85,713	381,385	287	10,000
Total	2,047,074	16,751,331	2,524,567	23,029,000
Alumina				
Jamaica	457,589	28,201,888	459,772	28,345,000
United States	191,096	14,148,495	183,751	13,684,000
Guyana (formerly British Guiana)	140,159	8,610,777	130,614	8,168,000
Republic of Guinea	11,023	684,755	33,560	2,086,000
Other countries	110	26,223	142	58,000
Total	799,977	51,672,138	807,839	52,341,000

Table 1 (cont'd)

	1965		1966P	
	Short Tons	$	Short Tons	$
Aluminum and aluminum alloy scrap	33,218	1,447,075	23,407	1,253,000
Aluminum paste and powder	904	571,162	893	588,000
Aluminum pigs, ingots, shot, slabs, billets, blooms and extruded wire bars	6,945	4,252,802	16,923	9,581,000
Aluminum, castings and forgings	1,565	3,646,320	2,449	6,377,000
Aluminum bars and rods, n.e.s.	789	1,010,453	958	1,209,000
Aluminum plates	2,776	2,898,740	3,942	4,199,000
Aluminum sheet and strip, up to .025 inch in thickness	..	..	5,929	4,945,000
Aluminum sheet and strip, over .025 inch up to .051 inch in thickness	..	..	2,430	2,505,000
Aluminum sheet and strip, over .051 inch up to .125 inch in thickness	..	..	7,972	6,033,000
Aluminum sheet and strip, over .125 inch in thickness	..	..	34,996	21,993,000
Total aluminum sheet and strip	39,286	28,257,139	51,327	35,476,000
Aluminum foil or leaf	570	774,282	455	633,000
Converted aluminum foil		966,259		1,030,000
Structural shapes, aluminum	1,409	3,165,134	1,355	3,416,000
Aluminum pipe and tubing	530	815,493	350	658,000
Aluminum wire and cable excluding insulated	349	321,477	622	569,000
Aluminum and aluminum alloy fabricated materials, n.e.s.		3,635,269		9,433,000
Exports				
Pigs, ingots, shot, slab, billets, blooms and extruded wire bars				
United States	347,990	156,388,857	382,147	172,256,000
Britain	183,548	96,446,783	145,097	76,559,000
Japan	25,944	11,996,273	32,076	15,319,000
Republic of South Africa	20,878	10,493,239	29,914	15,230,000
West Germany	17,965	8,106,420	17,057	7,539,000
Spain	11,982	5,132,231	13,526	5,897,000
Brazil	7,162	3,338,557	10,529	4,829,000
Ireland	7,823	3,965,925	9,385	4,865,000
Italy	14,559	6,206,346	9,169	4,079,000
Hong Kong	3,560	1,815,821	5,518	2,794,000
New Zealand	6,784	3,458,828	4,904	2,505,000
Argentina	7,536	3,841,173	4,823	2,440,000
Sweden	4,904	2,419,586	4,505	2,305,000
Other countries	46,877	23,544,719	47,732	23,628,000
Total	707,512	337,154,758	716,382	340,245,000
Bars, rods, plates, sheet, circles, castings and forgings				
United States	6,271	4,615,074	12,041	9,421,000
India	10,422	4,874,317	6,083	3,311,000
Britain	265	286,769	3,727	2,406,000
New Zealand	1,279	712,131	2,812	1,581,000
Republic of South Africa	680	572,860	2,716	1,538,000
France	418	313,236	1,237	889,000
Jamaica	486	407,573	1,015	768,000
Venezuela	316	252,199	791	548,000
Spain	1,754	888,324	776	361,000
Portugal	898	501,739	494	281,000
Other countries	3,632	2,473,632	2,434	1,723,000
Total	26,421	15,897,854	34,126	22,827,000

Table 1 (cont'd)

	1965		1966[p]	
	Short Tons	$	Short Tons	$
Foil				
United States	135	95,404	111	132,000
New Zealand	44	58,698	55	72,000
Britain	194	225,264	55	79,000
Mexico	3	4,082	28	45,000
Philippines	12	18,046	15	21,000
Other countries	47	60,090	30	44,000
Total	435	461,584	294	393,000
Fabricated materials, n.e.s.				
Mexico	1,365	690,659	3,163	1,621,000
United States	1,057	1,024,209	1,895	2,000,000
Pakistan	1,346	761,350	1,817	1,053,000
Venezuela	1,078	751,527	726	585,000
Nigeria	3,051	1,372,883	714	371,000
Nicaragua	242	148,419	552	369,000
Saudi Arabia	11	10,714	420	305,000
Other countries	3,472	2,691,302	3,051	2,506,000
Total	11,622	7,451,063	12,338	8,810,000
In ores and concentrates				
United States	7,273	853,087	12,719	1,403,000
Spain	–	–	221	45,000
Greece	33	1,682	66	3,000
Other countries	463	47,144	49	8,000
Total	7,769	901,913	13,055	1,459,000
Scrap				
United States	20,595	4,141,756	28,919	7,211,000
Italy	11,996	4,423,864	12,936	4,869,000
Japan	4,295	1,630,264	2,005	703,000
West Germany	1,224	194,223	905	209,000
Other Countries	806	237,365	1,006	298,000
Total	38,916	10,627,472	45,771	13,290,000

Source: Dominion Bureau of Statistics.
* Malaysia only in 1965. . . Not available as a separate class prior to 1966.
[p] Preliminary; – Nil; n.e.s. Not elsewhere specified; [r] Revised.

TABLE 2

Primary Aluminum Production, Trade, and Consumption in Canada
1957 – 66
(short tons)

	Production	Imports	Exports	Consumption*
1957	556,715	2,122	478,670	77,984
1958	634,102	11,257	484,438	101,886
1959	593,630	852	507,290	89,000
1960	762,012	501	552,155	120,831
1961	663,173	636	487,034	135,575
1962	690,297	3,855	576,206	151,893
1963	719,390	1,954	635,187	161,833
1964	842,640	3,996	627,992	172,443
1965[r]	830,505	6,945	707,512	213,094
1966[p]	907,659	16,923	716,382	243,064

* Producers' domestic shipments to 1959; consumption reported by consumers from 1960, includes primary, secondary, and scrap.
[r] Revised; [p] Preliminary.

TABLE 3

Canadian Consumption of Aluminum at First Processing Stage

(short tons)

	1963	1964	1965ʳ	1966ᵖ
Castings				
Sand	1,212	1,399	1,367	1,665
Permanent-mould	3,040	5,039	7,509	10,945
Die	6,806	7,702	13,202	15,431
Other	801	121	4,375	9,890*
Total	11,859	14,261	26,453	37,931
Wrought products				
Extrusions, including tubing	40,900	41,664	48,589	53,701
Sheet, plate, coil and other (including rod, forgings and slugs)	105,160	110,338	130,318	145,216**
Total	146,060	152,002	178,907	198,917
Destructive uses				
Non-aluminum-base alloys, powder and paste	1,559	2,662	3,600	. .
Deoxidizers	2,355	2,827	3,524	. .
Other uses	. .	691	610	. .
Total	3,914	6,180	7,734	6,217
Total consumed	161,833	172,443	213,094	243,064
Secondary aluminum produced	14,995	19,342	23,570	30,532
Receipts and inventories at plants	*Metal Entering Plants*		*On Hand Dec. 31*	
	1965	1966ᵖ	1965	1966ᵖ
Primary aluminum ingot and alloys	186,021	232,555	47,873	47,740
Secondary aluminum	8,110	16,260	719	1,745
Scrap originating outside plant	26,634	30,128	2,579	5,143

Source: Dominion Bureau of Statistics as reported by consumers, adjusted.
ᵖ Preliminary; ʳ Revised; . . Not available. * includes smelter busbar ** includes re-roll stock imported from U.S.

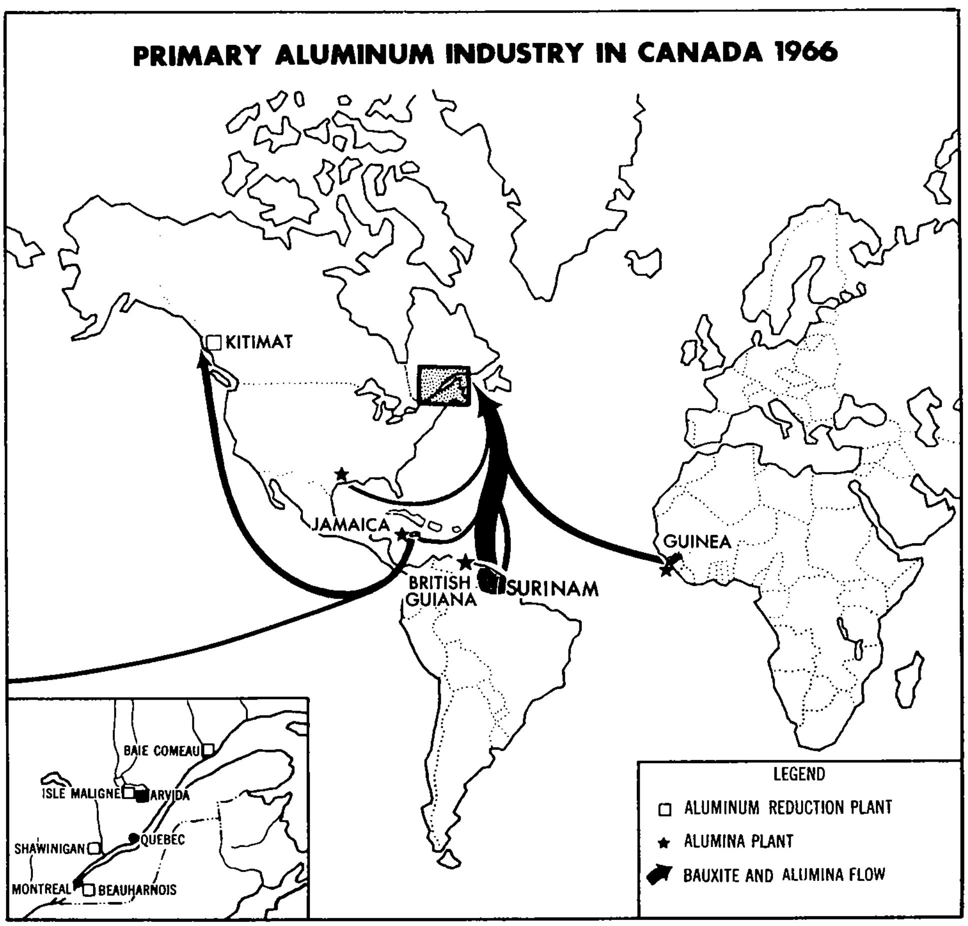
The geographic locations of Canadian smelters shown on the accompanying map illustrate the necessity of low-cost power combined with low-cost transportation for an export-oriented industry based entirely on imported ore supplies. Aluminum of Canadian origin still accounts for the greater part of all metal moving in international trade. Two companies operate smelters in Canada.

Canadian British Aluminium Company Limited operates a smelter at Baie Comeau, Quebec, that has a rated capacity of 105,000 tons of aluminum annually. Production in 1966 was about 102,000 tons. A capacity increment of 12,000 tons resulting from modernization will be available in 1967. Completion of a smelter addition, amounting to 60,000 tons of new capacity, is planned for 1970. A contract with The British Aluminium Company, Limited provides for the sale of all metal not sold within Canada. Reynolds Metals Company supplies alumina for the smelter and payment in 1966 was made by the barter of 24,230 tons of aluminum.

Aluminum Company of Canada, Limited (Alcan) operates smelters in Quebec at Arvida, Alma, Shawinigan and Beauharnois and one at Kitimat in British Columbia. Combined production in 1966 was 788,500 tons. A new addition of 24,000 tons annual capacity came into operation at Kitimat in May 1966 and a further 24,000-

ton-addition was scheduled for completion in the first half of 1967. At the end of 1965, Alcan smelters were operating at a rate of 770,000 tons annually, which increased to 847,000 tons a year by the end of 1966. Owing to a continuing program involving the modernization of older facilities, the rate of production in 1966 was in reality, effective capacity. By the end of 1967, nominal capacity will be about 970,000 tons a year.

Alcan is the main subsidiary of Alcan Aluminium Limited, a fully-integrated multinational company based in Montreal, engaged in mining, smelting and fabrication. The smelters of subsidiaries and affiliates outside of Canada in Brazil, India, Japan, Norway and Sweden produced 286,000 tons in 1966. Rated capacity was 304,000 tons, which may increase another 110,000 tons by 1970. For the group as a whole, sales of fabricated products were 724,000 tons in comparison with 1,136,000 tons of metal supplies. Other projects that will contribute to increased metal supply include a 40,000-ton-smelter in Australia near Newcastle scheduled for completion in 1969 and an interest acquired in Norwegian smelters. In January 1967, Alcan acquired a 50-per-cent interest in the Norwegian government-owned smelters of A/S Ardal og Sunndal Verk (ASV). The two smelters had a total annual capacity of 185,000 tons and another 50,000 tons were under construction. A 50-per-cent interest in the 32,000-ton-a-year Alcan smelter of A/S Norsk Aluminium Company was sold to ASV as part of the arrangement.



WORLD DEVELOPMENTS

ORE SUPPLY

As most aluminum producers are integrated or have negotiated long-term supply contracts for bauxite or alumina, there is a tendency to forget that exploration and mine development form the basis of future smelter expansion. Out of 42.5 million tons of bauxite produced in 1966, countries producing 2 million tons or more were: Jamaica (10.2), Surinam (5.3), Guyana (2.3), France (3.1), USSR (4.9), Yugoslavia (2.0), United States (2.0), Australia (2.0), and Guinea (2.0). World bauxite requirements by the end of 1970 (excluding USSR, Mainland China and East European countries) will be about 50 million tons a year, compared with 35.4 million tons in 1966, if planned smelter expansions are undertaken and completed.

Major expansion of bauxite production is scheduled for the Caribbean countries – Jamaica, Surinam, Guyana, Haiti and Dominican Republic. The area will continue to be the major source of ore for North America and for much of Europe. The main expansion will be in Jamaica where a consortium composed of Reynolds Jamaica Alumina Limited, Kaiser Jamaica Corporation, and Anaconda Jamaica Inc., will construct a new alumina plant on the north coast having an initial annual capacity of 875,000 tons with further expansion planned to 1.3 million tons. The plant will be based entirely in expanded mine production. Alcan Jamaica Limited will increase its alumina capacity to 1,215,000 tons a year in 1968 by adding 180,000 tons at Ewarton and 50,000 tons at Kirkvine.

Australia is also experiencing major bauxite mine development; production has increased from 21,000 tons in 1961 to 2 million tons in 1966. Mines are being developed in Guinea where the Boke deposits are being developed by Halco Mining Company. Through a 17.5-per-cent interest in Halco, Alcan will participate in the development and will purchase 1.2 million tons of bauxite annually for 5 years and 1.4 million tons annually for a further 15 years.

Bauxite is a mixture of minerals that are lateritic weathering products of rocks, such as limestone, nepheline syenite, basalt, or clay from which silica has been leached and alumina concentrated. The process is common in tropical or sub-tropical countries but deposits of ore grade are not easy to find or develop. Generally, metal-grade ore or concentrates contain over 40 per cent alumina (Al_2O_3) and less than 4 per cent reactive silica (SiO_2). The better ores contain about 2 per cent reactive silica.

The approximate average analysis of Jamaican bauxites listed by the Jamaican Department of Mines is, in per cent, as follows: extractable alumina, 45; total alumina, 49.6; reactive silica, 1.3; nonreactive silica, 0.2; iron and titanium oxides, 22.1; and water, 26.8. The Weipa deposits in Australia contain around 50 per cent extractable alumina and total silica ranges from 2 to 8 per cent.

The alumina content of bauxite is preferably in the form of the mineral gibbsite ($Al_2O_3 \cdot 3H_2O$) which can be leached with weak caustic soda solutions at 142°C at about 10 atmospheres pressure. Boehmite ($Al_2O_3 \cdot H_2O$) and diaspore ($Al_2O_3 \cdot H_2O$) are the other low silica aluminum minerals of commercial interest but these require stronger solutions and higher temperatures (225°C) and pressures up to 35 atmospheres. The other clay minerals, such as kaolinite and halloysite, are undesirable because of their silica content as this reacts with caustic soda. These must be minor constituents or be separable by washing and screening. Quartz is not a major impurity unless it is sufficiently fine-grained to react significantly. Phosphates, manganese minerals and, in particular, oxides of iron and titanium complicate recovery but are not as serious as the silica content or the proportions of aluminous minerals which determine whether the Bayer or the Combination process must be used in recovering alumina.

High silica bauxites, clays, shales and other aluminous rocks such as nepheline syenites or anorthosites are common in many parts of the world. Recovery processes for alumina are technically feasible from such rocks but the cost of recovery from them is much higher than from commercial grade bauxites because of the silica content.

METAL SUPPLY

The geographical distribution of aluminum smelting capacity is not related to ore source. Smelter locations are determined by the need for favourable cost combinations of power, transportation and tariffs in relation to markets, and by the desire for sites that are ideal for the ready assembly of raw materials, mainly alumina, petroleum coke and aluminum fluorides. The typical Hall electrolytic cell, operating at 960°C, uses 8 kilowatt hours of electricity to produce one pound of aluminum, which requires 2 pounds of alumina, 0.5 pound of carbon and 0.1 pound of sodium aluminum fluoride. Historically, aluminum plants have been built near low-cost sources of power but in recent years higher-cost power has become tolerable for locations close to markets. In the future, the availability of nuclear power should increase the number of alternative choices for smelter construction sites. The results of the Kennedy Round of trade negotiations among nations belonging to the General Agreement on Tariffs and Trade (GATT) will also have a bearing on smelter locations as economic factors relating to tariffs and anti-dumping regulations are important in the final decision of building aluminum processing facilities.

World primary aluminum production in 1966 was 7.7 million tons. Excluding Eastern Europe, the USSR and China it was 6.13 million tons, an increase of 11 per cent from 1965. Countries producing over 2.0 million tons were: USA (2.97), USSR (1.18), Canada (0.91), Japan (0.37) France (0.40), Norway (0.36), and West Germany (0.27).

In 1966, demand was pressing upon supply and, as available capacity was fully utilized, metal stocks declined. The surge in demand was due mainly to the combination of sustained high industrial consumption and continuing United States requirements for the Viet Nam conflict. A temporary shortage might have developed except for sales from the United States stockpile. Shipments from inventory by the General Services Administration totalled 326,000 tons out of the 1.4 million authorized for disposal. Six US producers and Alcan Aluminium Limited agreed to purchase the surplus metal over a period of 8 to 16 years.

The world aluminum industry has the raw material base for expansion. In scheduling new smelter construction, projections of the increase in demand become critical as the differences between a seven and an eight per cent world growth rate currently represents about 77,000 tons of capacity, or 61,000 tons for the non-communist world. As consumption can change over the short term faster than smelter construction schedules can be adjusted temporary imbalances can be expected. A slight amount of surplus capacity is therefore desirable. Non-communist world primary capacity is expected to increase from 6.5 million tons in 1966 to at least 8.8 million tons in 1970. Non-communist world consumption in 1966 was 8.1 million tons (6.45 primary and 1.65 secondary and scrap) compared with 7.2 million tons in 1965.

NEW SMELTING PROCESSES

The possibility of reducing capital costs of new reduction plants if processes other than conventional electrolysis can be developed has intrigued the aluminum industry for a number of years. Alcan at Arvida, Quebec, has been working at the monochloride process on a large pilot-plant scale to determine equipment response to high temperature operations, a major consideration in assessing operating costs and economics of the process. Reynolds Metals Company in the United States has been working on improved variants of a process used in Germany during World War II for the production of aluminum-silicon alloy from a charge containing alumina, silica, carbon and silicon. A second patent involves preparation of a raw alloy from a charge of alumina, silica, carbon and intermetallic complexes. Mercury is then added as a solvent forming an aluminum-mercury liquid which is separated from the solid phase. The solid phase is further treated and recycled in the process. Aluminum is separated by distillation and melting from the mercury.

These efforts are interesting but all future expansions of smelting facilities so far announced are based on conventional methods of refining alumina from low-silica bauxites and reducing the alumina by electrowinning. For the future, added benefits of a successful break-through in smelting technique would be the possible utilization of low grade bauxite or other aluminous rocks.

USES

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, railroad cars, doors and windows, for pipe and as tubing for lightweight furniture. Aluminum rod goes into the making of electrical wire and cable.

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.

In the United States, the Statistical Committee of the Aluminum Association estimates that of the 9.06 billion pounds shipped in 1966 to end-use markets the percentage going to each market was:

	%
Building and Construction	21.6
Transportation	23.1
Electrical	14.4
Consumer Durables	10.1
Containers and Packaging	8.1
Machinery and Equipment	7.2
Exports	6.5
Other	9.0

PRICES

The Canadian price for 99.5 per cent purity in 50-pound ingots was unchanged at 26.0 cents a pound delivered throughout 1966. Effective January 13, 1967, the price was increased to 26.5 cents. In the United States, a similar increase from 24.5 to 25.0 cents became effective January 18, 1967. The quoted Canadian producer export price c.i.f. main European ports was not affected and has remained unchanged at 24.5 cents (US) since November 1964.

In general, prices were reasonably firm on all markets but discounting by a producer is not uncommon in particular markets. The trend towards uniformity of prices in a number of national markets emphasizes the importance of tariffs and transportation costs as limiting factors in market penetration. Effective, October 15, 1966, French smelters raised the delivered price of metal in France to the equivalent of 24.5 cents (US). Quoted domestic prices in other countries were close to the Canadian export price being 25.25 cents in West Germany, 25.59 in Italy, 25.20 in Japan and 24.04 in Switzerland.

TARIFFS

	British Preferential	Most Favoured Nation	General
Canada			
Bauxite and alumina	free	free	free
Aluminum and aluminum alloys, pigs, ingots, blocks, notch bars, slabs, billets, blooms and wire bars	free	1¼¢ a lb	5¢ a lb
Bars, rods, plates, sheets, strips, circles, squares, disks and rectangles	free	3¢ a lb	7½¢ a lb
	(%)	(%)	(%)
Angles, channels, beams, tees, and other rolled, drawn or extruded sections and shapes	free	22½	30
Wire and cable, twisted or stranded or not, and whether reinforced with steel or not	free	22½	30
Pipes and tubes	free	22½	30
Leaf, n.o.p. or foil, less than 0.005 in. in thickness, plain, or embossed, with or without backing	free	30	30
Aluminum powder	free	27½	30
Aluminum leaf less than 0.005 mm in thickness	free	free	free
Aluminum scrap	free	free	free
Manufactures of aluminum n.o.p.	15	22½	30
Kitchen or household hollow ware of aluminum, n.o.p.	20	22½	30

n.o.p. Not otherwise provided for.

Tariffs (cont'd)

	British Preferential	Most Favoured Nation	General
United States			
Bauxite	50¢ per long ton (temporarily suspended)		
Unwrought aluminum			
Of uniform cross section throughout its length, the least cross section dimension of which is not greater than 0.375 in. in coils	2.5¢ a lb		
Other			
Aluminum other than alloys of aluminum	1.25¢ a lb		
Alloys of aluminum			
Aluminum silicon	2.125¢ a lb		
Other	1.25¢ a lb		
Aluminum waste and scrap	1.5¢ a lb (suspended)		
Wrought rods of aluminum	2.5¢ a lb		
Angles, shapes, and sections, all the foregoing which are wrought of aluminum	19% ad val.		
Aluminum wire			
Not coated or plated with metal	12.5% ad val.		
Coated or plated with metal	0.1¢ a lb + 12.5% ad val.		
Bars, plates, sheets, and strip, all the foregoing are wrought of aluminum whether or not cut, pressed or stamped to non-rectangular shapes			
Not clad	2.5¢ a lb		
Clad			
Wholly of aluminum	2.5¢ a lb		
Other	24% ad val.		
Aluminum powders and flakes			
flakes	5.1 ¢ a lb		
powders	19% ad val.		
Pipe and tubes and blanks therefore, pipe and tube fittings, all the foregoing of aluminum			
Hollow cast extrusion ingots	1.25¢ a lb		
Aluminum foils not backed or cut to shape			
Etched capacitor foil	17% ad val.		

Antimony

J.G. GEORGE*

Canada's antimony production is nearly all a byproduct of lead smelting operations, principally in the form of antimonial lead. Production in 1966 included some that was recovered in the form of flue dust and dore slag.

There has been no production of antimony metal or regulus in Canada since 1944. Canadian requirements of antimony metal, antimony oxide and antimony salts are imported. Regulus (metal) import statistics were discontinued in 1964 when the main suppliers were Communist China and Yugoslavia, which mine and refine antimony ores, and west European countries which import antimony ores and export refined metal and salts. A total of 742,700 pounds of antimony oxide were imported in 1966 with Britain supplying almost 77 per cent; the remainder came mostly from the United States and Belgium.

Cominco Ltd., which operates a lead smelter and refinery and an electrolytic zinc plant at Trail, British Columbia, was the sole producer of primary antimonial lead in Canada. Antimonial lead has a variable antimony content up to 35 per cent antimony, depending on the customers' requirements. Some antimonial lead was recovered from scrap metal by secondary smelters but no information is available concerning this production.

The source of most of the antimonial lead produced at Trail is the lead concentrate obtained from ores of the company's Sullivan mine at Kimberley, British Columbia. Lead-silver ores and concentrates shipped to Trail from other Cominco mines and from custom shippers account for the remainder. 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 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.

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. There are several antimony mineral occurrences on record in the Atlantic provinces, Quebec, British Columbia and the Yukon Territory, on which exploration and, in some cases, development have taken place. A deposit in the Yukon Territory has received considerable attention in 1965-66.

*Mineral Resources Division.

TABLE 1

Antimony – Production, Imports and Consumption, 1965-66

	1965		1966P	
	Pounds	$	Pounds	$
Production				
Antimony content of antimonial lead alloys	1,301,787	689,947	1,446,277*	681,136*
Imports				
Antimony oxide				
Britain	421,100	203,126	568,100	237,000
United States	65,700	32,429	89,400	37,000
Belgium and Luxembourg	7,000	3,458	58,000	24,000
Communist China	121,700	58,171	27,200	8,000
Total	615,500	297,184	742,700	306,000
Consumption				
Antimony regulus (metal) in production of:				
Antimonial lead alloys	363,752		744,446	
Babbitt	48,295		72,613	
Solder	24,925		21,594	
Type metal	181,499		176,572	
Other commodities**	41,166		82,937	
Total	659,637		1,098,162	

Source: Dominion Bureau of Statistics.

*Includes some antimony from flue dust and dore slag. **Includes foil, bronze, lead-base alloys, drop shot and other minor commodities.

PPreliminary.

TABLE 2

Antimony – Production, Imports and Consumption, 1957-66 (pounds)

	Production* (all forms)	Imports (regulus)	Consumption** (regulus)
1957	1,360,731	1,794,846	1,401,000
1958	858,633	808,053	1,027,000
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
1966P	1,446,277	..	1,098,000

Source: Dominion Bureau of Statistics.

*For 1957 – antimony content of antimonial lead alloys, flue dust and dore slag; 1958 to 1965 inclusive – antimony content of antimonial lead alloy; 1966 – antimony content of antimonial lead alloys, flue dust and dore slag. **Consumption of antimony regulus (metal) as reported by consumers. Does not include antimony in antimonial lead produced by Cominco Ltd.

P Preliminary;

Yukon Antimony Corporation Ltd. did further development work on its antimony property on Carbon and Chieftain Hills in the Wheaton River district of the Yukon Territory, about 55 miles south of Whitehorse. Work performed in 1966 included 1,400 feet of tunnelling in three adits on two levels, and over 1,800 feet of diamond drilling on the Becker-Cochran deposit on Carbon Hill. Probable ore reserves were reported to be 23,000 short tons grading 3.59 per cent antimony; possible ore reserves were estimated at 65,000 tons averaging 3.0 per cent antimony, without allowing for dilution.

Estimated world mine production of antimony was 75,350 short tons in 1966, almost 6,300 tons more than in 1965. Antimony is produced from ores and as a smelter byproduct in several countries with the major sources being Communist China, Republic of South Africa, Bolivia, USSR, and Mexico which together accounted for over 76 per cent of world output in 1965. National Lead Company operates the world's largest smelter of antimony 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.

TABLE 3

Consumption of Antimonial Lead Alloy*, 1964–66
(pounds)

	1964	1965	1966^p
Babbitt.......	22,000	**	**
Storage batteries....	1,927,643	2,042,475	1,892,067
Solder........	6,433	**	**
Type metal....	**	**	**
Other uses....	550,378	732,766	701,666
Total.....	2,506,454	2,775,241	2,593,733

Source: Dominion Bureau of Statistics.
*Antimony content of primary and secondary antimonial lead alloy.
**Included in "other" uses.
^p Preliminary.

TABLE 4

Consumption of Antimonial Lead Alloy*, 1959-66
(pounds)

1959	2,532,015
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^p	2,593,733

Source: Dominion Bureau of Statistics.
*Antimony content of primary and secondary antimonial lead alloy.
^p Preliminary.

World supplies of antimony increased in 1966, mainly because of higher output at the antimony-gold mine of Consolidated Murchison (Transvaal) Goldfields and Development Company Limited near Pietersburg in the northeastern part of the Republic of South Africa. Antimony supply and demand were in reasonably good balance in 1966, price fluctuations were mild, and Communist China's shipments of metal to Europe continued on a curtailed basis. This near-stability could, however, be affected by the recent strife in Communist China. Antimony metal contained in the United States Government stockpile, for conventional war requirements, totalled 49,433 short tons as at December 31, 1966, only 58 tons less than at the beginning of that year. The stockpile objective remained at 25,500 tons, leaving a surplus of 23,933 tons. Stockpiled antimonial lead amounted to 12,227 tons at the beginning of 1966 and dropped to 10,818 tons at the end of the year. A stockpile objective has not been established for antimonial lead.

TABLE 5

World Mine Production of Antimony, 1964-66
(short tons)

	1964	1965^p	1966^p
Communist China ..	16,500^e	16,500^e	*
Republic of South Africa	14,200	13,901	18,000^e
Bolivia (exports) ..	10,626	10,606	11,000^e
USSR	6,700^e	6,800^e	*
Mexico	5,278	4,924	5,500^e
Yugoslavia........	3,008	3,051	3,000^e
Morocco	1,720	2,477	*
Turkey	1,915	2,340^e	*
Czechoslovakia....	2,200^e	2,200^e	*
United States	632	845	850^e
Canada	796	651	723
Other countries	4,525	4,805	36,277^e
Total	68,100	69,100	75,350^e

Source: Dominion Bureau of Statistics for Canada for all three years. US Bureau of Mines *Minerals Yearbook 1965* for other 1964 and 1965 figures, and U.S. Bureau of Mines, Commodity Data Summaries, January 1967 for other 1966 figures.
*Included in "other countries".
^p Preliminary; ^e Estimate.

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. 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 6

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

Product	1965	1966P
Metal products		
Ammunition	36	*
Antimonial lead**	6,382	5,574
Bearing metal and bearings	821	656
Cable covering	68	78
Castings	76	35
Collapsible tubes and foil	49	17
Sheet and Pipe	104	100
Solder	244	139
Type metal	642	183
Other**	214	144
Total**	8,636	6,926
Nonmetal Products		
Ammunition primers	16	25
Fireworks	46	39
Flameproofing chemicals and compounds	1,971	2,045
Ceramics and glass	1,853	1,472
Matches	*	*
Pigments	855	441
Plastics	1,469	928
Rubber products	477	305
Other	1,596	1,838
Total	8,283	7,093
Estimated unreported	—	4,634
Grand Total	16,919	18,653

Source: US Bureau of Mines *Minerals Yearbook, 1965* and Mineral Industry Surveys "Antimony in First Quarter 1967".

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

**Includes primary antimony content of antimonial lead produced by primary lead smelters.

P Preliminary; — Nil.

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 in the production of intermetallic compounds.

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

The recovery of secondary antimony in the United States was 22,300 tons in 1964 and 24,300 tons in 1965. These tonnages, added to the amounts of primary antimony consumption shown in Table 6, gave a total use in the United States of about 38,000 tons in 1964 and 41,000 tons in 1965.

PRICES AND TARIFFS

The United States domestic price of antimony metal, as quoted by *E & MJ Metal and Mineral Markets, (E & MJ)* in bulk, 99.5 per cent, f.o.b. Laredo, Texas, remained unchanged throughout 1966 at 44.0 cents a pound.

The United States price of imported antimony metal, as quoted by *E & MJ*, in 5-ton lots, 99.5 per cent, f.o.b. New York, 2 cents a pound duty paid, was 45-46½ cents a pound at the beginning of 1966. Thereafter, the price declined in several stages and at the end of December 1966 it was quoted at 41½-42 cents a pound. Listed below are the price changes and the dates of issue of the E & MJ in which they were announced.

	(cents a pound)
February 28	44½-45
April 25	43½-44
June 20	42½-43½
September 12	42 -43
November 28	41½-42

Canadian and United States tariffs in 1966 were as follows:

	British Preferential	Most Favoured Nation	General
Canada			
Antimony, or regulus of, not ground, pulverized or otherwise manufactured	free	free	free
Antimony oxide	free	12½% ad val.	15% ad val.
Antimony salts	free	free	free

United States	
Antimony ore	free
Antimony metal, unwrought	2¢ per lb.
Antimony alloys:	
Containing by weight 83% or more of antimony	2¢ per lb.
Other	18% ad val.
Antimony metal, wrought	18% ad val.
Antimony, needle or liquated	0.25¢ per lb.
Antimony oxide	0.6¢ per lb.
Antimony sulphide	0.5¢ per lb. plus 12.5% ad val.
Other antimony compounds	0.8¢ per lb. plus 20% ad val.

Asbestos

A. A. WINER*

Asbestos production continued its general upward trend reaching a new high in 1966. Total production increased to 1.49 million tons valued at $166.9 million, an increase of 7.1 per cent in output and 14.2 per cent in value over 1965. The previous record production, established in 1964, was 1.42 million tons valued at $145 million. Production increased in three of the four producing provinces and although output dropped slightly in Newfoundland the value of production increased.

Canadian consumption of asbestos is small compared to production. Practically all of Canada's production is exported; in 1966, 45 per cent of total exports were to the United States.

TABLE 1

Asbestos – Production and Trade, 1965-66

	1965		1966p	
	Short Tons	$	Short Tons	$
PRODUCTION (shipments)				
By type				
Crude	163	140,419		
Milled fibres	659,598	109,232,857		
Shorts	728,451	36,815,197		
Total	1,388,212	146,188,473*	1,491,916	166,936,725*
By province				
Quebec	1,234,977	122,802,838	1,336,566	141,559,725
British Columbia	85,851	14,491,195	88,700	15,007,000
Newfoundland	65,626	8,825,182	64,850	10,300,000
Ontario	1,758	69,258	1,800	70,000
Total	1,388,212	146,188,473	1,491,916	166,936,725
EXPORTS				
Crude				
Japan	27	20,160	71	54,000
United States	25	35,170	65	68,000
West Germany	14	13,420	14	12,000
Other countries	57	47,381	22	17,000
Total	123	116,131	172	151,000

*Mineral Processing Division, Mines Branch.

Table 1 (Cont'd)

	1965		1966[p]	
	Short Tons	$	Short Tons	$
Milled				
Group 3				
United States	15,137	6,415,202	16,266	6,842,000
Britain	1,737	691,895	4,371	1,759,000
West Germany	2,302	898,129	2,849	1,154,000
France	1,352	505,809	2,616	997,000
Japan	1,165	471,129	1,632	658,000
India	16	6,009	1,174	420,000
Spain	432	160,350	380	152,000
Belgium and Luxembourg	309	124,451	310	124,000
Mexico	240	91,840	255	97,000
Brazil	90	33,779	236	99,000
Australia	60	20,950	55	19,000
Austria	105	39,919	74	28,000
Netherlands	23	8,415	—	—
Other countries	3,213	928,672	4,605	1,518,000
Total	26,181	10,396,549	34,823	13,867,000
Groups 4 and 5				
United States	198,290	33,354,907	200,775	33,425,000
Britain	46,199	8,170,001	72,985	13,888,000
France	38,627	6,920,990	54,838	9,838,000
West Germany	49,366	9,124,702	47,320	9,003,000
Spain	17,823	3,329,219	34,923	6,501,000
Australia	32,519	5,328,609	33,320	5,525,000
Belgium and Luxembourg	32,264	6,045,157	23,535	4,539,000
Austria	15,492	2,965,672	18,122	3,441,000
Mexico	15,441	2,780,956	17,813	3,230,000
Japan	27,069	3,903,939	17,732	2,688,000
Brazil	12,267	2,260,421	15,488	2,870,000
Netherlands	9,660	1,740,568	15,026	2,648,000
India	11,184	2,207,959	13,200	2,499,000
Other countries	98,395	17,356,465	132,685	23,909,000
Total	604,596	105,489,565	697,762	124,004,000
Total milled fibres (groups 3, 4 and 5)				
United States	213,427	39,770,109	217,041	40,267,000
Britain	47,936	8,861,896	77,356	15,647,000
France	39,979	7,426,799	57,454	10,835,000
West Germany	51,668	10,022,831	50,169	10,157,000
Spain	18,255	3,489,569	35,303	6,653,000
Australia	32,579	5,349,559	33,375	5,544,000
Belgium and Luxembourg	32,573	6,169,608	23,845	4,663,000
Japan	28,234	4,375,068	19,364	3,346,000
Austria	15,597	3,005,591	18,196	3,469,000
Mexico	15,681	2,872,796	18,068	3,327,000
Brazil	12,357	2,294,200	15,724	2,969,000
Netherlands	9,683	1,748,983	15,026	2,648,000
India	11,200	2,213,968	14,374	2,919,000
Other countries	101,608	18,285,137	137,290	25,427,000
Total	630,777	115,886,114	732,585	137,871,000

Table 1 (Cont'd)

	1965		1966^p	
	Short Tons	$	Short Tons	$
Shorts (groups 6, 7, 8 and 9)				
United States	447,668	25,389,506	440,075	24,639,000
Japan	52,663	4,640,437	56,030	4,903,000
Britain	51,784	3,003,431	53,655	3,023,000
West Germany	36,811	2,434,777	39,904	2,609,000
France	20,120	1,243,448	23,273	1,498,000
Belgium and Luxembourg	10,836	896,088	13,981	1,153,000
Netherlands	10,296	565,153	9,358	550,000
Australia	10,476	767,863	9,016	636,000
Spain	6,216	557,003	7,566	670,000
Other countries	41,634	3,157,077	60,547	4,780,000
Total	688,504	42,654,783	713,405	44,461,000
Grand total, crude, milled fibres and shorts	1,319,404	158,657,028	1,446,162	182,483,000
Manufactured products				
Brake linings and clutch facings				
Cuba		62,232		156,000
Lebanon		51,863		84,000
Australia		37,554		64,000
United States		125,315		39,000
Ecuador		36,350		31,000
Kuwait		14,321		29,000
Greece		16,143		18,000
Other countries		215,994		146,000
Total		559,772		567,000
Asbestos and asbestos-cement building materials				
United States		778,103		495,000
Pakistan		131,484		192,000
Australia		53,028		77,000
Jamaica		32,953		44,000
Colombia		..		39,000
Other countries		89,249		90,000
Total		1,084,817		937,000
Asbestos and asbestos-cement basic products, not elsewhere specified				
United States		271,737		445,000
Pakistan		1,658		313,000
Britain		18,805		19,000
Finland		6,810		19,000
Switzerland		17,804		17,000
Jamaica		1,967		15,000
Other countries		56,708		38,000
Total		375,489		866,000
Total, exports, asbestos manufactured products		2,020,078		2,370,000

Table 1 (Cont'd)

	1965		1966^p	
	Short Tons	$	Short Tons	$
IMPORTS				
Asbestos, unmanufactured	6,953	1,286,429	6,560	1,274,000
Asbestos, manufactured				
Cloth, dryer felts, sheets woven or felted......................		878,109		677,000
Packing......................		645,322		823,000
Brake linings..................		995,442		2,004,000
Clutch facings.................		202,865		207,000
Brake linings and facings, n.e.s.**		545,378		..
Asbestos-cement shingles and siding		226,412		167,000
Asbestos-cement board and sheets		861,288		842,000
Asbestos and asbestos-cement building material, n.e.s........		715,117		843,000
Asbestos and asbestos-cement basic products, n.e.s..........		1,370,446		1,279,000
Total asbestos, manufactured		6,440,379		6,842,000
Total asbestos, unmanufactured and manufactured.....		7,726,808		8,116,000

Source: Dominion Bureau of Statistics.
*Does not include value of containers. **Not a separate class after 1965. Included in preceding two classes.
^p Preliminary; —Nil; n.e.s. Not elsewhere specified; . . Not available.

TECHNOLOGY AND USES

The chrysotile variety of asbestos, a hydrated magnesium silicate, provides 90 per cent of the world's asbestos fibre and is the only variety mined in Canada. It occurs generally in two forms – a "cross fibre", in which parallel fibres lie across the vein and the width of the vein is an indication of the fibre length, and a "slip fibre", in which the fibres are oriented in an overlapping manner lengthwise along the vein. The latter form is normally found along fault planes in heavily sheared peridotite or serpentine bodies, as in the Pennington Dyke east of Thetford Mines, Que.

Chrysotile is mined in Canada by both open-pit and underground methods. The recovered fibre is graded for the market essentially by length but other factors are also important.

Because of its physical characteristics, chrysotile is an important raw material in many industrial processes. When of the proper texture, the longer fibres may be processed much as the organic staple fibres. Consequently it may be carded, spun and woven into cloths of different weights, thicknesses and qualities. These cloths are used in the manufacture of heat-resistant friction materials.

The fibre is prepared by a dry milling process consisting of crushing the ore, followed by impact milling, fiberization and separation into different grades and tailings.

Many of the uses of chrysotile are a result of the physical characteristics, which vary generally with the mineral's occurrence. Soft or silky fibres from Quebec are used for spinning yarn and textile products, whereas harsher fibres from other sources, because of their fast filtering quality, can be used in the asbestos-cement industry. Low-magnetite fibre from British Columbia has great importance in the electrical industry where it is used because of its electrical and insulating properties.

The volume of asbestos fibre classified as "shorts" exceeds that of all other grades but the shorter-fibre grades have also the greatest number of uses. These grades are used as reinforcements or fillers in floor tiling, plastics, paints and many other products. The most important single market for chrysotile is the asbestos-cement industry. Asbestos is combined with portland cement for the manufacture of a number of products, e.g. pipe, sheeting of all types, shingles, and millboard.

There is a continuing interest in short fibres for paper manufacture and for asphalt. Certain asbestos-asphalt mixtures have been shown to be impermeable to water penetration; and less asphalt is necessary for equivalent quality when asbestos is used. A new chrysotile research development has produced a colloidal fibrous product which can be used as a flow- and viscosity-control agent in plastics and paints. In another development, the fibre is used in asbestos-filled polypropylene which has grown to serve a large market. These products are used in solving certain corrosion problems such as in ventilator housings and in high-temperature parts, etc. Recently a US patent was issued claiming the use of short asbestos fibre grades as a binder in the production of taconite pellets.

PRODUCTION AND DEVELOPMENT

The free world's largest known deposits of chrysotile asbestos are in the Eastern Townships of Quebec. The reserves are adequate for many years. Other Canadian deposits are found in British Columbia, Yukon Territory, Ontario, northern Quebec and Newfoundland.

Chrysotile is the predominant variety of asbestos fibre used in the world and the only type produced commercially in Canada. Small amounts of crocidolite from South Africa are the principal Canadian imports. Crocidolite occurrences have been reported from the iron-ore region near the Labrador-Quebec boundary but no amosite occurrence has been reported. Other asbestos minerals, such as fibrous tremolite and anthophyllite, have also been reported but none is produced.

The supply and demand for Canadian chrysotile has reached an all-time high and productive capacity can therefore be expected to increase. Aspects of the economy which could have caused a drop in sales were offset by other factors. Increased demand for the fibre grades used in asbestos-cement products, as well as the construction of new plants using these grades of fibre and the higher level of industrial activity in the world, resulted in a banner year for the industry.

TABLE 2

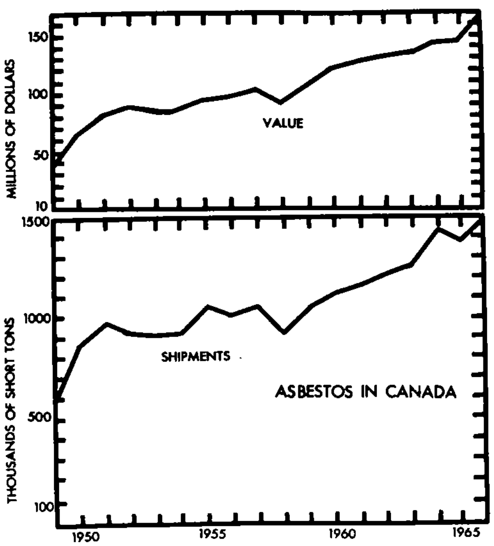
Asbestos – Production and Exports, 1957–66
(short tons)

	Crude	Milled	Shorts	Total
Production*				
1957	622	404,016	641,448	1,046,086
1958	605	342,562	582,164	925,331
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
1966P	..	..	..	1,491,916
Exports				
1957	638	393,311	636,611	1,030,560
1958	483	318,280	547,867	866,630
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

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

In the USA, an increase of fibre production (mainly in California) and a decline in housing starts during 1966 caused a slight reduction in demand for Canadian fibre – from 50 per cent in 1965 to 45 per cent in 1966. The United States decision to cease importing asbestos from Southern Rhodesia did not affect this trend greatly. Although the growth rate of asbestos imports from Canada appears to have stabilized, the United States will continue to be the largest single market for Canadian chrysotile fibre.

An optimistic outlook of increasing world demand for fibre has resulted in increased exploration, development and expansion of facilities in Canada and elsewhere. In Quebec, the industry is contemplating changes that will increase capacity and result in improved fibre quality.



Plans for the Clinton Creek property of Cassiar Asbestos Corporation Limited in the Yukon Territory are proceeding on schedule. Projected production beginning in 1968 has been increased to 60,000 tons fibre per annum instead of 40,000 tons planned earlier. This is expected to increase to 80,000 tons by 1970. Total capital outlay is now estimated at $21 million. Mainly asbestos-cement grades of fibre will be produced.

Canadian Johns-Manville Company, Limited, has completed an exploration program on its deposit in Reeves township 40 miles southwest of Timmins, Ont. The company plans to bring the deposit into production during 1968 with a capacity of 25,000 tons of fibre per annum.

Production in Ontario was derived from Hedman Mines Limited near Matheson where a pilot plant was in operation providing fibre for appraisal and market development.

Northeast of Chibougamau, Que., McAdam Mining Corporation Limited is planning to erect a pilot plant.

Asbestos Corporation Limited in April 1967, said it had suspended development work at Asbestos Hill in the Ungava area of northeastern Quebec because of a large increase in costs. Original estimates for the development of the project were $66.3 million in 1966. Present estimates, in 1967, place this at a total of $84.8. Production target was for 1970 with a capacity of 100,000 tons of fibre per annum. This deposit, located 40 miles south of Deception Bay, has reserves in excess of 20 million tons. The mill was expected to treat 3,000 tons of ore per day and produce mainly groups 4 and 5 fibre for the asbestos cement industry.

WORLD REVIEW

In 1966, the total world production of all types of asbestos was estimated at 3.7 million tons. On this basis Canada's production remained at about 40 per cent of the total. Production of asbestos fibre by the USSR, estimated at 1.6 million tons, slightly exceeded that of Canada. No asbestos production statistics are available from Russia.

TABLE 3

World Production
(short tons)

	1965	1966[e]
Canada	1,388,212	1,492,000
USSR	1,300,000	. .
Republic of South Africa	240,752	276,596
Southern Rhodesia	172,400	170,000
China	140,000	. .
United States	118,275	138,000
Italy	79,214	. .
Swaziland	40,884	. .
Other countries	90,263	. .
Total	3,570,000	3,660,000

Source: US Bureau of Mines Preprint, *Asbestos, 1965*, and US Bureau of Mines *Commodity Data Summaries*, January 1967.
[e] Estimate; . . Not available.

Exports of fibre from the USSR are believed to have increased in 1966 over those of 1965 but local demand presently consumes the largest part of fibre production.

Demand in the USA appears to have stabilized, but this has been offset by Western European markets. Increased demand for asbestos products in the developing countries, as well as an expected rise of economic activity generally, may lead to increased consumption of asbestos fibre in 1967.

TABLE 4

International Asbestos Market Structure in 1965
(thousand short tons)

	Importing Nation							
	United States	Japan	Common Market	Britain	Other EFTA	East Europe	Other	Total Exports
Canada	658	79	224	104	58	13	183	1,319
Rhodesia	12	10	24	41	8	14	75	184
South Africa	40	29	48	47	14	6[e]	26	210
Russia	–	17	105	3	23	97	29	274
Other	9	12	38	2	18	5[e]	61[e]	145[e]
Total imports	719	147	439	197	121	135	374[e]	2,132[e]
Canada's Share (%)	92	54	51	53	48	10	29	62

Source: Dept. of Trade and Commerce.
[e] Estimate.

The reduction of markets will continue to have a moderating effect on the exports of fibre from Southern Rhodesia. The fibre is low in magnetite and is especially desirable for the electrical industry.

South Africa is one of the larger world producers of asbestos and the major producer of crocidolite and amosite. In 1965 production increased by 11 per cent over that in 1964 and a similar increase in production was established in 1966. South African asbestos production is expected to continue this trend. Production capacity is being expanded and prospecting programs are continuing in anticipation of increased fibre demand.

Despite a moderate increase of asbestos fibre production in the USA and the demand for fibre apparently having stabilized, this country continues to remain the largest single world market for asbestos fibre.

PRICES

The prices quoted for 1966 include the increase for certain grades instituted in 1965. Further price increases of about 5 per cent have been announced for 1967.

Asbestos prices quoted in Canadian funds in the *E & MJ Metal Mineral Markets* issue of December 26, 1966 were as follows:

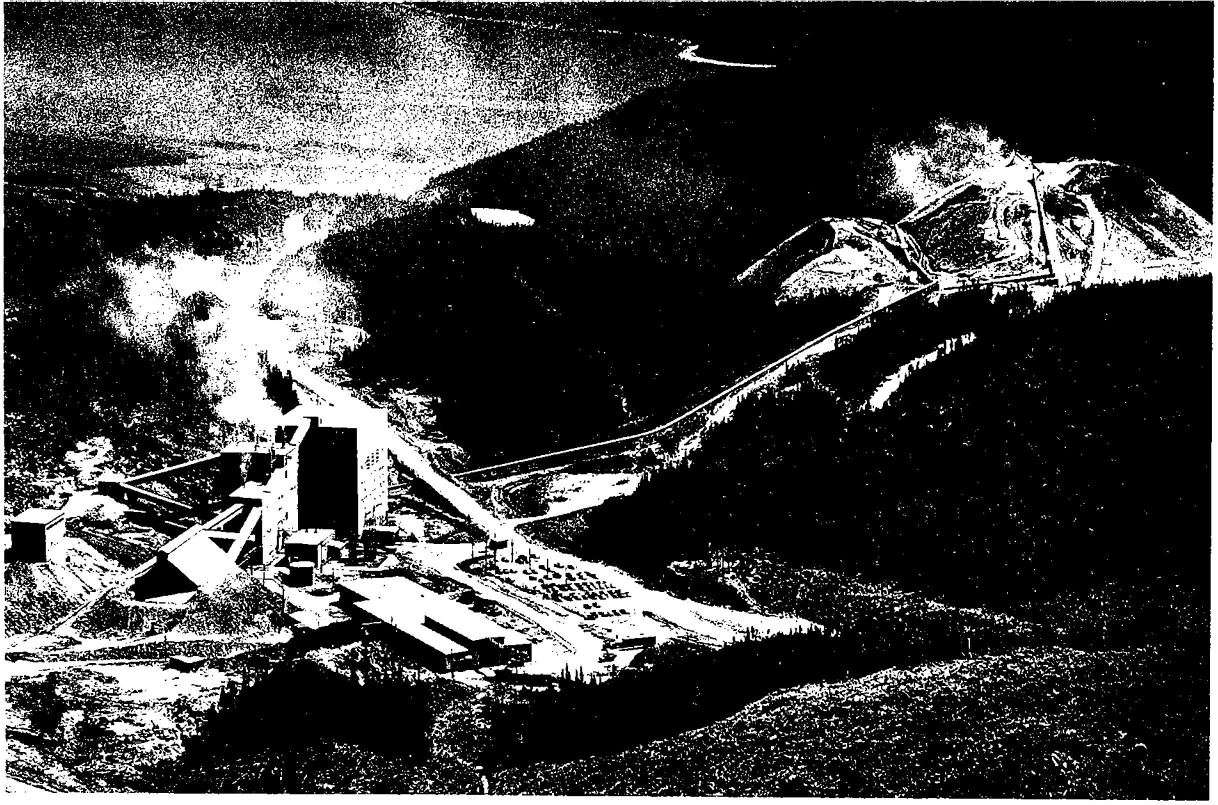
		per short ton, f.o.b. mine or mill, Que.
Crude No.	1	$1,400 – $1,410
"	2	750 – 760
Fibre	3F	565
	3K	480
	3R	408
	3T	370
	3Z	345
	4A	320
	4K	210
	4T	190
	5D	156
	5R	132
	6D	95
	7D	82
	7M	47
	7R	46
	8S	29

		per short ton, North Vancouver, B.C.
Crude No.	1	$1,522
Fibre	AAA	787
	AA	625
	A	470
	AC	325
	AD	273
	AK	231
	AS	190
	AX	168
	AY	126

TARIFFS

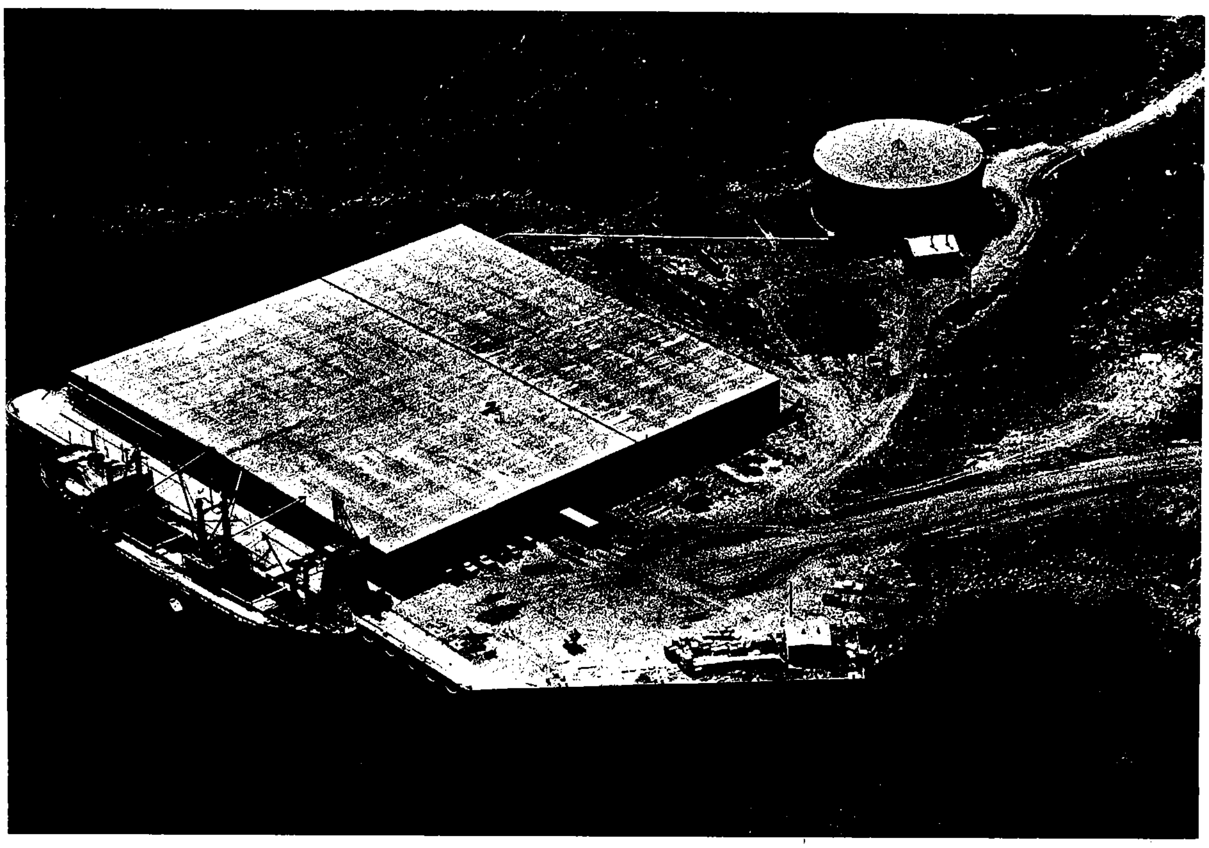
	British Preferential (%)	Most Favoured Nation (%)	General (%)
Canada			
Asbestos, crude	free	free	25
Asbestos in any form other than crude, and all manufactures thereof, n.o.p.	12½	12½	25
Asbestos in any form other than crude, and all manufactures thereof, when made from crude asbestos of British Commonwealth origin, n.o.p.	free	12½	25
Yarns, wholly or in part of asbestos, for use in the manufacture of clutch facings and brake linings	7½	12½	25
Woven fabrics, wholly or in part of asbestos, for use in the manufacture of clutch facings and brake linings	12½	12½	30

United States	
Asbestos, not manufactured, crude, fibres and stucco and asbestos sand and refuse containing not more than 15% by weight of foreign matter	free
Asbestos, yarn, slivers, rovings, wick, rope, cord, cloth, tape and tubing of asbestos, or of asbestos and any other spinnable fibre, with or without wire and articles of any of the foregoing	8% ad val.
Articles in part of asbestos and hydraulic cement: Pipes and tubes and fittings therefor	0.3¢ per lb
Other	0.225¢ per lb
Asbestos articles not specially provided for	9% ad val.



CANADA'S YOUNGEST ASBESTOS MINE: Advocate Mines Limited at Baie Verte on the northern coast of Newfoundland, as it was in 1966. Production of crysotile asbestos began in mid-1963. The plant is operated by Canadian Johns-Manville with financing by an international group.

Warehouse and dock facilities at Baie Verte.



Barite

J.E. REEVES*

Production of barite in Canada fluctuates with its demand in oil- and gas-well drilling, particularly in the United States. In 1966, mine shipments of crushed, lump and ground barite were about five per cent higher than in 1965. The total value of shipments declined somewhat because of a smaller proportion of higher-priced ground products.

Exports, consisting mainly of crushed and lump barite consigned to Gulf of Mexico ports of the United States, increased more than seven per cent. Exports of ground barite, restricted to the oil-well drilling industry in Trinidad, were considerably lower than in 1965. Imports of relatively high-priced ground barite, chiefly from the United States, remained small, but indicated a continuing increase.

World production continues to increase, mainly to supply the growing need for barite in the well-drilling industry. Canada's ability to supply a suitable product keeps it in the front ranks of world producers.

PRODUCERS

Barite was produced from four locations in Canada in 1966, one in Nova Scotia and three in southeastern British Columbia. The output from Nova Scotia is mainly in coarse form, for export. The barite from British Columbia is shipped to grinding plants in Alberta for final processing and domestic use.

Small amounts of barium and strontium metals are produced by Dominion Magnesium Limited at Haley, Ontario, principally for export.

NOVA SCOTIA

Magnet Cove Barium Corporation is by far the biggest producer. It mines barite from a large deposit near Walton by a modified method of block caving, beneficiates minus two inch crushed and lump material in a heavy media installation, and trucks the product to Walton for ocean shipment. It also recovers barite by flotation during the processing of sulphides from a deposit adjacent to the main barite orebody. A small part of the mine output is fine-ground at a plant in Walton.

The operation is dependent on exports of unground barite to grinding plants of the parent company adjacent to the Gulf of Mexico, principally Lake Charles, Louisiana, for ultimate use as a weighting agent in well drilling. The location of the operation near an ocean port permits it to compete in this market. The fine-ground barite is exported to Trinidad for use in well drilling and is also sold to the domestic paint market.

BRITISH COLUMBIA

Mountain Minerals Limited mines barite underground from deposits near Parson and Brisco, and ships most of it, after crushing and

* Mineral Processing Division, Mines Branch.

TABLE 1

Barite – Production, Trade and Consumption, 1965-66

	1965		1966P	
	Short Tons	$	Short Tons	$
Production (mine shipments)				
Crushed and lump	184,294	1,715,830	..	..
Ground	18,731	451,176	..	..
Total	203,025	2,167,006	213,854	2,011,300
Imports				
United States	3,531	198,232	4,043	232,000
West Germany	155	7,025	122	5,000
Total	3,686	205,257	4,165	237,000
Exports				
United States	162,625	1,314,533	189,775	1,738,000
Trinidad-Tobago	17,606	325,718	9,279	172,000
Venezuela	4,301	35,711	–	–
Norway	500	12,620	–	–
Total	185,032	1,688,582	199,054	1,910,000

	1964	1965
	Short Tons	Short Tons
Consumption*		
Well drilling	10,220	9,436
Paints	2,023	1,991
Glass	681	860
Rubber goods	184	62
Miscellaneous chemicals	158	146
Miscellaneous	271	130
Total	13,537	12,625

Source: Dominion Bureau of Statistics
* As reported by consumers.
Symbols: .. Not available; P Preliminary; – Nil

TABLE 2

Barite – Production, Trade and Consumption, 1957-66
(short tons)

	Production[1]	Imports	Exports	Consumption[2]
1957	228,048	1,831	199,785	30,094
1958	195,719	1,382	172,942	24,159
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
1966P	213,854	4,165	199,054	..

Source: Dominion Bureau of Statistics.
[1] Mine shipments; [2] Apparent consumption to 1958 and reported consumption from 1959.
P Preliminary; .. Not available.

TABLE 3

World Production of Barite, 1965-66

	1965	1966e
United States	845,656	947,000
West Germany	490,000	500,000
Mexico	406,405	410,000
USSR	240,000	..
Canada	203,025	213,854
Italy	156,412	160,000
Greece	132,000	..
Morocco	114,508	115,000
Peru	113,711	120,000
Yugoslavia	112,000	115,000
Other countries	976,283	..
Total	3,790,000	3,900,000

Source: U.S. Bureau of Mines Preprint, *Barite*, 1965, and U.S. Bureau of Mines *Commodity Data Summaries*, January, 1967.
e Estimate; .. Not available.

some screening, to its grinding plant at Lethbridge, Alberta. The ground products are used chiefly in well drilling.

Baroid of Canada, Ltd., recovers barite from tailings of the Giant mine, near Spillimacheen, and processes it in a grinding plant at Onoway, Alberta, for use in well drilling.

QUEBEC

Industrial Fillers Limited periodically processes barite in a grinding plant in Montreal.

OTHER OCCURRENCES

Barite occurs at many other places in Canada and has been mined in a small way from several deposits. Some noteworthy occurrences are at Buchans, Newfoundland, east of Lake Ainslie on Cape Breton Island, in Penhorwood and Langmuir Townships in northern Ontario, on McKellar Island in Lake Superior, and at Mile 397 on the Alaska Highway in British Columbia. Recently, deposits of near-white barite north of Mile 548 were reported. An attempt is being made to develop the deposits near Lake Ainslie as a source of barite and fluorite.

USES AND SPECIFICATIONS

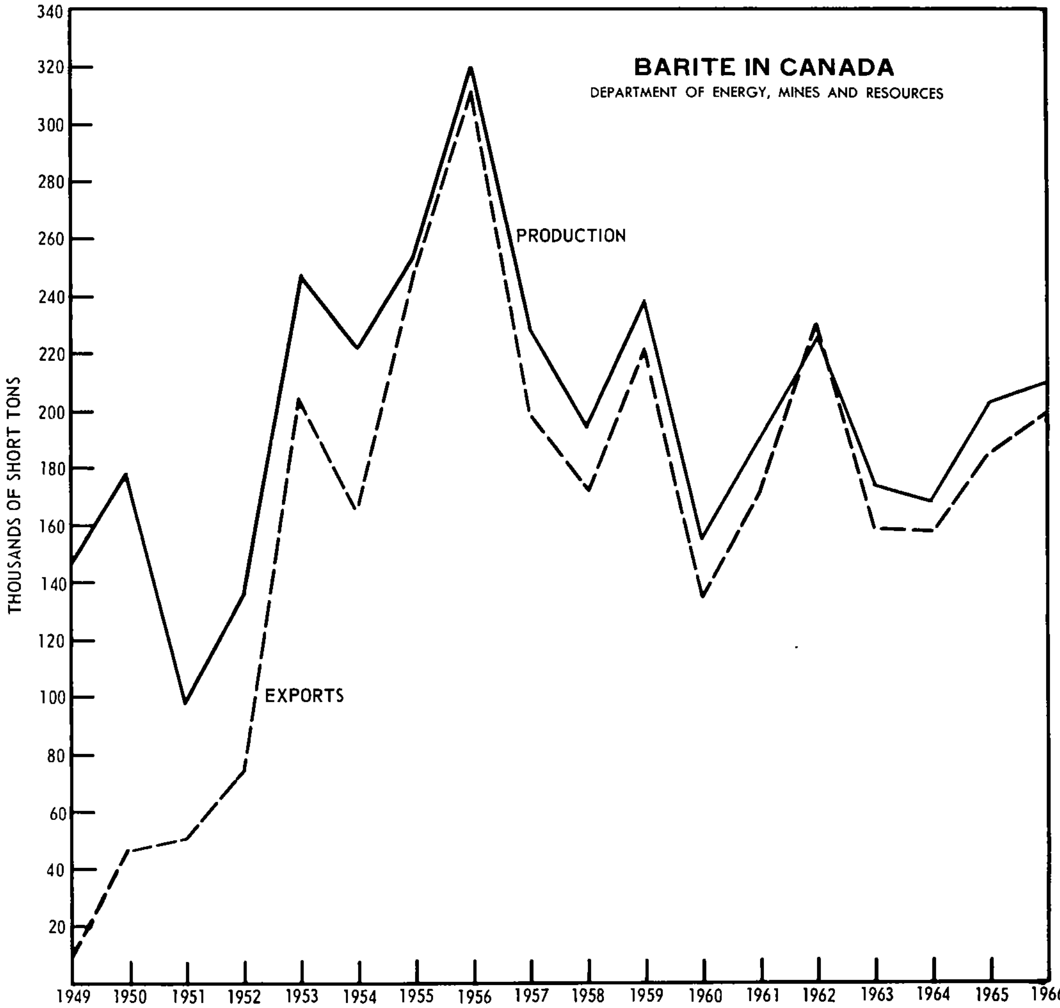
Barite, natural barium sulphate ($BaSO_4$), is used mainly because of its physical properties – its specific gravity of 4.5, its chemical inertness under normal conditions and, from some sources, its whiteness. Barite is also used to a small extent as the main source of the element barium in the production of barium chemicals.

TABLE 4

Barium Compounds – Imports and Consumption

	1964		1965	
	Short Tons	$	Short Tons	$
Imports				
Lithopone (70% $BaSO_4$)	574	79,520	218	31,000
Barium carbonate	6,410	561,268	3,623	321,000
	1963		1964	
	Pounds	$	Pounds	$
Consumption of some barium compounds in the production of chemical and chemical products				
Barium carbonate	1,369,742	67,000	1,423,534	70,000
Barium chloride	680,226	45,000	711,867	48,000
Barium nitrate	89,243	12,000	..	..
Blanc fixe	664,365	45,000	..	..
Lithopone	611,096	64,478	..	..

Source: Dominion Bureau of Statistics
.. Not available



The dominant use for barite is as a weighting agent in drilling muds. Its relatively high specific gravity assists in controlling abnormal fluid pressure in the well. Its relatively low cost makes it the most commonly used material for this purpose. Principal specifications are usually a minimum specific gravity of 4.25 (that is, no more than about 6 per cent impurities) and a particle size of at least 90 per cent minus 325 mesh.

The second most important use of barite is as a filler, mainly in paints but also in the manufacture of rubber and various other products. It should have a maximum particle size of 200 mesh, should contain at least 94 per cent $BaSO_4$ and, except in some rubber products, should have a high light reflectance.

The other main use is in the manufacture of glass, wherein it acts as a flux and improves the workability of the melt, and provides added lustre. Specifications normally require a minimum of 98 per cent $BaSO_4$, less than 0.15 per cent iron (in terms of ferric oxide, Fe_2O_3) and a particle size of essentially minus 20 plus 200 mesh.

A minor use for barite is as a heavy aggregate in concrete for nuclear shielding and for pipeline construction.

The barium chemicals industry is virtually nonexistent in Canada. The more common barium compounds manufactured throughout the world and some of their applications are: precipitated barium sulphate, or blanc fixe, as an extender and pigment in paints and as a filler in paper; lithopone, a mixture of barium and zinc sulphate, as a white pigment in paints; barium chloride, for case hardening of steel; and barium carbonate, for the reduction of scumming on brick and other ceramics and in the manufacture of optical glass and electronic tubes. Barium oxide, hydrate, titanate, chlorate, nitrate, sulphide, ferrite and phosphate are also manufactured. Several of the barite compounds are used as a source of barium metal. The titanate is important in electronics because of its high dielectric constant and its piezoelectric and ferroelectric properties. Specifications vary for barite for the manufacture of chemicals, but lump barite with a minimum of 94 per cent $BaSO_4$ and a maximum of 1 or 2 per cent Fe_2O_3 is usually required.

PRICES

According to *E & MJ Metal and Mineral Markets* of December 26, 1966, available barite prices in the United States were:

Chemical grade
- Hand-picked lump, 95% $BaSO_4$, 1% Fe $18.50
- Flotation or magnetic concentrate
  - 96-97½% $BaSO_4$, 0.3-0.7% Fe (in 100-lb bags, $3 extra) $19-23.50
- Wet ground, 99½% $BaSO_4$, minus 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, in 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

Some tariffs in effect at the time of writing were:

	British Preferential	Most Favoured Nation	General
Canada			
Crude or ground	free	20%	25%
For drilling-mud use	free	free	free

United States	
Barite	
Crude	$2.55 per long ton
Ground	6.50 per long ton
Witherite	
Crude	free
Ground	12.5% ad val.

Bentonite

J. E. REEVES*

The consumption of bentonite in Canada continues to grow at an impressive rate, principally because of the growth in the practice of pelletizing iron mineral concentrates. About 15 pounds of swelling bentonite is used in every long ton of pellets to ensure their strength. In 1966, 128,135 short tons of bentonite were used in iron mineral pellets, almost one third more than in 1965 and nearly twice as much as in 1964. The amount used in this way is bound to increase significantly during the next few years, despite the possibility of a more acceptable and similarly effective material being found to substitute wholly or partly for bentonite. Capacity for the production of pellets in Canada during 1966 was 15.58 million long tons. This will increase to about 26 million long tons by 1970 (probably requiring at least 195,000 short tons of bentonite) and to an estimated 40 million long tons by 1975. All the bentonite currently used in pelletizing is imported from Wyoming.

PRODUCTION AND TRADE

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

In Alberta, Magnet Cove Barium Corporation Ltd. recovers swelling bentonite from the Edmonton formation, of Upper Cretaceous age, a few miles south of Rosalind. Baroid of Canada, Ltd., mines a similar bentonite from the same formation, to the northwest of Onoway. Both companies dry, pulverize and size the bentonite, for use mainly in drilling muds.

In Manitoba, Pembina Mountain Clays Ltd. mines nonswelling bentonite from the Upper Cretaceous Vermilion River formation, northwest of Morden. Some is dried and pulverized in a plant at Morden; some is shipped to the company's Winnipeg plant for activation before being sold as a bleaching clay.

Canada relies heavily on imported bentonite, including all its requirements for pelletizing iron mineral concentrates. Imports from the United States, principally Wyoming, continued to increase in 1966. Nearly one half was imported in the crude state and processed by Carol Pellet Company at Labrador City, Labrador, and Arnaud Pellets at Pointe Noire, Quebec, for use in iron mineral pellets. Small but increased quantities of higher-priced fuller's earth and much more expensive activated clays were also imported, mainly from the United States. Small quantities of activated bentonite are exported periodically to the United States.

* Mineral Processing Division, Mines Branch.

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TABLE 1

Bentonite – Trade and Consumption

	1965		1966	
	Short Tons	$	Short Tons	$
Imports				
Bentonite				
United States	181,881	1,579,820	192,211	1,789,000
Other countries	281	7,288	–	–
Total	182,162	1,587,108	192,211	1,789,000
Activated clays and earths				
United States	3,060	500,325	4,127	575,000
France	66	22,309	54	17,000
West Germany	22	3,203	25	5,000
Total	3,148	525,837	4,206	597,000
Fuller's earth				
United States	6,831	195,459	7,621	220,000
Other countries	29	2,162	–	–
Total	6,860	197,621	7,621	220,000
Compounds and conditioners for use in drilling mud[1]				
United States	8,054	720,530	8,103	902,000

	1964	1965	1966
		(Short Tons)	
Consumption[2] (available data)			
Pelletizing	67,225	95,108	128,135
Well drilling	37,309[r]	36,174	..
Iron and steel foundries	24,088	37,387	..
Petroleum refining	1,343	1,520	..
Ceramic products and refractories	507	626	..
Paper	415	352	..
Other uses[3]	3,738	5,369	..
Total	134,625[r]	176,536	..

Source: Dominion Bureau of Statistics.
[1] Includes some bentonite not otherwise accounted for; [2] Includes fuller's earth but not bentonite used in construction; [3] Includes chemicals, soaps and detergents, asbestos products, gypsum products, paint, rubber products, explosives, pelletizing of zinc concentrates and other miscellaneous uses.
[r]Revised; – Nil; .. Not available.

CANADIAN OCCURRENCES

Bentonite deposits, some of which are thick and extensive, occur in formations of Cretaceous and Tertiary age in western Canada. In Alberta, the relatively high incidence of the swelling variety has made the deposits of more interest. Better types of swelling bentonite occur in the Edmonton formation near Rosalind, Onoway, Camrose and Drumheller, and in the Bearpaw formation near Dorothy and Irvine – both of Upper Cretaceous age.

In Manitoba, nonswelling bentonite occurs in the Vermilion River formation, and swelling and semiswelling varieties in the Riding Mountain formation, also of Upper Cretaceous age. Both horizons outcrop at intervals in the Morden-Miami area and for some distance to the northwest.

TABLE 2

Bentonite — Imports and Consumption, 1957-66

	Imports		Consumption	
	Short Tons	$	Fuller's Earth (Short Tons)	Bentonite[1] (Short Tons)
1957	..	1,536,512[2]	1,654	26,105
1958	..	980,585[2]	1,595	23,429
1959	..	1,082,593[2]	1,369	60,258
1960	..	1,590,441[3]	..	64,871
1961	..	1,528,170[3]	..	63,268
1962	..	1,524,080[3]	..	57,237
1963	..	2,005,337[3]	..	93,512
1964	123,533[4]	1,659,076[4]	..	134,625
1965	192,170[4]	2,310,566[4]	..	176,536
1966	204,038[4]	2,606,000[4]	..	..

Source: Dominion Bureau of Statistics.
[1] Larger survey coverage commencing 1959; includes fuller's earth.
[2] Activated clays and clay catalysts. [3] Also includes fuller's earth and clay for use in well drilling.
[4] Bentonite, activated clays and earths, and fuller's earth, but not the bentonite included in materials for use in drilling mud.
.. Not available.

In Saskatchewan, semiswelling bentonite occurs in the Tertiary Ravenscrag formation in the south-central part of the province, and in the Battle formation in the southwest and in the Vermilion River formation in the east, both Upper Cretaceous. Much of the bentonite in British Columbia is of Tertiary age and is found near Princeton, Merritt, Kamloops and Clinton.

TECHNOLOGY

Bentonite is the name commonly applied to a clay composed essentially of minerals of the montmorillonite group. Although the terms are only relative, bentonite is usually classified roughly as swelling or nonswelling.

Bentonite's usefulness is based on several unusual properties. It has a high capacity for ion exchange and a very high surface area. Montmorillonite minerals normally contain sodium and calcium in their structure, as exchangeable cations. When sodium predominates, bentonite forms a gel in water and more readily swells. Because of its high surface area, bentonite has the ability to adsorb certain substances. Treatment with sulphuric acid (activation) greatly improves its adsorptive property.

Bentonite is a very soft rock and is mined with comparative ease in surface pits. Except for activation, processing mainly involves drying, pulverizing and classifying.

Fuller's earth is an industrial term that refers to use rather than mineral composition, but it is commonly composed at least partly of montmorillonite minerals.

USES

Bentonite is used in many different ways but usually as only a small proportion of the final product.

Select swelling bentonite has thus far proven to be the most effective binder in the pelletizing of iron mineral concentrates, although the reason is open to some question. Only about three quarters of one per cent is required to provide the pellet with sufficient strength to withstand handling during the drying and firing stages, prior to being shipped to the steel industry.

Swelling bentonite is important to the well drilling industry. A mud consisting of 8 to 10 per cent bentonite in water is used principally to try to prevent the loss of drilling fluid into permeable zones, by coating the drill-hole wall. It also acts as a lubricant and keeps the drill cuttings in suspension. The bentonite should provide a high yield of mud having an apparent viscosity of 15 centipoises.

Swelling bentonite serves as a binder in moulding sands used by iron and steel foundries and in the pelletizing of zinc concentrate and stock feeds. It is used to plasticize abrasive and ceramic raw mixes; as a filler in paper, rubber, pesticides, cosmetics, medicinal products, soaps and cleansers; in the grouting of subsurface water-bearing zones; and in sealing such structures as dams and reservoirs. Bentonite slurry is effective in fighting forest fires and in retaining walls of excavations prior to the placement of concrete or other structural materials.

Some nonswelling bentonite is used in pelletizing stock feed, as a carrier for pesticides, as a binder in some low-temperature foundries, and a cleansing powder for certain pets.

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

PRICES

The price of US bentonite, as quoted in *Oil, Paint and Drug Reporter* of December 26, 1966, for a minus 200 mesh product, in bags and car lots, f.o.b. mine, was $14 a short ton.

TARIFFS

Tariffs in effect at the time of writing included:

	British Preferential (%)	Most Favoured Nation (%)	General (%)
Canada			
Clays, not manufactured further than ground...	free	free	free
Activated clays			
For refining oils	10	10	25
Not for refining oils	15	20	25

United States

Bentonite, per long ton – 81 1/4¢

Clays, artificially activated – 1/10¢ a pound plus 12 1/2% ad val.

Bismuth

J.G. GEORGE*

Bismuth is obtained in Canada as a byproduct in the processing of certain lead-zinc, molybdenum and copper ores. Cominco Ltd. recovers refined bismuth from the treatment of lead-zinc ores at Trail, B.C. The processing of molybdenum ores in the Val d'Or district of western Quebec and copper ores by Gaspé Copper Mines, Limited, near Gaspé in eastern Quebec resulted in byproduct recovery of impure bismuth metal. Kam-Kotia Mines Limited (Refinery Division) intermittently recovers small amounts of bismuth in a base bullion produced during the treatment of silver-cobalt ores and concentrates from the Cobalt-Gowganda area of northern Ontario. The refinery, at Cobalt, Ont., was formerly operated by Cobalt Refinery Limited.

Based on preliminary figures, bismuth production totalled 574,872 pounds in 1966, an increase of 34 per cent from 1965. Quebec accounted for 82 per cent of production, with the remainder coming from British Columbia.

In 1965, world production of bismuth, according to an estimate prepared by the United States Bureau of Mines, was 9.3 million pounds. Peru was again the leading producer with output of 1.7 million pounds, mainly from Cerro de Pasco Corporation. Other substantial producers in declining order of output were Japan, Mexico, South Korea, Communist China and Bolivia. The United States does not publish its production statistics.

Demand for bismuth increased again in 1966, mainly because of increased use for pharmaceuticals and chemical compounds. An important outlet for bismuth as a catalyst in the production of acrylic fibers suffered a setback because of the development of another catalyst using spent uranium and no bismuth. It is not yet known to what extent the future demand for bismuth as a catalyst will be affected by the new substitute. The United States is the world's largest consumer of bismuth and a substantial part of its requirements is imported from Peru, Mexico and Canada. 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 1966.

DOMESTIC SOURCES

British Columbia

Cominco Ltd. was 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 treated to give it a purity of up to 99.9999 per cent.

*Mineral Resources Division.

TABLE 1

Bismuth – Production and Consumption, 1965–66

	1965		1966p	
	Pounds	$	Pounds	$
Production, All Forms*				
Quebec	280,246	738,966	470,753	2,053,012
British Columbia	144,630	446,906	104,119	416,476
Ontario	3,883	9,600	–	–
Total	428,759	1,195,472	574,872	2,469,488
Consumption, Refined Metal				
Fusible alloys and solders	23,787		29,241	
Other uses**	24,492		27,187	
Total	48,279		56,428	

Source: Dominion Bureau of Statistics.
*Refined metal from Canadian ores plus bismuth content of bullion and concentrates exported. **Includes metal used in manufacture of pharmaceuticals and fine chemicals, other alloys and malleable iron.
p Preliminary; – Nil; .. Not available.

Quebec

During its fiscal year ended September 30, 1966, Molybdenite Corporation of Canada Limited milled 236,096 tons of ore and recovered 135,746 pounds of bismuth in impure metal ingots from its operations at Lacorne, 23 miles northwest of Val d'Or. 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 is electric-arc furnaces. The resulting bullion in cast into ingots containing about 96 per cent bismuth, minor amounts of lead and silver and traces of copper, iron and antimony.

Production of bismuth was considerably higher at the molybdenum-bismuth property of Anglo-American Molybdenite Mining Corporation which, in 1966, completed its first full year of operations. Mill capacity was increased from 1,000 to 1,200 tons of ore a day. About 404,000 tons of ore were treated in 1966 compared with 179,000 tons the previous year when bismuth output was 38,622 pounds. The mine and plant are 3 miles north of Cadillac. Preissac Molybdenite Mines Limited, in which Molybdenite Corporation of Canada Limited holds a substantial interest, also had considerably higher bismuth output as a result of its first full·year's operation. The property is in the Lake Preissac area about 5 miles north of Cadillac; the company produces metallic bismuth of about 95 per cent purity.

Gaspé Copper Mines, Limited, recovered 36,913 pounds of byproduct bismuth in impure metal ingots in 1966 from the treatment of flue dust derived from copper-smelting operations at Murdochville.

TABLE 2

Bismuth – Production, Exports and Consumption, 1957–66
(pounds)

	Production (all forms)[1]	Exports[2]	Consumption[3]
1957	319,941	143,000	55,000
1958	412,792	352,000	39,800
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
1966p	574,872	..	56,400

Source: Dominion Bureau of Statistics.
[1]Refined metal from Canadian ores plus bismuth content of bullion and concentrates exported. [2]For 1957 – refined metal; 1958 and subsequent years – refined and semi-refined metal. [3]Refined metal reported by consumers. p Preliminary; .. Not available.

TABLE 3

Estimated World Production of Bismuth, 1965

(pounds)

Peru	1,715,000
Japan (metal)	1,115,611
Mexico	1,100,000
South Korea (in ore)	1,100,000
Communist China (in ore)	660,000
Bolivia	582,000
Canada	428,759
Yugoslavia (metal)	196,000
Other countries	2,418,630*
Total	9,316,000

Source: US Bureau of Mines *Minerals Yearbook, 1965*, and for Canada, Dominion Bureau of Statistics.
*Includes US production, not available for publication.

USES

A major use of bismuth is in pharmaceuticals, cosmetics, and industrial and laboratory chemicals, including catalytic compounds. 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. Type metal contains bismuth because the latter expands on solidification and imparts expansion to its alloys. Bismuth is also used as an additive to improve the machinability of aluminum alloys, malleable irons and steel forgings, and for holding lenses and positioning parts in aerospace work. The US Atomic Energy Commission uses bismuth in many nuclear research applications because of the metal's low thermal neutron absorption rate.

TABLE 4

United States Consumption of Bismuth, by Principal Uses

(pounds)

	1965	1966p
Fusible alloys	783,283	938,035
Other alloys	573,844	546,780
Pharmaceuticals*	1,523,904	1,684,096
Experimental uses	15,275	6,000e
Other uses	35,367	25,111
Total	2,931,673	3,200,022

Source: US Bureau of Mines, *Mineral Industry Surveys, Bismuth Metal* in the fourth quarter of 1966.
*Includes industrial and laboratory chemicals.
p Preliminary; e Estimate.

PRICES AND TARIFFS

Canadian and United States prices of bismuth did not change during 1966. 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 *E & MJ Metal and Mineral Markets* and expressed in United States currency, was \$4.00 a pound in ton lots, delivered.

Tariffs on bismuth in 1966 were:

Canada

Bismuth metal enters Canada duty free.

United States

Bismuth metal, unwrought	1.875% ad val.
Alloys of bismuth	
Containing not less than 30% by weight of lead .	1.0625¢ per lb. on lead content
Other	18% ad val.
Bismuth metal, wrought ..	18% ad val.
Bismuth compounds	28% ad val.

Cadmium

D.B. FRASER*

Cadmium occurs mainly as a sulphide closely associated with sphalerite, the zinc sulphide. While most zinc ores contain some cadmium the amount is often so small as not to be recoverable. Canadian zinc concentrates vary in content from a negligible amount up to 0.75 per cent, or 15 pounds per ton of zinc concentrate.

Output in 1966, expressed as refined metal produced from domestic ores and concentrates plus the recoverable content of cadmium in exported ores and concentrates, was an estimated 2 million pounds.

Cadmium is recovered as a byproduct in 3 electrolytic zinc plants operated by the following companies: Canadian Electrolytic Zinc Limited, at Valleyfield, Quebec; Cominco Ltd., at Trail, British Columbia and Hudson Bay Mining and Smelting Co., Limited, at Flin Flon, Manitoba. Total output of refined cadmium in 1966 was 1,705,344 pounds.

World cadmium production, which in 1966 was approximately 28 million pounds, is derived largely from countries with large zinc smelting capacity. The United States is the leading producer with an output of about 10 million pounds annually. The second and third producers are the USSR with about 4 million pounds annually, and Japan, with 2.7 million pounds. Canada ranks fourth with 2 million pounds annually. Other major producers in order of output are Australia, the Republic of the Congo, Poland, France and Belgium.

Consumption in Britain and the United States, where most Canadian cadmium is sold, was significantly greater in 1966 than in 1965, rising by 9 per cent and 25 per cent respectively. Canadian exports to these countries were correspondingly higher. The United States government, to satisfy increasing demand, released 638,900 pounds of cadmium during 1966 from its surplus stocks, practically all of it in November and December. The government-held inventory at the end of the year was 14.8 million pounds of which 5.1 million pounds was specified as the minimum strategic requirement. On December 30, 1966, the United States government announced that its cadmium disposal program would be extended into 1967 and would make available 600,000 pounds for sale each quarter, all restricted to domestic consumption.

*Mineral Resources Division.

TABLE 1

Cadmium – Production, Exports and Consumption, 1965–66

	1965		1966p	
	Pounds	$	Pounds	$
Production				
All forms[1]				
British Columbia	486,419	1,352,245	804,405	1,930,572
Quebec	346,649	963,684	304,421	730,610
Ontario	209,724	583,033	220,112	528,269
Northwest Territories	185,840	516,635	200,000	480,000
Manitoba	213,639	593,916	193,818	465,163
Saskatchewan	133,078	369,957	138,755	333,012
Yukon	138,918	386,192	105,824	253,978
New Brunswick	41,658	115,809	38,902	93,365
Total	1,755,925	4,881,471	2,006,237	4,814,969
Refined[2]	947,755		1,705,344	
Exports				
Cadmium metal				
Britain	839,237	2,319,932	1,192,205	2,769,000
United States	442,870	1,125,993	765,125	1,729,000
India	48,655	110,616	51,912	106,000
Other countries	33,883	97,090	3,081	7,000
Total	1,364,645	3,653,631	2,012,323	4,611,000
Consumption (cadmium metal)[3]				
Plating	135,595		134,437	
Solders	19,618		14,429	
Other products[4]	16,345		21,739	
Total	171,558		170,605	

Source: Dominion Bureau of Statistics.

[1] Production of refined cadmium from domestic ores plus cadmium content of ores and concentrates exported.
[2] Includes metal derived from foreign lead and zinc ores. [3] As reported by consumers. [4] Mainly chemicals, pigments and alloys other than solder.

p Preliminary; .. Not available

TABLE 2

Cadmium – Production, Exports and Consumption, 1957–66

(pounds)

	Production		Exports	Consumption[3]
	All Forms[1]	Refined[2]	Cadmium Metal	
1957	2,368,130	2,018,000	1,941,680	177,000
1958	1,756,050	1,634,000	1,263,617	170,000
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	1,364,645	172,000
1966p	2,006,237	1,705,000	2,012,323	171,000

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. [3] Reported by consumer.

p Preliminary;

TABLE 3

World Production of Cadmium Metal

(thousand pounds)

	1965	1966[e]
United States	9,671	10,500
USSR	4,189	..
Japan	2,678	2,600
Canada	1,756	2,006
Australia	1,197	1,200
Republic of the Congo	1,038	1,100
Other countries	5,971	..
Total	26,500	28,000

Source: United States Bureau of Mines Mineral Trade Notes, July 1966 and United States Bureau of Mines Commodity Data Summaries, January 1967.

e Estimate; .. Not available.

DOMESTIC PRODUCTION

BRITISH COLUMBIA

Zinc-lead mines of British Columbia were again the main source of cadmium, the largest producer being Cominco Ltd. Other producers were Aetna Investment Corporation Limited, The Anaconda Company (Canada) Ltd., Canadian Exploration, Limited, Mastodon-Highland Bell Mines Limited, and Reeves MacDonald Mines Limited. Output of refined cadmium at Trail, from the processing of lead-zinc ores and concentrates from all sources, totalled 787 tons, compared with 359 tons during 1965 when extensive plant revisions were in progress.

YUKON TERRITORY

United Keno Hill Mines Limited recovered cadmium in concentrates produced from silver-lead-zinc ores at its 500-ton-a-day concentrator at Elsa, 200 miles north of Whitehorse. Ore production was at a reduced rate during the fourth quarter of the year.

NORTHWEST TERRITORIES

Pine Point Mines Limited operated a 5,000-ton-a-day concentrator on the south shore of Great Slave Lake and, in addition, shipped high-grade crude ore to British Columbia and Idaho for treatment.

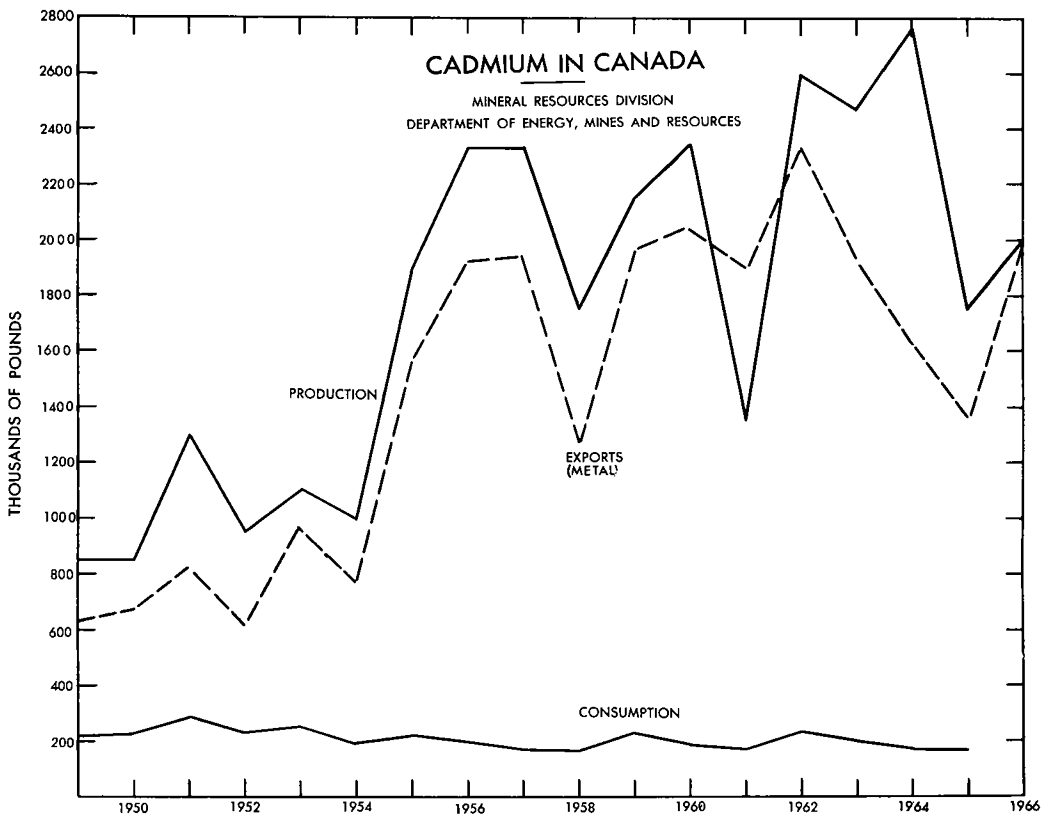
SASKATCHEWAN AND MANITOBA

Cadmium was recovered from copper-zinc ores by Hudson Bay Mining and Smelting Co., Limited, which operated 2 mines at Flin Flon and two at Snow Lake, as well as copper and zinc smelting plants at Flin Flon. Production of refined cadmium from all sources totalled 352,405 pounds.

EASTERN CANADA

Cadmium-bearing zinc concentrates were produced in Quebec, Ontario and New Brunswick. Byproduct cadmium was recovered by Canadian Electrolytic Zinc Limited, Valleyfield, Quebec, from the treatment of zinc concentrates from mines at Matagami and Noranda-Rouyn in Quebec and Manitouwadge in Ontario. Facilities for the production of refined cadmium were completed during the first quarter of 1966.

Of the cadmium exported from eastern Canada in zinc concentrates, the cadmium content was reported only when it was paid for.



USES

Cadmium is used chiefly for plating steel and, to a lesser extent, for plating copper alloy products. Zinc and cadmium anticorrosive coatings on less active metals protect the metals electrochemically as well as by physical enclosure. Other metals that are commonly used as protective coatings must be applied in greater thicknesses to give the same protection. Cadmium is preferred to zinc as a coating because it can be deposited more uniformly especially in recesses of intricately shaped parts, is more ductile, is slightly more resistant to atmospheric corrosion and can be electrodeposited with less electric current per unit of area covered. It compares unfavourably with zinc because of its much greater cost, which makes cadmium vulnerable to substitution.

Cadmium-plated articles are widely used in parts and accessories for automobiles, household appliances, electrical equipment and aircraft.

The second-largest use is in the manufacfacture of pigments. Cadmium sulphides give yellow to orange colours while cadmium sulphoselenides give pink to red and maroon. Cadmium pigments are valued for their clarity and brilliance and for their chemical stability. They are widely employed in the production of paints, ceramics and glass, and are being increasingly used in plastics. Cadmium phosphors are used in television tubes.

Cadmium is also used in making solders, particularly of the cadmium-silver type. Fusible alloys with low melting point, of the cadmium-tin-lead-bismuth type have long been used in automatic sprinkler systems, fire-detection apparatus and valve seats for high-pressure gas containers. Owing to its high strength, high conductivity, ductility and resistance to wear, low-cadmium copper (about 1 per cent) is used in the manufacture of trolley and telephone wires. Cadmium is also used in devices to control the fissionable elements in atomic reactors. Cadmium, because it has a hardening effect when small amounts are added to silver, is used in the manufacture of sterling silverware.

Production of nickel- and silver-cadmium storage batteries is an important outlet for cadmium. These batteries have a longer life than the standard lead-acid battery, are smaller and are superior during low-temperature operation. Because of these characteristics, they are being used in airplanes, earth satellites, missiles and ground equipment for polar regions as well as in small portable items such as battery-operated shavers, toothbrushes, drills and handsaws.

PRICES AND TARIFFS

The Canadian price of cadmium in sticks, bars or balls, 99.98 + per cent pure, was $2.60 a pound for lots of 5,000 pounds or more until early in December, when it was increased to $2.75 a pound.

The United States price as quoted in *E & MJ Metal and Mineral Markets* was $2.40 a pound for one ton lots until November 22, when the price was increased to $2.55 a pound.

Tariffs in Canada and the United States during 1966 were as follows:

	British Preferential %	Most Favoured Nation %	General %
Canada			
Cadmium in metal, lumps, powder, ingots, blocks, etc.*	free	15	25
Cadmium, in rod, shot, or processed form	15	20	25

*If ruled as a class or kind made in Canada, this item would come under tariff class 71100-1 and carry duties as follows:

British Preferential	15%
Most Favoured Nation	20%
General	25%

United States	
Cadmium in ores and concentrates	free
Cadmium metal, unwrought	3.75¢ per lb.
Cadmium metal, wrought	18% ad val.
Cadmium alloys	18% ad val.
Cadmium flue dust	free

Calcium

W.H. JACKSON*

The Canadian producer, Dominion Magnesium Limited, is the main commercial source of calcium metal. The other sources are Société Métallurgique du Planet in France and Nelco Metals Inc., Div. of Charles Pfizer Company, in the United States. All use thermal reduction methods and capacity is adequate to meet the current and future needs of industry. World demand is in the order of 500 tons.

DOMESTIC INDUSTRY

Dominion Magnesium Limited produces three grades of calcium at the Haley smelter in Ontario in addition to its main product, magnesium, which is covered in another review in this series. To produce the Commercial grade, 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 to 740°C. Higher purities are obtained by subsequent refining operations.

The Commercial grade contains 98 to 99 per cent calcium, 0.5 to 1.5 per cent magnesium, 1 per cent maximum nitrogen and 0.35 per cent aluminum maximum. High purity calcium contains 99.5 per cent calcium plus magnesium with 0.5 as maximum for magnesium. It is low in major impurities, the maximum being 0.004 per cent manganese, iron 0.005 per cent, nitrogen 0.025 per cent, and aluminum 0.010 per cent. Such elements as nickel, lithium, boron, sodium and cadmium are extremely minor impurities. The Chemical Standards grade is nominally 99.9 per cent pure. Minor impurities are similar to those in the High Purity grade.

Calcium shipments in 1966 were 248,830 pounds compared with 157,875 pounds in 1965 with most of it being exported as Canadian demand is about 10 tons a year. Production of minor metals at Haley in 1966 was: thorium (1,275 lb), mainly for magnesium alloys; titanium (9,120 lb) for nickel alloys and in powder form for fuses; zirconium-magnesium master alloy (6,670 lb); barium (228 lb), a getter in vacuum tubes; and strontium (125 lb) for laboratory use.

USES

Calcium can be safely handled in air but, since it is reactive and has low strength, it has not been possible to develop structural uses.

*Mineral Resources Division.

TABLE 1

Canadian Calcium Production and Exports, 1965-66

	1965		1966P	
	Pounds	$	Pounds	$
Production (metal)*	159,434	152,848	268,000	254,600
Exports (metal)				
United States	75,700	52,404	165,500	153,000
Belgium and Luxembourg	44,000	28,450	44,200	31,000
West Germany	15,400	15,060	20,000	24,000
Japan	1,900	2,073	7,000	7,000
Britain	10,700	18,157	5,700	10,000
Other countries	600	980	400	2,000
Total	148,300	117,124	242,800	227,000

Source: Dominion Bureau of Statistics.

*Smelter use and shipments; P Preliminary.

TABLE 2

Canadian Calcium Production and Exports, 1957-66

	Production* (pounds)	Exports (pounds)
1957	221,225	60,500e
1958	25,227	63,700e
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
1966P	268,000	242,800

Source: Dominion Bureau of Statistics.

* Production from 1956 to 1960 inclusive; shipments from 1961.

P Preliminary; e Estimated.

Commercial grade calcium is in demand for the production of calcium hydride, a portable source of hydrogen gas, and for debismuthizing lead, for sulphur removal in maraging and other high quality steels, and for selenium recovery. High Purity calcium is mainly a reducing agent in the production of uranium and thorium. Small quantities of the Chemical Standards grade are used for experimental or pilot plant work where pure metal is needed for chemicals and isotope separation.

PRICES

The Canadian price in 1966 quoted by Dominion Magnesium Ltd., f.o.b. Haley, Ontario was 85 cents a pound for the Commercial grade up to $3.50 a pound for the Chemical Standards grade.

TARIFFS

	British Preferential (%)	Most Favoured Nation (%)	General (%)
Canada			
Calcium metal, pure, in lumps, ingot, powder*	free	15	25
Calcium metal alloys, or calcium metal in rods, sheet or any semiprocessed form	15	20	25

TARIFFS (Cont'd)

United States
Calcium metal, unwrought — 15%
Calcium metal, wrought — 18%

*Must be ruled to be of a class or kind not produced in Canada, otherwise the tariff governing semiprocessed forms applies.

Cement

N.G. ZOLDNERS*

Construction in Canada reached another all-time record with $11.2 billion in total construction, an increase of 13.5 per cent over the 1965 value of $9.9 billion.

Continuing growth in construction is stimulating the production of building materials. Cement production in 1966 reached another peak amounting close to 9 million short tons**, a 6.5 per cent increase over the 1965 production. Cement is ranking eighth in importance compared with the production values of other Canadian leading minerals.

Two new plants in Quebec and the addition of a second kiln in the existing cement plant in New Brunswick added about 6.5 million barrels to Canada's annual rated capacity, increasing it by about 10 per cent over that of 1965 to 73.5 million barrels.

Although the total cement production in terms of shipment volume has increased, the operating ratio of the cement industry in 1966 has dropped to an estimated 70 per cent of the year-round total plant capacity as compared with 72 per cent for 1965.

Major expansions of two cement plants in British Columbia will increase Canada's production capacity in 1967 by 3.7 million barrels.

Expansion of another existing plant and construction of a new plant, both in Ontario, scheduled for completion in 1968 will add another 7 million barrels, increasing Canada's total annual rated capacity to 84.2 million barrels.

PRODUCTION

Canada produces portland, masonry and oil-well cements, as well as white cement 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 1966, of the total cement produced, 97 per cent was portland and practically all the rest was masonry cement.

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*Mineral Processing Division, Mines Branch.

**1 short ton = 2,000 lb; 1 barrel = 4 bags = 350 lb; 1 USA barrel = 360 lb.

TABLE 1

Cement — Production and Trade, 1965-66

	1965		1966[p]	
	Short Tons	$	Short Tons	$
Production*				
By province				
Ontario	3,145,873	50,055,554	3,184,372	51,307,104
Quebec	2,836,645	45,805,893	2,976,610	49,361,015
Alberta	871,738	15,597,836	844,500	16,676,000
British Columbia	601,878	11,199,607	713,966	14,566,526
Manitoba	421,840	8,884,734	496,180	11,010,300
New Brunswick	177,254	2,940,644	260,000	4,290,000
Saskatchewan	233,630	5,286,894	231,070	5,921,000
Nova Scotia	45,067	764,787	210,000	3,549,000
Newfoundland	93,777	1,987,220	55,441	1,219,700
Total	8,427,702	142,523,169	8,972,139	157,900,645
By type				
Portland	8,186,683	137,976,261	..	..
Masonry**	241,019	4,546,908	..	..
Total	8,427,702	142,523,169	8,972,139	157,900,645
Exports				
Portland cement				
United States	316,637	4,942,692	407,111	6,564,000
Other countries	18,250	270,993	267	7,000
Total	334,887	5,213,685	407,378	6,571,000
Cement and concrete basic products, n.e.s.				
United States		322,989		762,000
Other countries		28,537		26,000
Total		351,526		788,000
Imports				
Portland cement+				
United States	80	2,190	..	..
Portland cement, white				
United States	10,439	482,034	13,899	645,000
Japan	4,740	130,723	3,584	98,000
Belgium and Luxembourg	2,285	68,959	1,857	57,000
Denmark	2,866	84,869	1,764	55,000
Britain	1,842	53,445	1,609	44,000
West Germany	998	49,330	911	43,000
Other countries	131	3,960	—	—
Total	23,301	873,320	23,624	942,000
Cement, n.e.s.++				
Britain	7,981	296,968	12,061	378,000
United States	3,896	247,802	5,309	385,000
Belgium and Luxembourg	—	—	5,209	77,000
West Germany	2,361	126,963	2,838	151,000
France	—	—	875	34,000
Other countries	—	—	699	11,000
Total	14,238	671,733	26,991	1,036,000
Total cement imports	37,619	1,547,243	50,615	1,978,000

TABLE 1 (cont'd)

Cement – Production and Trade, 1965-66

	1965		1966p	
	Short Tons	$	Short Tons	$
Refractory cement and mortars				
United States		1,187,775		1,385,000
Ireland		360,473		372,000
Japan		182,254		139,000
Other countries		21,684		38,000
Total		1,752,186		1,934,000
Cement and concrete basic products, n.e.s.				
United States		230,907		162,000
Britain		20,152		15,000
Other countries		11,443		20,000
Total		262,502		197,000
Cement clinker				
United States (white)	18,759	484,353	17,290	454,000
Jamaica (normal)	15,497	112,914	–	–
Total	34,256	597,267	17,290	454,000

Sources: Dominion Bureau of Statistics.
*Producers shipments plus quantities used by producers. **Includes small amounts of other cements. +Not available as a separate class after 1965. ++Includes masonry, acid-proof, aluminious and other specialty types of cement.

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

The total amount of cement shipped from all Canada's plants during 1966 was 8,972,139 short tons, valued at $157,900,645 (Table 1). Of the volume, 69 per cent was produced in the provinces of Ontario and Quebec where 13 of total 23 cement plants in Canada are located. No cement is being produced in Prince Edward Island, or Yukon and Northwest Territories.

Table 2 shows a continuous increase of Canada's cement production during the last ten years. The amount produced in 1966 is about 60 per cent greater than that produced in 1956. The slight decrease in production in 1960 and 1961 was fully recovered in 1962.

In 1966 cement clinker was produced in 23 plants containing 54 rotary kilns. Of all these plants 16 employed the wet process and seven used the dry method. The approximate cement plant capacities at the end of 1966 are shown in Table 3; the location of these plants is shown on the accompanying map.

In addition, Canada Cement Company, Limited, operated a separate clinker grinding plant in Edmonton and another came into operation at Floral, near Saskatoon in September, 1966. Medusa Products Company of Canada, Limited, grinds imported clinker at Paris, Ontario, for the production of white cement.

In 1965*, the raw materials consumed in the production of cement included 11,517,771 tons of limestone, 1,193,290 tons of clay, 405,889 tons of gypsum, 347,981 tons of shale, 297,124 tons of high-silica sand and 59,757 tons of iron oxide.

Table 4 summarizes changes in the production capacity of Canada's cement industry since 1956 showing that in the last 10 years the total rated capacity of the industry has increased by 122 per cent. In this period the average plant capacity increased by 55 per cent, whereas average kiln capacity increased by 43 per cent, indicating a trend towards more kilns per plant and higher productivity per kiln.

*1966 figures not yet available.

TABLE 2

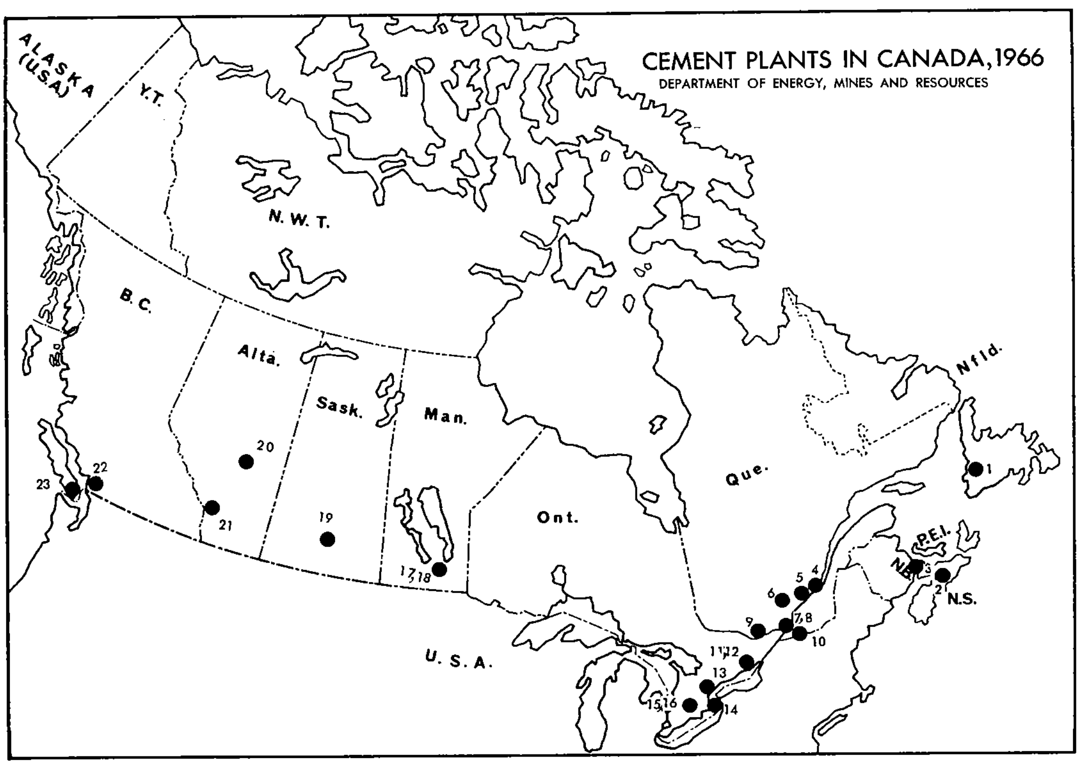
Cement – Production, Trade and Consumption, 1956-66
(short tons)

	Production*	Exports**	Imports**	Apparent Consumption+
1956	5,021,683	124,566	599,624	5,496,741
1957	6,049,098	338,316	92,380	5,803,162
1958	6,153,421	141,250	41,555	6,053,726
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[p]	8,972,139	407,378	50,615	8,615,376

Source: Dominion Bureau of Statistics.

*Producers' shipments plus quantities used by producers. **Does not include cement clinker. +Production plus imports less exports.

[p] Preliminary.



CEMENT PLANTS IN CANADA, 1966
DEPARTMENT OF ENERGY, MINES AND RESOURCES

TABLE 3

Approximate Cement-Plant Capacities* at End of 1966
(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)	1,400,000	245,000
New Brunswick		
Maritime Cement Company Limited, Havelock (3)	2,000,000	350,000
Quebec		
St. Lawrence Cement Company, Villeneuve (4)	4,500,000	788,000
Ciment Quebec Inc., St. Basile (5)	2,500,000	438,000
Independent Cement Inc., Joliette (6)	2,500,000	438,000
Miron Company Ltd., St. Michel (7)	6,000,000	1,050,000
Canada Cement Company, Limited, Montreal (8)	8,000,000	1,400,000
Canada Cement Company, Limited, Hull (9)	1,200,000	210,000
Lafarge Cement Quebec Ltd., St. Constant (10)	3,000,000	525,000
Ontario		
Lake Ontario Cement Limited, Picton (11)	4,500,000	788,000
Canada Cement Company, Limited, Belleville (12)	4,400,000	770,000
St. Lawrence Cement Company, Clarkson (13)	4,200,000	735,000
Canada Cement Company, Limited, Port Colborne (14)	1,200,000	210,000
Canada Cement Company, Limited, Woodstock (15)	3,400,000	595,000
St. Mary's Cement Co., Limited, St. Mary's (16)	4,300,000	753,000
Medusa Products Company of Canada, Limited, Paris (grinding only)		
Manitoba		
Canada Cement Company, Limited, Fort Whyte (17)	5,270,000	922,000
Inland Cement Industries Limited, Winnipeg (18)	2,000,000	350,000
Saskatchewan		
Inland Cement Industries Limited, Regina (19)	1,300,000	227,000
Canada Cement Company, Limited, Floral (grinding only – 1,900,000 bbl)		
Alberta		
Inland Cement Industries Limited, Edmonton (20)	3,300,000	577,000
Canada Cement Company, Limited, Exshaw (21)	3,100,000	542,000
Canada Cement Company, Limited, Edmonton (grinding only – 1,900,000 bbl)		
British Columbia		
Lafarge Cement of North America Ltd., Lulu Island (22)	1,700,000	297,000
Ocean Cement Limited, Bamberton (23)	2,800,000	490,000
Total	73,470,000	12,850,000

Source: Published data and private correspondence.

*Not including the capacities of the separate grinding plants. **Calculated.

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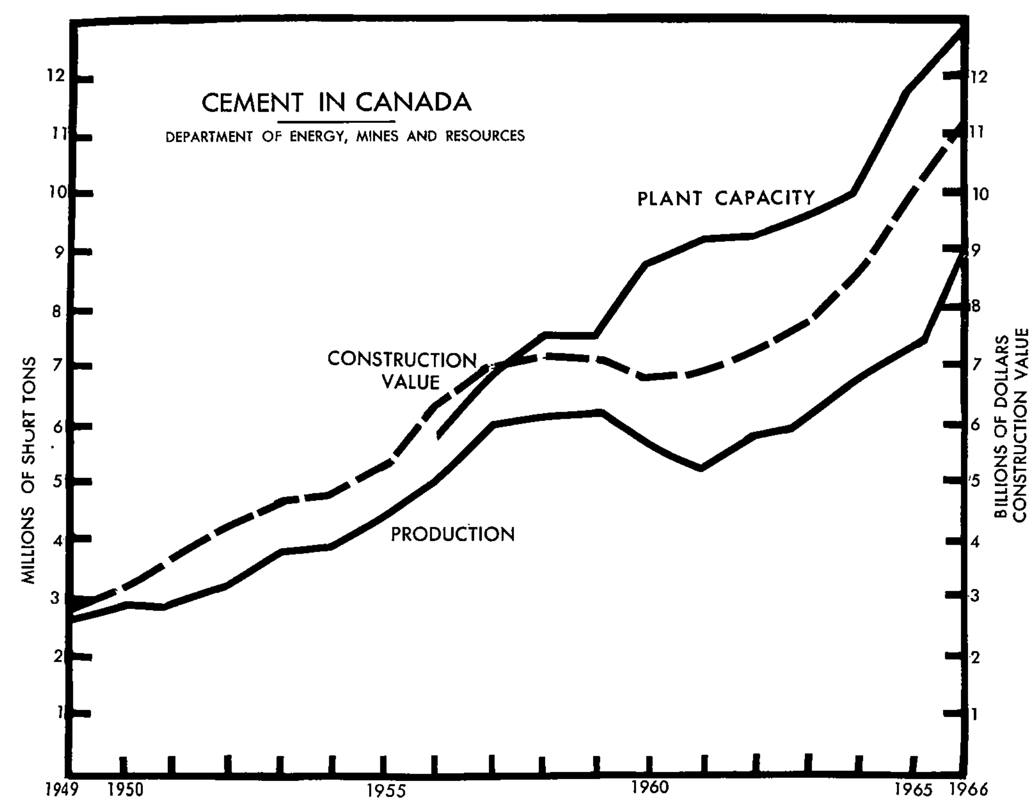
TABLE 4

Cement — Rated Production Capacity*, 1956-66

	No. of Plants**	No. of Kilns**	Approximate Capacity** Barrels per Year	Short tons per Year	Average Capacity** Per Plant (million bbl. /year)	Per Kiln (million bbl. /year)	Production Shipments (short tons)	As % of Year-end Capacity
1956	16	34	33,300,000	5,827,500	2.08	0.98	5,021,683	86
1957	16	38	39,200,000	6,860,000	2.45	1.03	6,049,098	88
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	12,850,000	3.20	1.36	8,972,138++	70
1967+	23	57	82,170,000					
1968+	24	58	84,170,000					

*Clinker-producing plants. **Year-end. +Scheduled to date. ++Subject to revision.



In 1964 Canada's cement industry operated on the average at about 79 per cent of its rated annual capacity. With the opening of new plants and expansion of existing clinker producing facilities the production rate decreased in 1966 to 70 per cent of the year-end production capacity. With another new plant under construction in Ontario and expansion of the two existing plants in British Columbia, the production rate of the cement industry can be expected to decrease further.

The total production capacity and actual cement production figures from Table 4 are plotted in the following graph showing also Canada's total construction values at the same time.

WORLD PRODUCTION

The pattern in world cement production is changing. For many years the United States was the leading world cement producer, but in 1965 the lead was taken by the USSR. The production increase in per cent during the 10-year period ending in 1965 is shown in Table 5. Canada has nearly doubled its production from 4.4 million tons in 1955 to 8.4 million in 1965, remaining in twelfth place among other countries.

TABLE 5

World Production of Cement, 1965
(thousand short tons)

Country	1955	1965	Production Increase, %
USSR	23,071	79,802	245.9
United States	55,113	73,102	32.6
West Germany	18,658	37,624	101.6
Japan	10,839	36,033	232.4
France	10,898	24,894	128.4
Italy	10,940	22,304	103.9
Britain	13,052	18,704	43.3
China	4,618	12,125	162.5
India	4,678	11,693	150.0
Spain	4,445	10,847	144.0
Poland	3,913	10,552	169.7
Canada*	4,404	8,428	91.2
Czechoslovakia	2,968	7,521	153.4
Belgium	4,812	6,509	35.3
Other countries	50,639	118,275	132.3
Total	223,048	478,413	114.5

Source: US Bureau of Mines Preprint, Cement, 1965.
*Dominion Bureau of Statistics.

Particularly large increases in cement output during the above 10-year period were recorded by the USSR (246 per cent) and Japan (232 per cent), indicating a construction boom in these countries.

The development of the cement industry in a country is best reflected by the cement production figure per capita of population. Table 6 shows these figures compiled for the world's nine leading cement producing countries. Canada with its 850 pounds per capita in 1965 has the fifth highest rating in the world. Table 6 indicates also that largest per-capita production increase during the last 10 years has been shown by Japan – 202 %, followed by the USSR – 200%.

TABLE 6

World Cement Production Per Capita of Population

Country	Pounds of Cement 1955	Pounds of Cement 1965	Increase %
1. Belgium	1,085	1,380	27
2. West Germany	743	1,324	78
3. France	503	1,015	102
4. Italy	455	867	91
5. Canada	563	857	52
6. United States	667	749	12
7. Japan	244	736	202
8. Britain	510	685	34
9. USSR	230	690	200

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 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, 1965 exports and imports for the world's largest producer, the United States, were 0.2 and 1.3 per cent of that country's production. For Canada these proportions were 4.0 and 0.4 per cent in 1965, and 4.5 and 0.6 in 1966. Data compiled in Table 2 show that both export and import of cement by volume has increased in Canada during the last five years.

Canada's cement export in 1966 increased by 22 per cent over the previous year, reaching an all-time high of 407,378 tons valued at $6,571,000. Practically all of it went to the United States. In 1966 Canada supplied about 35 per cent of US cement imports, shipped mainly to New York State.

Canada's cement import in 1966 was by volume about 12 per cent of its cement export volume. However, the import being mostly white cement and other expensive special cements from the US, Europe and Japan, had a value of $1,978,000 or 33 per cent of exported cement value. About half of the imported cement was white cement, which is not manufactured in Canada. In addition Canada imported refractory cements and mortars valued at $1,934,000, and 17,290 tons of white cement clinker from the US valued at $454,000.

DEVELOPMENTS

For the fourth successive year the cement industry in Canada expanded considerably. This expansion is expected to continue at least into 1968. In 1966 two new plants began production and construction started at another new plant; major expansion was completed at one and conversion from wet to dry process at another plant; major expansions were continued at three plants; another clinker grinding plant was put in operation.

The addition of two new plants made Quebec the largest cement producing province in Canada with seven operating plants having a total capacity of 27 million barrels. Independent Cement Inc. at Joliette started production in October with one kiln, followed by a second kiln in November, thus having installed rated annual capacity of 2.5 million barrels for a wet process operation. The second new plant commencing production in Quebec in November is operated by the Lafarge Cement Quebec Ltd. at St. Constant. This is a dry process operation having one of the largest kilns in Canada with a 1,600 tons daily clinker burning capacity or 3 million barrels annual capacity. Canada Cement Company, Limited, completed in April the expansion of its Havelock, New Brunswick, plant, doubling its capacity by adding another kiln. North Star Cement Limited completed the conversion of its plant at Corner Brook, Newfoundland, to dry process, increasing its production capacity by about 50 per cent, as shown in the Cement Review for 1965.

The two new plants and the addition of another kiln to the existing plant facilities raised the annual rated capacity of the industry by the end of 1966 by about 6.5 million barrels. Canada Cement Company, Limited, also completed its new 1.9 million barrel clinker grinding plant at Floral, Saskatchewan, which went into operation in September.

Major expansions of existing facilities, scheduled for completion in 1967, were under construction at 2 existing cement plants in British Columbia. Ocean Cement Limited is adding another kiln, increasing the capacity of its plant at Bamberton, B.C., by 2 million barrels. The addition of the second kiln by the Lafarge Cement of North America Ltd. will double the capacity of its cement plant on Lulu Island, B.C., raising it by 1.7 million barrels per annum. These expansions will raise the rated capacity of the industry by the end of 1967 by about 3.7 million barrels.

St. Lawrence Cement Company will expand the production capacity of its plant at Clarkson, Ontario, by the addition of another kiln and new equipment for the dry-process facilities. It is estimated that by 1968 the capacity of this plant will be increased by about 5 million barrels. Construction work has been started at the $22 million new cement producing plant at Bowmanville, Ontario, by the St. Mary's Cement Co., Limited. Scheduled for completion also in 1968, this plant will have a 2 million barrels rated capacity. Thus by the end of 1968 the annual capacity of Canadian cement industry may be expected to be over the 84-million-barrels mark.

The schedule for installation of the additional kiln at its Woodstock, Ont., plant, has not been decided yet by the Canada Cement Company, Limited.

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

TABLE 7

Cement-plant Expansion

Company and Location	Capacity Increase (million bbl. /year)	Year Started	Year Scheduled for Completion	Approximate Cost ($ million)
Ontario				
St. Mary's Cement Co., Limited, Bowmanville	2.0*	1966	1968	22
St. Lawrence Cement Company, Clarkson	5.0**	1965	1968	..
British Columbia				
Lafarge Cement of North America Ltd., Lulu Island	1.7	1965	1967	...
Ocean Cement Limited, Bamberton	2.0**	1965	1967	2.5

Source: Data obtained from publications and private correspondence.
*New plant. **Expansion.
.. Not available.

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 (see Table 2). The graph on page 6 indicates that the volume of cement production varies directly with the total cost of the construction. Expenditure in the construction work in Canada for 1967 has been forecast by the Dominion Bureau of Statistics amounting to another record of $11.5 billions. Consequently, cement production should also attain a new peak in 1967. However, the slight increase in the construction value of 2.3 per cent is much less than the 13.5 per cent gain registered in 1966. This may be an indication of a slowdown in the construction work and also in the growth of the cement consumption in Canada.

TABLE 8

Destination of Domestic Cement Shipments* 1966
(short tons)

Ontario	3,084,953
Quebec	2,735,343
Manitoba, Saskatchewan, Alberta and British Columbia	2,131,375
Newfoundland, Prince Edward Island, Nova Scotia and New Brunswick	604,043
Yukon and Northwest Territories	4,450
Canada total	8,560,164
Exports	403,107
Total shipments	8,963,271

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

The destination of domestic cement shipments in 1966 is shown in Table 8. Ontario and Quebec are by far the largest cement consuming provinces, absorbing two thirds of the volume shipped. While shipments to Ontario have increased by about 6.5 per cent, Quebec's share remained practically the same as in 1965. Cement shipments to the Maritime provinces in 1966 increased by about 31 per cent but to the Western provinces by only 5.5 per cent. The amount of cement consumed by the Yukon and Northwest Territories was about half of the amount used in 1964.

The 6.5 per cent increase in Ontario was due mainly to greater activity in general construction and highway building.

In Quebec the construction boom which started in 1965, continued in 1966. Most of this activity was evident in the greater Montreal area and at the large hydro-electric power development in northern Quebec. Considerable quantity of cement has been used in the construction of roads, bridges and tunnels in connection with the Trans-Canada Highway, new expressways and subway on the Montreal island, and for the numerous structures of the Expo '67. With all the above construction geared for completion for the opening of Expo in the spring of 1967, a slowdown in construction activities in the Montreal area is inevitable.

Cement consumption in the western provinces continues to increase due to hydro-electric power developments in British Columbia, Saskatchewan and Manitoba. A large amount of cement is being used for soil-cement highway construction, stabilization of mill tailings for back-fill of mines and grouting of oil and gas wells. The newly established potash mining industry in Saskatchewan also used large amounts of cement in 1966.

Statistics are not available to provide a reliable breakdown of cement consumption by types of construction. However, based on results of a study conducted by the Portland Cement Association in Chicago, an approximate breakdown has been adopted by the Canadian cement industry. Of all cement consumed in Canada about 20 per cent is used in residential construction; the non-residential construction, including commercial, industrial and institutional buildings, consumes approximately 30 per cent; highways, streets, underpasses, bridges, tunnels and subways use about 25 per cent; about 8 to 10 per cent of cement is used in the hydro-electric power dams and stations. The remaining 15 per cent is made up of many small categories, too numerous to mention here.

The proportion of the total consumption of cement used for ready-mixed concrete and concrete products in industry has been increasing steadily during the last few years. The production figures shown in Table 9 indicate that the output of the ready-mixed concrete in 1966 was about 9 per cent higher than in 1965, consuming about 40 per cent of the total cement shipments.

TABLE 9

Production of Concrete Products

		1965	1966[p]
Concrete bricks	(no.)	98,550,167	101,218,433
Concrete blocks (except chimmey blocks)			
Gravel	(no.)	142,608,585	139,232,681
Cinder	(no.)	6,714,592	6,377,499
Other	(no.)	46,904,439	51,327,748
Concrete drain pipe, sewer pipe, water pipe and culvert tile	(tons)	1,466,233	1,303,047
Concrete, ready mix	(cu. yd.)	13,544,076	14,787,246

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

SPECIFICATIONS

Cement produced in Canada conforms to the specifications of the Canadian Standards Association (CSA Standard A5-1961). This Standard covers the three main types of portland cement as follows: Normal, High Early Strength and Sulphate-Resisting cements. The types not covered by this Standard generally meet specifications of the American Society for Testing and Materials. A low heat portland cement is being manufactured by three cement companies located in Quebec according to the specifications supplied by Hydro-Quebec and designed for mass concrete used in dam construction.

PRICES

Prices vary depending on supply and demand, quantity of shipment, location of the point of delivery and type of cement. The average value of all Canadian shipments in 1965 amounted to $16.91 per ton. This increased to $17.60 in 1966, ranging from a low of $16.11 per ton for Ontario shipments to a high of $25.62 for Saskatchewan shipments. The latter province has only one cement producer which hauls all its limestone about 275 rail-miles from Manitoba.

TARIFFS

	British Preferential (¢)	Most Favoured Nation (¢)	General (¢)
Canada			
Portland cement and hydraulic lime, in bulk or barrels or in casks, the weight of the barrel, bag or cask to be included in the weight for duty, per 100 lb	5	8	8
White portland-cement clinker for use in the manufacture of white portland cement, per 100 lb	2	3½	6

United States

The United States import tariff on portland, roman and other hydraulic cements and cement clinker remained 2¼ cents per 100 pounds including the weight of the container. For white, nonstaining portland cement it is 3 cents per 100 pounds including the weight of the containers.

Chromium

G.P. WIGLE*

Canada is not a producer of chromite. Some was produced in Quebec between 1940 and 1950 with peak production reaching 29,595 tons in 1943. The Bird River deposits in the Lac Du Bonnet district of Manitoba are large but low grade averaging about 26 per cent Cr_2O_3 and 12 per cent iron, with a chromium-to-iron ratio of about 1.4 to 1. Chromite has been mined during periods of emergency in the Eastern Townships of Quebec where many occurrences are on record. Other occurrences are found in Manitoba, Newfoundland and British Columbia.

Chromium content of chromium ore (chromite) imported in 1966 amounted to 20,880 tons valued at $1.6 million compared with 35,408 tons valued at $2.5 million in 1965. Imports of ferrochromium were 12,536 tons valued at $3.6 million compared with 15,336 tons valued at $4.2 million in 1965. Canada's exports of ferrochromium dropped to 35 tons from 205 tons in 1965; most of it in both years went to Britain.

Several chromite-producing countries have, in recent years, become producers and exporters of ferrochromium and other chromium additives. Russia has remained the principal supplier of high-grade chromium ores. Rhodesia and the Republic of South Africa are developing chromium-additive industries; the latter is a major supplier of chromite and ferrochromium to the United States.

The only commercially important ore-mineral of chromium (Cr) is chromite ($FeO.Cr_2O_3$) which has a theoretical chromic oxide (Cr_2O_3) content of 68 per cent. Chromite ores are basically a combination of oxides of chromium and iron with varying amounts of alumina and magnesia. Chromite ores seldom contain more than 50 per cent Cr_2O_3 but Russia produces metallurgical grade chromite containing 55 per cent Cr_2O_3. Some representative analyses of chromite shipments are listed in Table 4.

The only producer of chromium additives in Canada is Union Carbide Canada Limited, Metals and Carbon Division. It produces high-carbon ferrochromium, charge ferrochromium, and ferrochromium-silicon. Production of the latter two increased since they replaced exothermic grades previously imported.

Suppliers of chromite and chromium additives include Chromium Mining & Smelting Corporation, Limited; Philipp Brothers (Canada) Ltd.; Derby Metals & Minerals Limited; Metallurg (Canada) Ltd.; Continental Ore Co. (Canada) Limited and Engelhard Industries of Canada Limited.

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*Mineral Resources Division.

TABLE 1

Chromium — Canadian Trade and Consumption, 1965-66

	1965		1966P	
	Short tons	$	Short tons	$
Imports				
Chromium in ore and concentrates				
United States	11,442	895,123	8,448	843,000
Philippines	10,645	835,582	6,445	442,000
Rhodesia	7,973	452,812	3,063	125,000
Republic of South Africa	3,020	115,848	1,256	54,000
Iran	—	—	1,142	68,000
Other countries	2,328	200,477	526	66,000
Total	35,408	2,499,842	20,880	1,598,000
Chromic acid (chromium trioxide)				
Britain	660	426,023	434	258,000
United States	607	371,343	426	256,000
USSR	—	—	55	26,000
Australia	42	28,934	14	10,000
Other countries	15	8,476	14	8,000
Total	1,324	834,776	943	558,000
Chromium sulphates, basic, for tanning				
United States	1,143	258,452	805	192,000
Britain	246	50,007	379	76,000
West Germany	2	516	17	3,000
Total	1,391	308,975	1,201	271,000
Chrome dyestuffs				
West Germany	41	90,726	45	101,000
United States	82	158,557	42	87,000
Britain	70	109,673	21	47,000
Poland	—	—	13	14,000
Switzerland	10	28,100	10	45,000
Other countries	12	24,983	17	33,000
Total	215	412,039	148	327,000
Ferrochromium				
Republic of South Africa	5,601	1,303,615	5,033	1,251,000
France	1,695	550,926	4,174	1,340,000
United States	4,886	1,511,656	2,514	805,000
Norway	414	75,304	399	96,000
Rhodesia	1,275	365,138	284	86,000
Other countries	1,465	426,678	132	36,000
Total	15,336	4,233,317	12,536	3,614,000
Exports				
Ferrochromium				
United Kingdom	118	25,049	34	8,000
Other countries	87	10,412	1	1,000
Total	205	35,461	35	9,000
Consumption				
Chromite	69,105		64,550	

Source: Dominion Bureau of Statistics.
P Preliminary; — Nil;

TABLE 2

Chromium – Canadian Trade and Consumption, 1957-66
(short tons)

	Imports		Exports	Consumption[2]	
	Chromite[1]	Ferrochromium[2]	Ferrochromium[2]	Chromite	Ferrochromium
1957	111,453	..	10,332	70,971	7,000
1958	38,136	..	10,460	36,297	4,714
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
1966p	20,880	12,536	35	64,550	..

Source: Dominion Bureau of Statistics.
[1] To 1963 gross weight, from 1964 chromium content.
[2] Gross weight.
p Preliminary; .. Not available.

Consumers of chromium in Canada include Atlas Steels Division of Rio Algom Mines Limited; Crucible Steel of Canada Ltd.; Fahr-alloy Canada Limited; The Steel Company of Canada, Limited; Canadian Refractories Limited and General Refractories Company of Canada Limited.

WORLD PRODUCTION AND TRADE

Estimated world mine production of chromite was 5.5 million tons in 1966 compared with 5.4 million tons in 1965. Russia, the Republic of South Africa, Rhodesia, the Philippines and Turkey supplied about 80 per cent of the world's chromite requirements. The United Nations recommended that its members place an embargo on the import of chromium ores from Rhodesia. Some countries complied with the request but there was no significant change in the pattern of world chromite production to the end of 1966.

Chromite production in the Republic of South Africa, reported by its Department of Mines in "Minerals, July to September 1966", was 863,016 tons during the period January to September 1966 compared with 794,806 tons in the same period of 1965; exports were 700,713 tons and 541,154 tons in the comparable periods. Domestic sales of chromite in the Republic during the period January to September 1966 decreased to 135,731 tons from 152,578 tons in the first nine months of 1965. Total domestic sales in 1965 were 203,628 tons.

The United States is the largest importer and consumer of chromite. US imports of chromite in 1966 amounted to 1,864,400 tons; consumption was 1,436,315 tons.(1) The metallurgical industry continued to be the largest user of chromite, accounting for 56 per cent of the total consumption. The refractories industry used 31 per cent of US consumption and the chemical industry 13 per cent. The largest supplier to the United States was the Republic of South Africa followed by the Philippines, USSR, Turkey and Southern Rhodesia. The USSR supplied the largest tonnage of ore grading over 46 per cent chromic oxide (Cr_2O_3).

World mine production of chromite increased from 1.9 million tons in 1947 to the estimated 5.5 million tons of 1966. Few countries have been thoroughly explored for chromium ore resources and estimates of reserves are mostly approximations. South Africa's reserves were estimated to be 2,000 million tons containing 40 per cent or more Cr_2O_3.(2) In 1965, the chromite reserves of Southern Rhodesia were

[1] US Bureau of Mines, Mineral Industry Surveys prepared March 9, 1967.
[2] Republic of South Africa, National Resources Development Council, Investigation Report, Volume IV.

estimated by the Rhodesian Department of Mines at more than 600 million tons of which a large part is estimated to be metallurgical grade. The South African and Rhodesia deposits are capable of supplying ore at an expanded rate. The USSR, the Philippines, Turkey, Albania and Iran are known to have large deposits of chromite.

TABLE 3

World Production of Chromium Ore, 1964-66
(thousands of short tons)

	1964	1965	1966[e]
USSR	1,435[e]	1,565[e]	1,500
Republic of South Africa	936	1,038	1,050
Philippines	516	611	650
Southern Rhodesia	493	624	600
Turkey	455	625	650
Albania	342[e]	347[e]	340
Iran	132	165	160
Yugoslavia	97	88	90
Other countries	274	307	510
Total	4,680	5,370	5,550

Source: US Bureau of Mines Minerals Yearbook, 1965; US Bureau of Mines Commodity Data Summaries, January, 1967; and trade publications.
[e] Estimates

SPECIFICATIONS AND USES

Chromite used by industry contains from 30 to 50 per cent Cr_2O_3, and less commonly up to 55 per cent. Variations in chemical and physical properties are the basis for grading the ores into three groups: metallurgical, refractory, and chemical grades and 'friable' or 'hard lumpy'.

METALLURGICAL-GRADE CHROMITE

Metallurgical-grade chromite should contain 45 to 50 per cent Cr_2O_3 and have a chromium-iron ratio of at least 2.8 to 1, preferably 3 to 1. It is used for making chromium ferroalloys and chromium metal. Ferrochromium, 50 to 70 per cent Cr, is an alloy of chromium and iron used chiefly as a carrier for adding chromium to iron or steel. Low-carbon ferrochromium containing .010 to 2 per cent carbon, is used in heat and corrosion-resistant stainless steels with low-carbon specifications. Medium (2 to 3 per cent C) and high-carbon (3 to 6 per cent C) ferrochromium are suitable for additions of chromium to low-alloy engineering steels in which both chromium and carbon are required. Chromium greatly improves the strength, corrosion and oxidation resistance of iron and steel. Chromium content ranging between 16 and 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 handling-equipment for hot or corrosive chemicals. Chromium appears in a wide variety of alloys ranging from less than 1 per cent to 35 per cent chromium.

REFRACTORY-GRADE CHROMITE

The refractory industry in the United States uses chromite averaging about 35 per cent Cr_2O_3. Specifications for refractory-grade chromite are not as rigid as for metallurgical grade but mineralogical constituents are important in the making of good quality refractory brick. 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 must be hard and lumpy and above 10-mesh in size. Chromite fines are suitable for the manufacture of brick cement and chrome-magnesite brick. Chromite refractories have a chemically neutral character and are used extensively for furnace linings.

CHEMICAL-GRADE CHROMITE

The chemical industry in the United States uses chromite averaging 45 per cent Cr_2O_3. Specifications are less rigid than for other grades. Suitable ores should contain not more than 15 per cent alumina (Al_2O_3) and 20 per cent iron oxide (FeO) or less than 8 per cent silica (SiO_2). Sulphur must be low and the chromium-iron ratio is usually about 1.6 to 1. Friable ores and fines are preferred because the ore is ground, in processing, to make sodium and potassium chromates and bichromates.

Chromium chemicals are used in the manufacture of pigments, dyes, leather tanning, treatment of textiles and electroplating; many other uses are important. Chromium plating of plastic parts for automobiles, appliances and home furnishings is a growing industry.

TABLE 4

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
S. Africa							
Chemical	44.50	19.20	15.02	10.04	.31	3.86	1.57:1
Philippines							
(Masinloc)							
Refractory	33.35	10.30	28.23	18.56	.45	4.58	2.2 :1

Source: *E & MJ Metal and Mineral Markets, Market Guide, Chrome, May 30, 1966.*

PRICES

Chrome prices in United States as quoted by *E & M J Metal and Mineral Markets*, December 26, 1966 were as follows:

Chromium Metal	
electrolytic, 99.8%, f.o.b. shipping	
point, per lb.	96 – 98¢
vacuum melting	3¢ more
9% C	140.5¢
aluminothermic, per lb., delivered	
98.5%	98 – 102¢
99.25%	102 – 106¢
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	
Rhodesia (nominal)	
45-50% Cr_2O_3, 3½ to 1 ratio, lump	\$31-\$35
53% Cr_2O_3, 2.4 to 1 ratio, concentrate	\$28-\$29
Transvaal	
44% Cr_2O_3, no ratio	\$18-\$21.50
Turkish (nominal)	
48% Cr_2O_3, 3 to 1 ratio	\$32.50 – \$33.50
Russian (nominal)	
54-56% Cr_2O_3, 4 to 1 ratio	\$30.50 – \$33
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 to 6% C or 6 to 8% C	19¢ (nominal)
Low carbon, 67 to 73% Cr	
0.025% C	25.5¢
0.05% C	24.5¢
0.05% C, 65% Cr, 5% Si	24.5¢
Simplex low carbon, No. 2, 0.01% C	26.5¢
No. 1, 0.025% C	24.5¢
36/40 ferrochrome silicon	11.0¢
40/43 ferrochrome silicon	11.9¢
Charge chrome	
63-71% Cr, 3% Si, 0.04% S, 4.5-6% C	15.3¢
Blocking chrome, 10-14% Si	17.9¢
14-17% Si	18.9¢

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 tin plate	free	free	25%
United States			
Chrome ore		free	
Chromium metal		10½%	
Ferrochromium			
Less than 3% C		8½%	
3% or more C		5/8¢ per lb. on Cr content	
Chromic Acid		10½%	
Chromium carbide		12½%	
Chrome brick		25%	
Chrome colours		10%	
Chromate and dichromate		2.25¢ per lb.	

Clays and Clay Products

J. G. BRADY*

Common clays and shales occur in most regions and are the principal raw materials used for brick and tile. Deposits of high-quality argillaceous materials used for such products as papers, refractories, high-quality whitewares, and stoneware products are scarce in Canada. Consequently, china clay (kaolin), fireclay, ball clay and stoneware clay are usually imported.

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.

Extension of plant facilities and installation of new kilns continued during the year in the clay products industries. During the past twenty years the number of plants has decreased but plant efficiency has increased enormously. Large modern plants have been established while many small, seasonal operations that lacked technical personnel, good raw materials, and modern equipment have discontinued operations. Automation is becoming increasingly important for efficiency and production of good quality products. A list of ceramic plants is shown in Operator's List 6, Ceramic Plants in Canada, which is published yearly by the Mineral Resources Division, Department of Energy, Mines and Resources, Ottawa.

PRODUCTION, TRADE AND CONSUMPTION

Statistics for production, trade and consumption of clay and clay products are shown in Tables 1 to 6. In general it is difficult to get a true picture of the value of clay products because in some categories products are included that contain no clay. The items in Table 1 are made almost entirely of domestic clay or shale. The whitewares and refractories that are produced in Canada and listed in Tables 3 and 4 respectively generally contain clay as one of several major ingredients, although basic refractories, which are included in Table 4, contain no clay. The imports and exports of ceramic products shown in Table 2 generally contain clay as a major ingredient although there are such items as chrome, magnesite and silica firebrick, and some ceramic tableware that contain no clay.

*Mineral Processing Division, Mines Branch.

The preliminary figures for 1966 (Table 1 and Table 5) for production of clay products from domestic clays show that the value of these products is at an all-time high, although prices are much the same as ten years ago. Imports of clay products and refractories showed a major increase from $59.4 million in 1965 to $71.7 million in 1966, while exports rose from $10.3 million in 1965 to $12.6 million.

Seventy-one plants were producing such clay products as facing brick (glazed and unglazed), common brick, structural tile, drain tile and quarry tile, primarily from local common clays and shales.

TABLE 1

Production of Clay and Clay Products from Domestic Sources, 1965-66

		1965		1966P	
		Quantity	$	Quantity	$
Production, shipments from domestic sources					
By main classes					
Clays, including bentonite			1,001,332		*
Clay products from					
Common clay			33,066,752		32,358,994
Stoneware clay			6,000,586		6,810,404
Fire clay			735,213		*
Other			2,033,699		5,639,771
Total			42,837,582		44,809,169
By products					
Clay					
Fireclay	sq. ft.	5,663	81,386		
Other clay, including bentonite	ʻʻ	..	919,946		
Fireclay blocks and shapes		..	69,465		
Firebrick	no.	4,969,510	665,748		
Brick					
Soft mud process					
Face	no.	56,345,834	2,863,572		
Common	ʻʻ	13,917,395	528,283		26,531,420
Stiff mud process					
Face	ʻʻ	324,190,769	17,141,888		
Common	ʻʻ	35,208,956	1,063,206		
Dry process					
Face	ʻʻ	45,700,894	2,349,336		
Common	ʻʻ	30,689,647	1,865,951		
Fancy or ornamental	ʻʻ	3,280,871	307,084		
Sewer brick	ʻʻ	2,512,658	93,648		
Paving brick	ʻʻ	1,115,880	118,631		
Structural tile					
Hollow blocks	st.	94,197	1,974,038		1,384,466
Floor tile	sq. st.	380,660	174,316		
Drain tile	no.	67,347,504	4,586,779		4,443,108
Sewer pipe	ft.	8,884,868	3,803,667		4,955,389
Flue linings	ʻʻ	1,426,608	933,622		
Pottery		..	1,263,297		1,855,015
Other products					5,639,771†
Total			42,837,582		44,809,169

Source: Dominion Bureau of Statistics.

* Included under "other".

† Includes fireclay, bentonite and other clay, fireclay blocks and shapes, firebrick and other miscellaneous clay products.

P Preliminary; .. Not available.

TABLE 2

Imports and Exports of Clay, Clay Products and Refractories

		1965		1966	
		Quantity	$	Quantity	$
Imports					
Clay, clay products and refractories					
Bentonite	s.t.	182,162	1,587,108	192,211	1,789,000
Drilling mud	"	8,054	720,530	8,103	902,000
China clay, ground or unground	"	193,966	4,163,758	196,777	4,483,000
Fireclay, ground or unground	"	66,769	531,734	52,556	730,000
Clays, ground or unground	"	86,668	1,068,779	82,975	1,123,000
Clays and earth, activated	"	3,148	525,837	4,206	597,000
Brick, building					
Glazed	M	6,346	506,666	2,744	221,000
n.e.s.	"	21,764	1,289,068	18,814	1,150,000
Building blocks	"	..	623,615	..	526,000
Earthenware tiles					
Under 2½ x 2½"	sq. ft.	11,103,491	2,457,179	9,256,206	1,936,000
Over 2½ x 2½"	" "	11,797,871	2,286,113	12,606,408	2,473,000
Clay bricks, blocks, tiles, n.e.s.		..	161,116	..	143,000
Firebrick					
Alumina	M	2,922	2,622,632	2,988	4,009,000
Chrome	"	245	325,093	579	689,000
Magnesite	M	578	1,084,807	725	1,646,000
Silica	"	2,086	1,539,890	5,307	3,773,000
n.e.s.	"	37,585	10,332,047	45,595	13,759,000
Refractory cements and mortars		..	1,752,186	..	1,934,000
Pottery settings and firing supplies		..	230,613	..	213,000
Crude refractory materials	s.t.	4,544	331,178	6,126	356,000
Grog (refractory scrap)	"	20,457	670,370	18,955	697,000
Refractories, n.e.s.		..	2,196,674	..	2,641,000
Acid-proof brick		..	379,516	..	432,000
Tableware, china or porcelain*			8,471,788		
Tableware, ceramic			10,225,447		21,934,000
Porcelain insulating fittings			3,325,492		3,590,000
Total clay, clay products and refractories			59,409,236		71,746,000
By main countries					
United States			32,125,597		39,255,000
Britain			17,270,495		20,327,000
Japan			6,515,081		6,687,000
West Germany			806,693		2,083,000
France			1,051,011		864,000
Ireland			409,554		514,000
Belgium and Luxembourg			21,905		507,000
Hong Kong			165,432		323,000
Denmark			197,379		293,000
Italy			212,588		246,000
Other countries			633,501		647,000
Total			59,409,236		71,746,000

Table 2 (concl.)

		1965		1966	
		Quantity	$	Quantity	$
Exports					
Clays, clay products and refractories					
Clays, ground and unground	s.t.	1,319	50,696	2,703	78,000
Crude refractory materials	"	905,416	1,878,030	1,302,361	2,690,000
Building brick, clay	M	11,713	729,283	11,238	901,000
Clay bricks, blocks, tiles, n.e.s.		..	260,661*	..	234,000
Firebrick and similar shapes		..	5,438,033	..	5,389,000
Refractories, n.e.s.		..	391,745	..	703,000
High tension insulators and fittings		..	817,680	..	1,941,000
Tableware, n.e.s.		..	702,343	..	636,000
Stone, clay and concrete end products			8,717		7,000
Total clays, clay products and refractories			10,277,188		12,579,000
By main countries					
United States			7,069,902		9,319,000
Puerto Rico			232,539		329,000
Chile			351,581		273,000
France			93,908		204,000
Bahamas			96,908		198,000
Pakistan			157,684		188,000
Greece			149,025		155,000
Italy			89,987		144,000
New Zealand			185,605		132,000
Britain			135,558		112,000
Other countries			1,714,491		1,525,000
Total			10,277,188		12,579,000

Source: Dominion Bureau of Statistics.

* Not available as a separate class after 1965 and combined with "Tableware ceramic" in 1966. The totals for 1964 and 1965 have been revised to include "Tableware ceramic" amounting to $9,721,505 in 1964 and $10,225,447 in 1965.

.. Not available; n.e.s. Not elsewhere specified.

Six plants manufactured such products as clay sewer pipe, flue liners, conduits and wall coping. Their raw materials were mainly domestic low-grade fireclay, stoneware clay, common clay and plastic shale. Two plants in Ontario imported low-grade fireclay from the United States for production of these products; one of them mixed local clay with the imported fireclays to form a suitable production mix.

Eighteen plants manufacturing refractories used clay as the principal ingredient in many of their products. Only four, all in western Canada, used domestic clays.

Five sanitaryware plants, eight electrical porcelain plants, three wall tile plants, four dinnerware plants and numerous souvenir and art potteries were the principal users of ceramic-grade china clay and ball clay, which is imported mainly from the United States and the United Kingdom.

The use of kaolin in Canada has increased yearly in the past few years (Table 6). No statistics on consumption of fire clay and ball clay are available. About 2.5 million tons of domestic clay are consumed in the products included in Table 1.

TABLE 3

Shipments of Clay Products Manufactured in Canada from Imported Clays*

		1962		1963		1964	
		Quantity	$	Quantity	$	Quantity	$
Glazed floor and wall tile,	sq. ft.	12,613,000	4,859,000	14,587,214	5,100,000	18,448,215	6,176,000
Electrical porcelains		..	5,703,000	..	6,279,000	..	7,918,000
Pottery, art and decorative ware		..	802,000	..	806,000	..	1,053,000
Pottery tableware		..	1,377,000	..	1,563,000	..	1,806,000
All other products (sanitaryware, etc.)		..	10,378,000	..	12,016,000	..	14,289,000

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

TABLE 4

Shipments of Refractories Manufactured in Canada

		1962		1963		1964	
		Quantity	$	Quantity	$	Quantity	$
Fireclay blocks and shapes	s.t.	..	56,742	..	47,621	..	73,674
Firebrick	M	4,013	514,260	4,775	636,112	3,807	598,897
Other firebrick and shapes*	s.t.	..	11,964,000	..	12,257,000^r	..	14,715,000
Refractory cements, mortars castables and other refractory materials	s.t.	60,581	6,889,000	71,724	8,350,000	66,079	7,677,000

Source: Dominion Bureau of Statistics.
* Includes rigid firebrick, stove linings and other shapes made from imported clays, chrome ore, magnesite, etc.
.. Not available; ^r Revised

TABLE 5

Clays and Clay Products Production and Trade, 1957-66
($ millions)

	Production			Imports	Exports†
	Domestic Clays*	Imported Clays**	Total		
1957	35.9	19.9	55.8	47.4	4.3
1958	41.7	23.7	65.4	44.8	4.2
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[r]	8.9
1965	42.8	31.4	75.2	59.4[r]	10.3
1966[p]	44.8	..	..	71.7	12.6

Source: Dominion Bureau of Statistics.
* Production (shipments) of clay and clay products from domestic material.
** Production (shipments) of clay products from imported clay, from 1961 does not include refractories.
† From 1964 includes additional categories of refractories.
[p] Preliminary; [r] Revised; .. Not available.

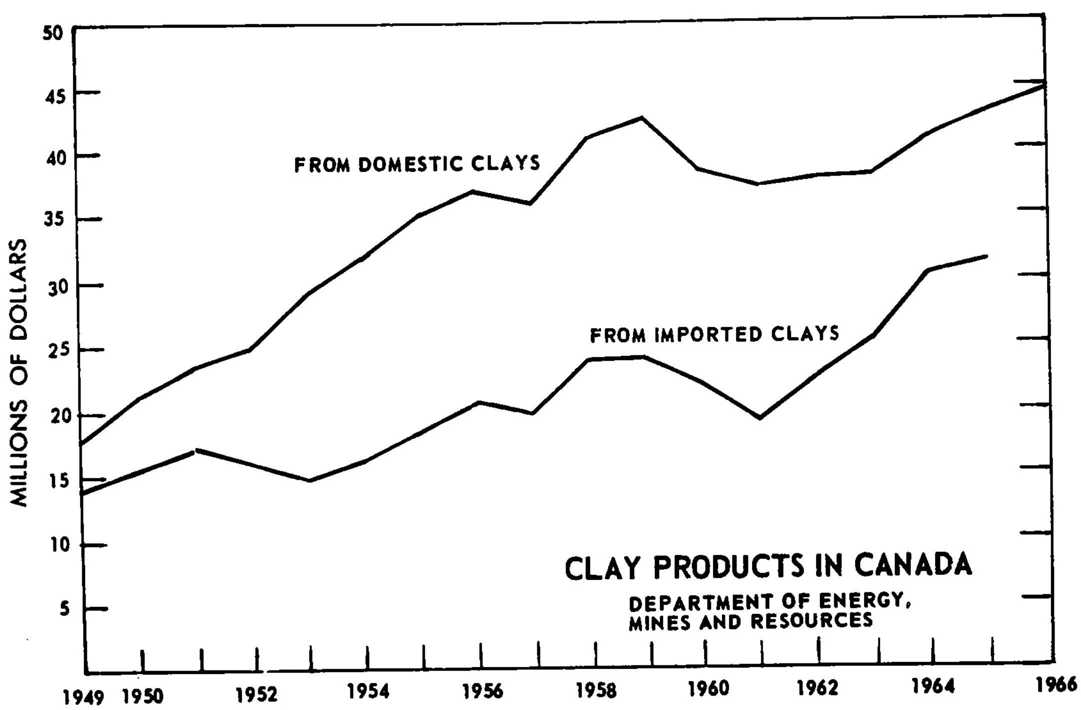

TABLE 6

Consumption (available data) of China Clay by Industries, 1964-65
(short tons)

	1964	1965
Ceramic products	12,715	12,719
Paint and varnish	1,980	2,298
Paper and paper products	103,379	112,881
Rubber and linoleum	12,305	12,919
Other products*	11,502	13,880
Total	141,881	154,697

Source: Dominion Bureau of Statistics.

* Includes miscellaneous chemicals, cleansers, detergents, soaps, medicinals and pharmaceuticals and other miscellaneous products.

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. 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 made up principally of 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.

Extensive deposits of sandy kaolin occur near Wood Mountain, Fir Mountain, Knollys, Flintoft and other localities in southern Saskatchewan. Considerable work had been carried out by the Government of Canada, the University of Saskatchewan and the Government of Saskatchewan, but so far beneficiation has not been successful.

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.

A clay deposit at Arborg, Manitoba, contains colloidal iron, a considerable quantity of quartz and some other impurities in addition to kaolinite. Kaolin-bearing rock occurs in Quebec at St. Remi d'Amherst, Papineau County; Brebeuf, Terrebonne County; Point Comfort, on Thirtyone 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.

Kaolinized deposits occur extensively in northern Ontario. To date certain difficulties with quality and exploration have not been overcome. Work on these deposits continued during the year in several laboratories.

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 in 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 Flintoft 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.

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 Mountain 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 Missinabi, Abitibi, Moose and Mattagami rivers. Adverse terrain and climate have made exploration difficult. One of the various interested companies did some sampling in the area in 1962 and another took samples in 1963. 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, Saskatchwan, 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 fire clays. 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 kaolinite group and various mixed layer clay minerals are found in them.

Clays and shales suitable for the manufacture of clay products usually contain 15 to 35 per cent small-particle quartz. If the quartz exceeds this proportion and there are other nonplastic 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.

BENTONITE

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

PRICES

Prices are not available for all types of clays. China clay generally commands the highest prices because of the cost of its beneficiation and the special processes necessary to produce it for various industries. For example, the paper industry's specifications and requirements for china clay are different from those of the ceramic industry. The prices of ball clays and high-quality fireclays are about the same as those of most china clays. Low-grade fireclays and stoneware clays generally sell for less than ball clays but are priced higher than common clays and shales. Ball clays and kaolins are sold in bags or in bulk; low-grade fireclays, stoneware clays and common clays and shales are usually sold in bulk.

According to *Oil, Paint and Drug Reporter*, December 26, 1966, prices in the United States were as follows, per short ton:

Ball clay	
Domestic, air-floated, bags, car lots, f.o.b. Tennessee	$18.00-$22.00
Domestic, crushed, moisture repellent, bulk, car lots, f.o.b. Tennessee	8.00- 11.25
China clay	
Domestic, dry-ground, calcined, air-floated, bags, car lots, f.o.b. works	$45.00-$68.00
Domestic, dry-ground, uncalcined, air-floated, 99% 325 mesh, f.o.b. Georgia, bags, car lots, f.o.b. works	17.50
Domestic, water-ground, bags, car lots, f.o.b. works	22.50- 51.00

TARIFFS

	British Preferential	Most Favoured Nation	General
Canada			
Clays, including china clay, fireclay, and pipe clay not further manufactured than ground	free	free	free
Activated clay, when imported for use in refining of oils	10%	10%	25%
Varying tariffs are in effect for clay products glazed and unglazed and clay building materials.			
United States			
Clays, whether or not washed, ground, or otherwise beneficiated, per long ton			
China clay or kaolin	67¢		
Fuller's earth			
Not beneficiated	50¢		
Wholly or partly beneficiated	$1		
Bentonite	$1.25		
Common blue clay and other ball clays			
Not beneficiated	62¢		
Wholly or partly beneficiated	1.21		
Other clays			
Not beneficiated	50¢		
Wholly or partly beneficiated	$1		
Any of the foregoing clays artificially artivated with acid or other material	0.1 per lb plus 12.5% ad val		
Varying tariffs exist on clay products			

Coal and Coke

Coal

T.E. TIBBETTS*

In 1966 there were decreases in production, imports and consumption of coal in Canada while exports of metallurgical grade coal to Japan increased. Bituminous coal production decreased while small increases in the production of both lignite and subbituminous coals were registered. Substantial increases in the values of bituminous coals, particularly those from Nova Scotia mines reflected the continued rise in production costs of these coals. Government subvention assistance was continued and expanded to help offset the rising production and transportation costs. There were large increases in the use of coal in Canada by thermal electric generating stations but other coal markets declined appreciably.

At the year's end the outlook for coal was mixed. In Eastern Canada rising costs and declining markets indicated a continuing decline in production levels, while in Western Canada there was optimism that coal production levels would increase to meet the demands of the thermal power industry and possibly the metallurgical industry.

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* Fuels Research Centre, Mines Branch.

COAL AREAS AND PRINCIPAL PRODUCERS

(with approximate production in thousands of short tons)

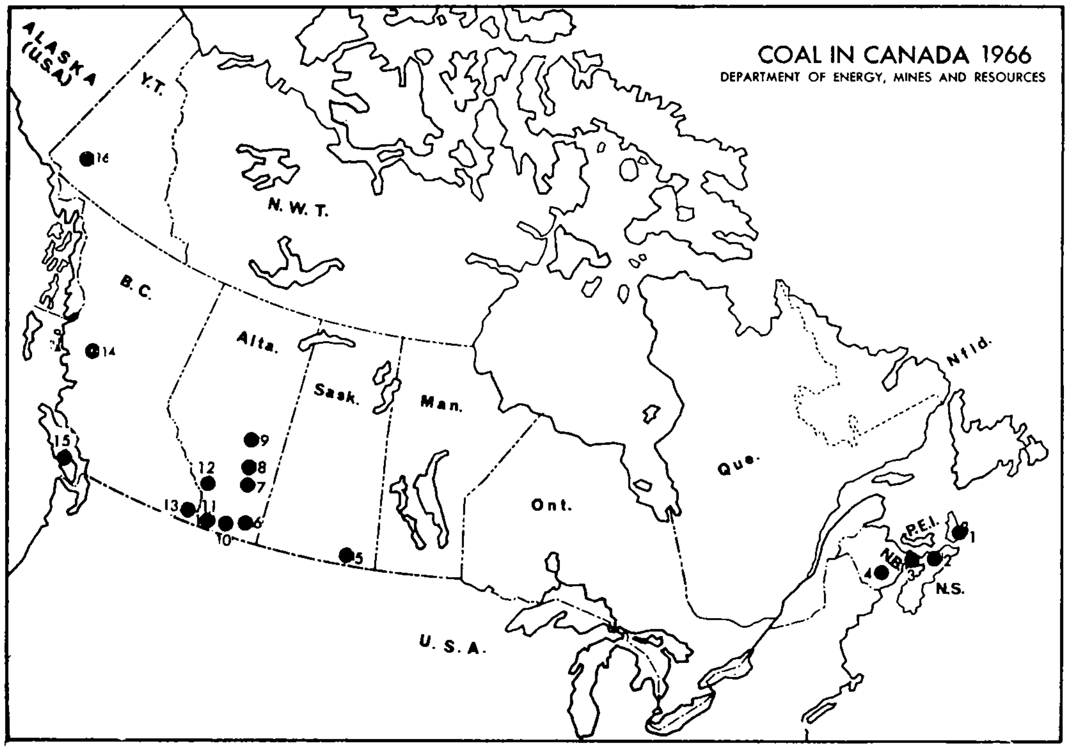
(numbers refer to numbers on map)

Nova Scotia	
1. Sydney and Inverness areas *(high-volatile bituminous)*	
Bras d'Or Coal Co. Ltd. (Four Star mine)	110
Chestico Mining Corporation Limited	17
Dominion Coal Company, Limited	2,651
Dominion Steel and Coal Corporation, Limited, Old Sydney Collieries Division	624
Evans Coal Mines Limited	49
2. Pictou area *(medium- and high-volatile bituminous)*	
Dominion Steel and Coal Corporation, Limited, Acadia Coal Company Division	191
Drummond Coal Company Limited	57
Greenwood Coal Company, Limited	11
3. Springhill and Joggins areas *(high-volatile bituminous)*	
River Hebert Coal Company Limited	60
Springhill Coal Mines Limited	85
Joggins Mining Company Limited	1
New Brunswick	
4. Minto area *(high-volatile bituminous)*	
Avon Coal Company, Limited	230
D.W. & R.A. Mills Limited	257
Dufferin Mining Limited	29
Grand Lake Mining Co. Limited	3
Midland Mining Co. Ltd.	60
Miramichi Lumber Company (Limited)	212
C.H. Nichols Co. Ltd.	46
Norman I. Swift, Ltd.	7
V.C. McMann, Ltd.	53
Saskatchewan	
5. Souris Valley area *(lignite)*	
Battle River Coal Company Limited	762
Manitoba and Saskatchewan Coal Company Limited	389
Utility Coals Ltd.	927
Alberta	
6. Brooks and Taber areas *(subbituminous)*	
Alberta Coal Sales Limited	61
The Kleenbim Collieries, Limited	6
7. Drumheller, Sheerness and Carbon areas *(subbituminous)*	
Century Coals Limited	175
Fox, Alfred	1
Fox Coulee Coals Ltd.	41
Battle River Coal Company Limited	199
Nottal Brothers	8
Subway Coal Limited	16
8. Castor, Ardley and Camrose areas *(subbituminous)*	
Battle River Coal Company Limited	264
Burnstad Coal Ltd.	16
Camrose Collieries Ltd.	2
Forestburg Collieries Limited	502
Lynass, John	5
Sissons, R.C.	25
Stettler Coal Company Limited	7
9. Edmonton, Tofield, Westlock and Pembina areas *(subbituminous)*	
Alberta Coal Ltd. (mines Nos. 419 and 1757)	1,110
Egg Lake Coal Company Limited	13
Jet Construction Ltd.	15
North Point Coal Company, Limited	19
Ostertag, Charles	10
Star-Key Mines Ltd.	51
Warburg Coal Co. Ltd.	12
Whitemud Creek Coal Co. Ltd.	15
10. Lethbridge area *(high-volatile bituminous)*	
Lethbridge Collieries, Limited	1
11. Crowsnest area *(medium-volatile bituminous)*	
Coleman Collieries Limited	631
12. Cascade area *(low-volatile bituminous and semianthracite)*	
The Canmore Mines, Limited	245
British Columbia	
13. East Kootenay (Crowsnest) area *(medium-volatile bituminous)*	
Crows Nest Industries Limited	1,059
14. Northern area *(medium- and high-volatile bituminous)*	
Bulkley Valley Collieries, Limited	12
15. Vancouver Island area *(high-volatile bituminous)*	
Comox Mining Company Limited	16
Yukon Territory	
16. Carmacks area *(high-volatile bituminous)*	
Yukon Coal Company Limited	6

PRODUCTION

Production of coal decreased 1.7 per cent to 11.4 million tons valued at $81.8 million in 1966. Production of bituminous coal decreased 3.5 per cent, whereas production of subbituminous coal and lignite increased 1.3 per cent and 0.7 per cent respectively.

Nova Scotia's coal production decreased 6.8 per cent and amounted to 33.8 per cent of the total coal production in Canada. High volatile bituminous coking coal was produced in the Sydney, Cumberland and Pictou areas and non-coking high-volatile bituminous coal was produced in the Inverness area, all from underground mines.



New Brunswick, where production decreased 9.8 per cent produced 7.9 per cent of Canada's total coal production. This was high-volatile bituminous coking coal mainly from underground and strip mines in the Minto area but also from strip mines in the Chipman and Coal Creek areas. More than 83 per cent of New Brunswick's coal is from strip mines.

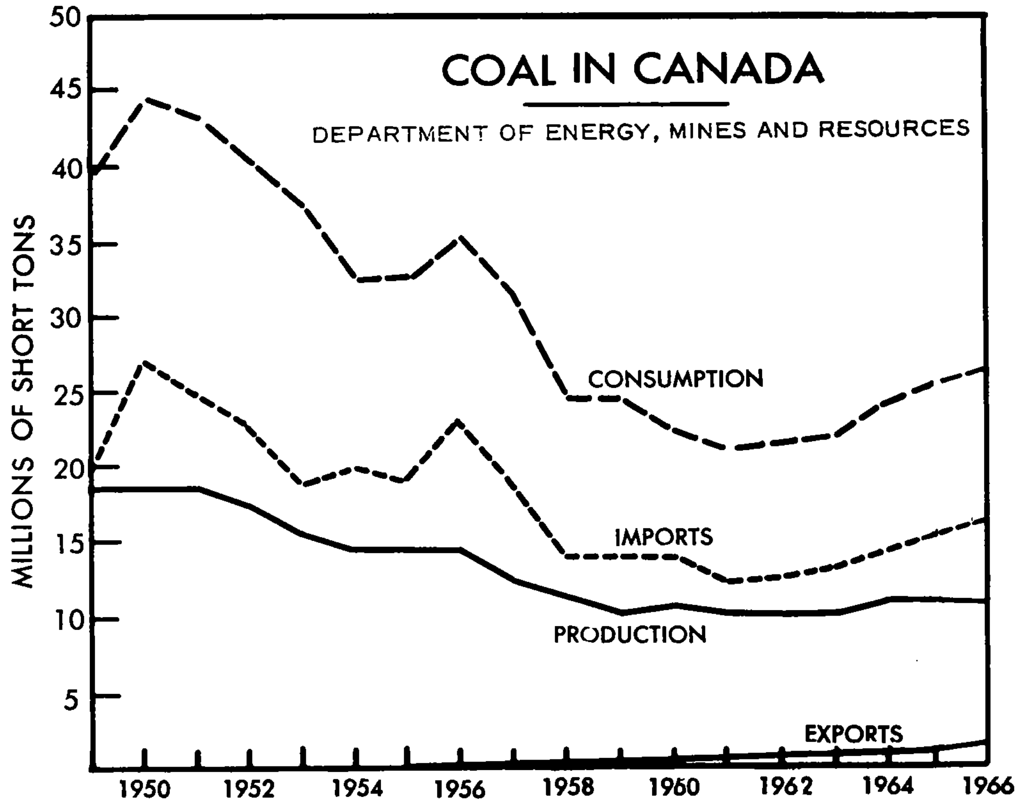
All of Saskatchewan's production is lignite from strip mines located in the Bienfait and Estevan areas of the Souris Valley and the production in 1966 was 18.2 per cent of the national output.

In Alberta where coals ranging from semianthracite to subbituminous were mined, production amounted to 30.4 per cent of that for all of Canada. The largest output was from the subbituminous mines and thirty-one such mines operating in 1966 produced almost 75 per cent of Alberta's coal. Six mines in the Pembina, Castor, Drumheller, Sheerness and Taber areas produced more than 85 per cent of the subbituminous coal. Total production of coal in Alberta increased 1.6 per cent in 1966; there was an increase of 2.4 per cent in the production of bituminous coal and an increase of 1.3 per cent in the production of subbituminous coal. About 70 per cent of Alberta's production was from strip mines.

In British Columbia coal production in 1966 increased about 12.0 per cent and represented about 9.5 per cent of the nation's coal output. All of British Columbia's coal production is bituminous and the Crowsnest area (East Kootenay district on the mainland) accounted for all but a small quantity of the production. Underground mines produced 89.2 per cent of the total output in the province.

The Yukon Territory produced about 5,700 tons of coal from a single underground mine.

The weighted average output per man-day for all coal mines in Canada increased 1.696



tons to 18.060 tons. For strip mines, which accounted for 47.2 per cent of the coal production, the output per man-day increased by 3.686 tons and the output from underground mines increased by 0.294 ton per man-day.

Coal produced in Canada in 1966 had an average value of $7.18 a ton, or 31.77 cents per million BTU. Bituminous coal, which accounted for 88.2 per cent of the total value, averaged $10.74 a ton; this is an increase of about $1.30 a ton from the previous year, resulting largely from an increase of $2.36 a ton for Nova Scotia coals. Lignite decreased only one cent a ton in value; subbituminous coals decreased 24 cents a ton. Nova Scotia coal is by far the most expensive at 49.85 cents per million BTU, and Saskatchewan lignite at 12.09 cents per million BTU, is the cheapest source of coal-derived energy in Canada.

TRADE

Nova Scotia shipped about 61.3 per cent of its output to other parts of the country; 88.1 per cent of this went to Quebec and Ontario. A small amount of Nova Scotia coal was exported to the island of St. Pierre. New Brunswick shipped about 7.3 per cent of its output to Quebec and about 1.5 per cent to the United States.

More than 35 per cent of Saskatchewan's coal production was shipped to Manitoba and Ontario.

Alberta shipped 20.6 per cent of its coal production to other provinces, Saskatchewan and British Columbia taking, respectively, 10.9 and 5.7 per cent. About 3.3 per cent went to Manitoba and 0.7 per cent to Ontario. About 80 per cent of the bituminous coking coals produced in the Crowsnest area was exported to Japan to upgrade the Japanese coal blends for metallurgical use.

About 12.6 per cent of the coal output of British Columbia was shipped to Manitoba and 2.2 per cent went to markets in Ontario. About 34.7 per cent of the production from this province was exported, mainly to Japan.

There was a decrease of 1.0 per cent in coal imports. Imports of bituminous coal from the United States decreased 0.7 per cent and imports of anthracite, mainly from the United States with some from Britain, decreased 7.2 per cent. More than one-third of the bituminous coal imported was high-grade coking coal used in the metallurgical industry in Ontario and Nova Scotia.

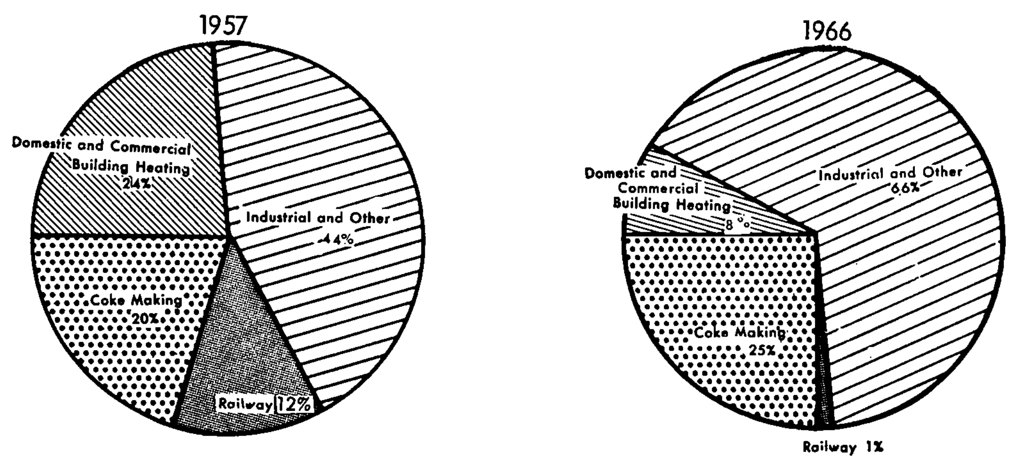
CONSUMPTION

Consumption of coal in Canada decreased 0.8 per cent in 1966 to 26.5 million tons. Almost 62 per cent of the coal consumed was imported.

A large part of the output of Nova Scotia and New Brunswick coal mines is used locally for industrial steam-raising (including that in thermal electric plants) and household and commercial heating. The use of Nova Scotia coal in the generation of thermal electric power increased 26.2 per cent in 1966. This is the greatest single use of this coal and is followed by its use in the manufacture of metallurgical coke for the steel industry at Sydney. Increasing quantities of Alberta's subbituminous coals are being employed industrially, particularly for thermal electric power generation. A large part of the bituminous coals produced in the Crowsnest areas of Alberta and British Columbia are exported for metallurgical purposes. Lignite from Saskatchewan was used for fuel for thermal electric generating stations and for commercial and household heating and industrial purposes.

In 1966 coal used in the household and commercial building heating market decreased almost 16 per cent. Total industrial consumption of coal, including that used by thermal electric generating stations, decreased 2.4 per cent. The use by thermal electric generating stations increased 2.4 per cent. The proportion of Canadian coal used industrially was about 46.6 per cent, the remainder being mainly bituminous coal from the United States. Use of coal in thermal electric generating stations in

CONSUMPTION OF COAL IN CANADA BY USES



Other uses include coals for bunkers, colliery and waste

SOURCE: DOMINION BUREAU OF STATISTICS

DEPARTMENT OF ENERGY, MINES AND RESOURCES

TABLE 1

Coal — Production, Trade and Consumption, 1965-66
(short tons)

	1965		1966P	
	Short Tons	$	Short Tons	$
Production				
All Classes				
Nova Scotia	4,134,161	45,486,833	3,854,534	51,518,674
New Brunswick	996,328	8,637,619	898,315	7,892,427
Saskatchewan	2,063,933	3,715,385	2,078,165	3,717,586
Alberta	3,413,928	12,173,846	3,467,254	11,947,258
British Columbia and Yukon	980,266	5,887,443	1,093,301	6,757,203
Total	11,588,616	75,901,126	11,391,569	81,833,148
Exports				
Bituminous				
Bermuda	15	420	—	—
United Kingdom	—	—	58	6,000
St. Pierre	4,825	63,011	2,097	29,000
United States	198,020	1,994,464	167,148	1,754,000
Japan	1,023,134	10,613,890	1,059,502	11,413,000
Total	1,225,994	12,671,785	1,228,805	13,202,000
Briquettes				
United States	7,420	111,063	24,659	373,000
Imports (for consumption)				
Anthracite				
United States	635,113	7,593,686	594,193	6,747,000
United Kingdom	5,048	101,727	—	—
Total	640,161	7,695,413	594,193	6,747,000
Bituminous				
United States	15,955,232	118,250,949	15,842,562	134,063,000
Briquettes				
United States	7,934	253,692	6,583	228,000
Consumption				
Domestic	10,181,171		10,117,756	
Imported	16,593,547		16,435,111	
Total	26,774,718		26,552,867	

PPreliminary; — Nil.

1966 is estimated at 7.9 million tons, an increase of about 2.4 per cent from the previous year and representing about 29.7 per cent of the total coal consumed in Canada.

There was a small decrease to just under 5.9 million tons in the use of coal to manufacture coke, although consumption of imported coal for coke making increased 1.8 per cent. Use of Canadian coal for this purpose decreased more than 20 per cent mainly as a result of substitution of Canadian coal for higher quality, imported coal at the Sydney steel works.

BRIQUETTES

There was a decrease of almost 16 per cent in the production of coal briquettes in 1966. Lignite briquette production was down about 5 per cent and production of bituminous coal briquettes was down more than 24 per cent. Apparent consumption of briquettes was about 44.2 per cent less than in 1965.

SUBVENTION ASSISTANCE

Payments by the Federal Government through the Dominion Coal Board to assist the movement of coal to markets increased by almost $6.3 million in 1966. Subvention assistance amounting to about $3 million was applied to the export of more than a million tons of coal from the Crowsnest area of Alberta and British Columbia.

Payments under the Atlantic Provinces Power Development Act, 1958 totalled almost $3.1 million in 1966.

TABLE 2

Coal – Production, Imports, Exports and Consumption, 1956-66
(short tons)

	Production	Imports[1]	Exports	Consumption		
				Domestic[2]	Imported[3]	Total
1956	14,915,610	22,613,374	594,166	14,115,095	22,198,049	36,313,144
1957	13,189,155	19,476,249	396,311	12,478,626	19,041,030	31,519,656
1958	11,687,110	14,491,315	338,544	11,054,757	14,154,121	25,208,878
1959	10,626,722	14,236,118	473,768	10,589,263	13,958,996	24,548,259
1960	11,011,138	13,564,836	852,921	9,973,308	13,276,599	23,249,907
1961	10,397,704	12,306,498	939,336	9,572,805	12,057,086	21,629,891
1962	10,284,769	12,614,189	893,919	9,510,293	12,377,965	21,888,258
1963	10,575,694	13,370,406	1,054,367	9,504,903	13,105,686	22,610,589
1964	11,319,323	14,989,114	1,291,664	10,080,243	14,987,656	25,067,899
1965	11,588,616	16,595,393	1,225,994	10,181,171	16,593,547	26,774,718
1966P	11,391,569	16,436,755	1,228,805	10,117,756	16,435,111	26,552,867

Source: Dominion Bureau of Statistics.

[1] Imported coal referred to by DBS as 'Entered for Consumption' represents amounts cleared from customs ports, duty paid. Before 1962, 'Landed Imports' were shown; these were the amounts which actually entered the country, recorded before customs clearance. [2] Sum of sales at Canadian coal mines, colliery consumption, coal supplied to employees and coal used in making coke and briquettes, less coal exported. [3] Deductions have been made to account for foreign coal re-exported from Canada and bituminous coal removed from warehouse for ships' stores. Imports of briquettes not included.

P Preliminary.

TABLE 3

Coal Production, by Types, Provinces and Territories, 1965-66

	1965		1966P	
	Short tons	$	Short tons	$
Bituminous*				
Nova Scotia	4,134,161	45,486,833	3,854,534	51,518,674
New Brunswick	996,328	8,637,619	898,315	7,892,427
Alberta	859,176	5,771,661	879,569	6,047,369
British Columbia and Yukon Territory	980,266	5,887,443	1,093,301	6,757,203
Total	6,969,931	65,783,556	6,725,719	72,215,673
Subbituminous*				
Alberta	2,554,752	6,402,185	2,587,685	5,899,889
Lignite*				
Saskatchewan	2,063,933	3,715,385	2,078,165	3,717,586
All types				
Total, Canada	11,588,616	75,901,126	11,391,569	81,833,148

Source: Dominion Bureau of Statistics.

*Coal classification of the American Society for Testing and Materials as in ASTM standards on Coal and Coke, 'Classification of Coals by Rank' (ASTM Designation: D-388-64T).

P Preliminary.

TABLE 4

Coal Production, by Type of Mining and Average Output per Man-day, 1966
(short tons)

	Production		Average Output per Man-day^p	
	Underground	Strip	Underground	Strip
Nova Scotia	3,854,534	–	2.529	–
New Brunswick	145,649	752,666	1.922	5.328
Saskatchewan	–	2,078,165	–	47.482
Alberta	1,040,909	2,426,345	5.239	31.929
British Columbia	969,804	117,827	7.252	25.913
Yukon	5,670	–	3.113	–
Canada 1966^p	6,016,566	5,375,003	3.745*	34.085*
1965	6,035,484	5,553,132	3.451*	30.399*
Total, all mines 1966^p	11,391,569		18.060*	
1965	11,588,616		16.364*	

Source: Dominion Bureau of Statistics.
*Weighted average.
p Preliminary; – Nil.

TABLE 5

Comparison of Average Values of Canadian Coals, 1966^p

	Average Btu/lb.*	Average Value per Short ton** ($)	Average Value per Million Btu (¢)
Nova Scotia, bituminous	13,400	13.36	49.85
New Brunswick, bituminous	12,000	8.78	36.58
Saskatchewan, lignite	7,400	1.79	12.09
Alberta			
Bituminous	13,700	6.87	25.07
Subbituminous	8,900	2.28	12.81
British Columbia, bituminous	13,700	6.17	22.52
Yukon Territory, bituminous	11,900	8.18	34.37
Total			
Bituminous	13,300	10.74	40.38
Subbituminous	8,900	2.28	12.81
Lignite	7,400	1.79	12.09
Average, Canada	11,300	7.18	31.77

*Fuels Research Centre, Department of Energy, Mines and Resources, commercial coal survey reports of analyses. **Dominion Bureau of Statistics.
p Preliminary.

TABLE 6

Interprovincial Shipments of Coal, 1966
(short tons)

Destination	Originating Province				
	Nova Scotia	New Brunswick	Saskatchewan	Alberta	British Columbia
Newfoundland	46,829	–	–	–	–
Prince Edward Island	22,765	–	–	–	–
Nova Scotia	–	–	–	–	–
New Brunswick	211,143	–	–	–	–
Quebec	1,120,649	66,021	–	15	–
Ontario	960,210	5	225,452	24,893	24,346
Manitoba	–	–	516,261	115,771	137,188
Saskatchewan	–	–	–	376,589	313
Alberta	–	–	–	–	65
British Columbia and Yukon	–	–	–	197,521	–
Total	2,361,596	66,026	741,713	714,789	161,912

Source: Dominion Bureau of Statistics.

TABLE 7

Exports of Coal, 1966
(short tons)

Destination	Shipments from Mines by Provinces*					
	Nova Scotia	New Brunswick	Saskatchewan	Alberta	British Columbia	All
St. Pierre	3,272	–	–	–	–	–
United States	–	13,254	7,408	12,206	1,171	34,039
Japan	–	–	–	709,962	376,249	1,089,483
Total	3,272	13,254	7,408	722,168	377,420	1,123,522

Source: Dominion Bureau of Statistics.
*Destined for export.
– Nil.

TABLE 8

Imports of Coal for Consumption, 1965-66
(short tons)

Country of Origin		Anthracite	Bituminous*	Total
United States	1966P	594,193	15,842,562	16,436,755
	1965	635,113	15,955,232	16,590,345
United Kingdom	1966P	–	–	–
	1965	5,048	–	5,048
Total	1966P	594,193	15,842,562	16,436,755
	1965	640,161	15,955,232	16,595,393
Value	1966P	$6,747,000	$134,063,000	$140,810,000
	1965	7,695,413	118,250,949	125,946,362

Source: Dominion Bureau of Statistics, Trade of Canada.
*Includes coal dust and coal not otherwise provided for and coal exwarehoused for ships' stores.
P Preliminary; – Nil.

TABLE 9

Consumption of Canadian and Imported Coal, 1956-66

	Canadian		Imported		Total
	Short tons*	% of Consumption	Short tons**	% of Consumption	Short Tons
1956	14,115,095	38.9	22,198,049	61.1	36,313,144
1957	12,478,626	39.6	19,041,030	60.4	31,519,656
1958	11,054,757	43.9	14,154,121	56.1	25,208,878
1959	10,589,263	43.1	13,958,996	56.9	24,548,259
1960	9,973,308	42.9	13,276,599	57.1	23,249,907
1961	9,572,805	44.3	12,057,086	55.7	21,629,891
1962	9,510,293	43.4	12,377,965	56.6	21,888,258
1963	9,504,903	42.0	13,105,686	58.0	22,610,589
1964	10,080,243	40.2	14,987,656	59.8	25,067,899
1965	10,181,171	38.0	16,593,547	62.0	26,774,718
1966P	10,117,756	38.2	16,435,111	61.8	26,552,867

Source: Dominion Bureau of Statistics.

*Sum of Canadian coal-mine sales, colliery consumption, coal supplied to employees, and coal used in making coke and briquettes, less tonnage of coal exported. **Deductions have been made to account for foreign coal re-exported from Canada and bituminous coal removed from warehouse for ships' stores. Imports of briquettes not included.

PPreliminary.

TABLE 10

Consumption of Coal – Major Uses, 1965-66
(short tons)

	1965	1966P
Household and Commercial-Building Heating		
Canadian		
Bituminous	419,692	381,917
Subbituminous	349,960	307,339
Lignite	159,649	121,998
Briquettes	21,632	18,464
Total	950,933	829,718
Imported		
Anthracite	203,877	147,998
Bituminous	893,591	750,867
Briquettes	13,785	5,149
Total	1,111,253	904,014
Total, all types	2,062,186	1,733,732

	1965	1966P
Industrial*		
Canadian		
Bituminous	4,035,367	3,736,017
Subbituminous	1,514,187	1,719,666
Lignite	1,635,685	1,608,171
Total	7,185,239	7,063,854
Imported		
Anthracite	298,008	304,916
Bituminous	8,040,735	7,779,533
Total	8,338,743	8,084,449
Total, all types	15,523,982	15,148,303
Coke Making		
Canadian		
Bituminous	523,516	413,976
Imported		
Bituminous	5,379,343	5,476,601
Total	5,902,859	5,890,577

Source: Dominion Bureau of Statistics.

*Does not include firms using less than 500 tons of coal per annum nor coal used to make coke.

P Preliminary.

TABLE 11

Coal Used by Thermal Electric Generating Stations, by Provinces, 1965-66
(thousands short tons)

	1965	1966P
Nova Scotia	700	884
New Brunswick	368	324
Ontario	3,934	3,857
Manitoba	192	89
Saskatchewan	1,195	1,232
Alberta	1,311	1,501
Canada, Total	7,700	7,887

Source: Dominion Coal Board.

P Preliminary.

TABLE 12

Briquettes – Production and Consumption, 1965-66
(short tons)

	1965	1966P
Production		
Saskatchewan	31,562	30,000e
Alberta* and British Columbia	36,854	27,904
Total, Canada	68,416	57,904e
Consumption (briquettes available for consumption)**	68,596	38,290

Source: Provincial government reports, and Fuels Research Centre, Mines Branch, Survey of Carbonization Plants in Canada.

e Estimated from published report on plant capacity and domestic heating product distribution.

* Alberta production excludes 38,804 tons of char in 1965, and 11,387 tons in 1966. (Carbonized briquettes previously known as 'char' are now defined as 'coke').

** Production (excluding char) plus 'landed' imports less exports.

P Preliminary.

TABLE 13

Coal Moved Under Subvention, 1965-66
(short tons)

Origin of Coal	1965	1966
Nova Scotia	3,465,093	3,647,386
New Brunswick	582,192	767,899
Saskatchewan	176,224	200,273
Alberta and British Columbia	1,125,317	1,167,295
Total	5,348,826	5,782,853
Value of Subvention Assistance	$26,669,551	$32,968,220

Source: Dominion Coal Board.

Coke

J.C. BOTHAM*

Of the 26.5 million tons of coal consumed in Canada in 1966 about 5.9 million tons were carbonized to produce coke. The coke was used mainly in the making of primary iron and, to a lesser extent, in foundry practice, base-metal recovery, chemical processes and domestic heating.

Canadian-produced byproduct coke is manufactured mainly at five plants in batteries of standard slot-type ovens, the plants in operation varying in annual coal capacity from 600,000 to two million tons. With the exception of one coke oven plant built primarily for the production of domestic coke, they are owned and operated by the steel companies. Apart from the conventional slot-type byproduct coke ovens, Canada has a Curran-Knowles carbonization plant at Crows Nest Industries Limited's collieries in Michel, British Columbia. About 95 per cent of the coal used in the production of coke is processed at these six plants.

There is interest in North America toward a return of the use of non-recovery ovens. The Mitchell oven and modifications of this design are the ovens of this type that are of principal interest at present. Their growing popularity stems primarily from the loss of markets for coke oven byproducts to the petrochemical industry. Some incentives for their use are lower capital cost and lower labour costs than the early beehive oven through improved coal- and coke-handling facilities. Also these ovens can be shut down if not needed. Three Mitchell 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.

In the Cascade area of Alberta a carbonizing retort commenced operation on a commercial scale early in 1963. A coke product is made by carbonizing briquettes prepared from low-volatile and semianthracite coals; a form-coke could be produced if desired. The product is used primarily for the electric smelting process used in the manufacture of elemental phosphorus; however, markets other than the chemical industry — mainly for metallurgical applications — are envisaged.

Other nonconventional carbonization processes include the Lurgi carbonization retorts which carbonize and briquette a Saskatchewan lignite coal to produce a high fixed-carbon product for domestic fuel and for use in barbecues. A distinctive stoker-type coking plant is operated by the Shawinigan Chemicals Limited, Shawinigan, Quebec.

In 1966 Lethbridge Collieries, Limited continued to operate their 26-foot rotary hearth carbonizing oven on a continuous basis supplying the product for the production of pig iron. Further experimental work on upgrading fine material is in progress.

* Fuels Research Centre, Mines Branch.

TABLE 1

Standard Slot-Type Byproduct Coke Oven Plants in Canada

Coke Plant	Battery	Type of Oven	Number of Ovens	Year Built	Byproduct Recovered	Plant Capacity	Coke Distribution
The Algoma Steel* Corporation, Limited, Sault Ste. Marie, Ont.	No. 6	Koppers-Becker Underjet	57	1953	Tar, sulphate of ammonia, pyridine oil, benzole, toluene, xylene, solvent naphtha, naphthalene, light oil, gas	4 batteries of 253 ovens with an annual rated capacity of 2,100,000 tons of coal	Blast furnace use — 3½ x ¼ inch; base metal industry ¾ x 3/8 inch and 3/8 x 3/16 inch; sintering — 3/16 x 0 inch.
	No. 5	Koppers-Becker Underjet	86	1943			
	No. 2	Wilputte gun flue	53	1938			
	No. 7	Wilputte Underjet	57	1958			
The Steel Company* of Canada, Limited, Hamilton, Ont.	No. 5	Wilputte Underjet	47	1953	Tar, sulphate of ammonia, naphthalene, pyridine, benzole, toluene, xylene, solvent naphtha, sodium phenolate, gas	3 batteries of 191 ovens with an annual rated capacity of 1,470,000 tons of coal	Blast furnace use — plus 5/8 inch; domestic heating — 5/8 x 5/16 inch; sintering — minus 5/16 inch.
	No. 3	Wilputte Underjet	61	1947			
	No. 4	Wilputte Underjet	83	1952			
Dominion Foundries* and Steel, Limited, Hamilton, Ont.	No. 1	Koppers-Becker Gun Type Comb.	25	1956	Tar, light oil, gas	3 batteries of 105 ovens with an annual capacity of 930,000 tons of coal	Blast furnace use — plus ¾ inch; sintering — 1/8 x 0 inch; other uses — ¾ x 1/8 inch.
	No. 2	Koppers-Becker Gun Type Comb.	35	1951			
	No. 3	Koppers-Becker Gun Type Comb.	45	1958			
Dominion Steel and Coal Corporation, Limited, Sydney Works, Sydney, N.S.	No. 5	Koppers-Becker Underjet	53	1949	Tar, crude oil, gas	2 batteries of 114 ovens with an annual rated capacity of 900,000 tons of coal	Blast furnace use — 3½ x 1½ inch, 2½ x 1½ inch domestic heating — 2½ x 1½ inch, 1½ x 7/8 inch, 7/8 x ¼ inch; sintering — ¼ x 0 inch.
	No. 6	Koppers-Becker Underjet	61	1953			
Quebec Natural Gas Corporation, Ville LaSalle, Que.	No. 1	Koppers-Becker	59	1928	Tar, sulphate of ammonia, light oil, gas	2 batteries of 74 ovens with an annual rated capacity of 626,300 tons of coal	Foundry coke, domestic heating, chemical industry, blast furnace use, base metal industry, rockwool producers.
	No. 2	Koppers-Becker	15	1947			

* New coke oven batteries presently under construction.

TABLE 2

Other Carbonization Plants in Canada

Coke Plant	Type of Unit	No. of Units	Year Built	Coal Capacity of Each Unit (tons/day)	Byproducts Recovered	Plant Capacity (annual rated capacity in tons of coal)	Product Distribution (sizes in inches)
Husky Oil (Alberta) Ltd.,* Bienfait, Sask.	Lurgi carbonizing retort	2	1925	150-175	Creosote, lignite tar, lignite pitch	2 units: 110,000	Domestic heating – 30,000 tons char; other – 1,900 tons
Shawinigan Chemicals Limited, Shawinigan, Que.	Travelling grate coking stoker	8	1939	70	Low-grade producer gas	8 units: 200,000	Manufacture of calcium carbide in electric furnaces
The Canmore Mines, Limited, Canmore, Alta.	Vertical retort	1	1963	100	Crude tar, gas	1 unit: 30,000 (agglomerated)	Chemical Industries
Crows Nest Industries Limited,** Fernie, B.C.	Mitchell	3	1963	7	No by-products	The 3 ovens are being used mainly to evaluate the foundry coke market	Foundry market
	Curran-Knowles	10	1939	5.5	Crude tar, gas	4 batteries of 52 Curran-Knowles ovens: 243,000	Base metal industry – 7 x 3; beet sugar industry – 7 x 3; iron reduction in electric furnaces – 7 x 3 and 3 x 1; sintering – minus 1/4.
		10	1943	5.5			
		16	1949	7.5			
		16	1952	7.5			
Lethbridge Collieries, Limited, Lethbridge, Alta.	Rotary hearth	1	1964	150	No by-products	1 unit: 50,000	Iron reduction in electric furnaces; sintering

*Formerly Dominion Briquettes & Chemicals Ltd. **Formerly the Crow's Nest Pass Coal Company, Limited.

In Canada, petroleum coke is used mainly in the production of electrodes for the aluminum industry; pitch coke is obtained only from surplus coal-tar pitch that is not required for such other industrial uses as the production of electrodes or briquettes.

For many years gas-retort plants operated in Canada producing manufactured gas and domestic coke for space-heating, and other domestic and commercial uses. These plants are now practically nonexistent and the markets are largely supplied by natural gas, liquid petroleum gases and oil.

Recently the uses of metallurgical coke have changed because of alterations in the methods of producing pig iron and steel. An increase in the use of agglomerated ores in the iron blast furnace has resulted in an increase in the demand for small sizes of coke and coke breeze. This has made possible, to a greater extent than was previously considered practical, the preparation of sized coke for iron blast furnaces.

Continuing developments in the use of supplementary liquid and gaseous fuels in iron blast furnaces by introduction through the tuyeres have led to an increase in the throughput of standard furnaces with a corresponding reduction in the quantity of coke used for each ton of pig iron produced. However, blast furnace coke has maintained its level of consumption through an increase in pig-iron production. These changes have contributed materially to a more efficient production of pig iron in the standard blast furnaces.

TABLE 3

Coke – Production and Trade

	1965		1966P	
	Short tons	$	Short tons	$
Production*				
Coal coke				
Ontario	3,527,224		3,537,891	
Other provinces	841,567		888,160	
Total	4,368,791		4,426,051	
Pitch coke	–			
Petroleum coke**	242,813		285,062e	
Total	4,611,604		4,711,113	
Imports (all types)				
United States	982,952	18,115,167	1,084,119	21,000,000
Total	982,952	18,115,167	1,084,119	21,000,000
Exports (all types)				
United States	86,596	1,228,633	87,615	1,421,000
United Kingdom	2,022	78,165	–	–
Other countries	14	342	–	–
Total	88,632	1,307,140	87,615	1,421,000

Source: Dominion Bureau of Statistics.

* Value of coke production and selling price of coke are not available. Practically all coke output is that produced in the primary iron and steel industry as material used in process.

**Includes quantities of catalytic carbon.

P Preliminary; e Estimated; – Nil.

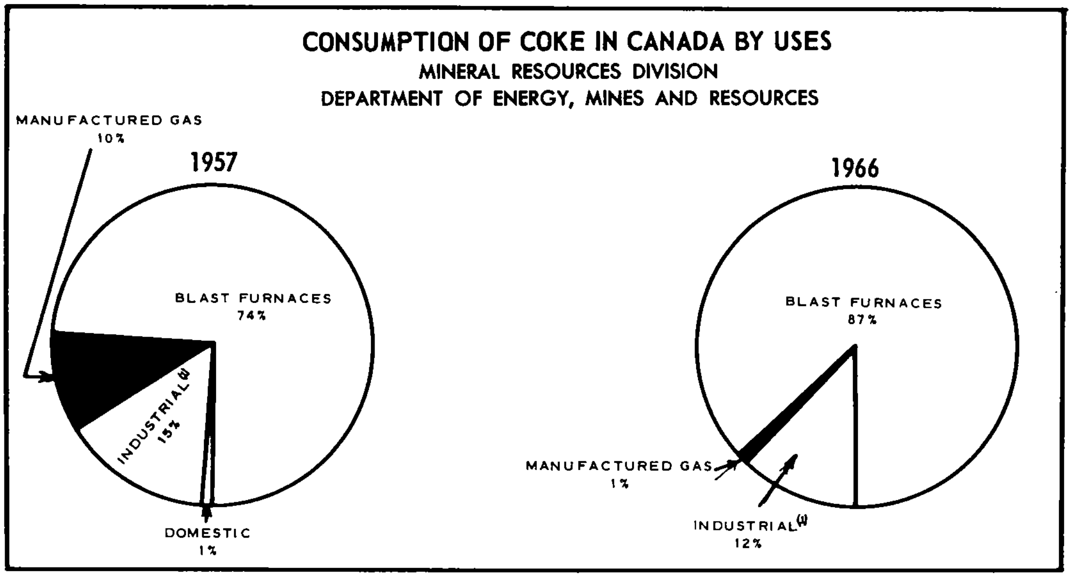
TABLE 4

Coke – Production and Trade, 1956-66
(short tons)

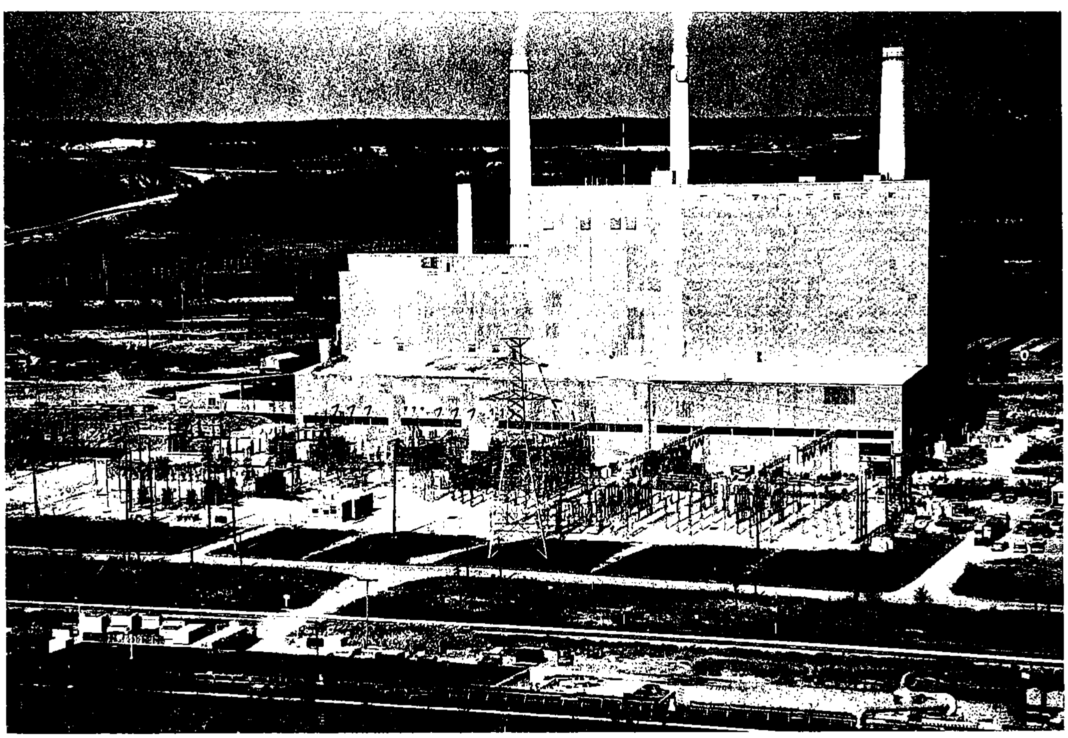
	Production				Imports			Exports
	Coal	Pitch	Petroleum	Total	Coal	Petroleum	Total	Total
1956	4,320,616	8,089	270,905	4,599,610	500,489	442,850	943,339	159,667
1957	4,117,623	5,395	273,296	4,396,314	650,540	426,849	1,077,389	158,298
1958	3,474,985	8,155	462,797	3,945,937	305,330	300,366	605,696	145,202
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
1966P	4,426,051	–	285,062	4,711,013	584,965	499,154	1,084,119	87,615

Source: Dominion Bureau of Statistics.

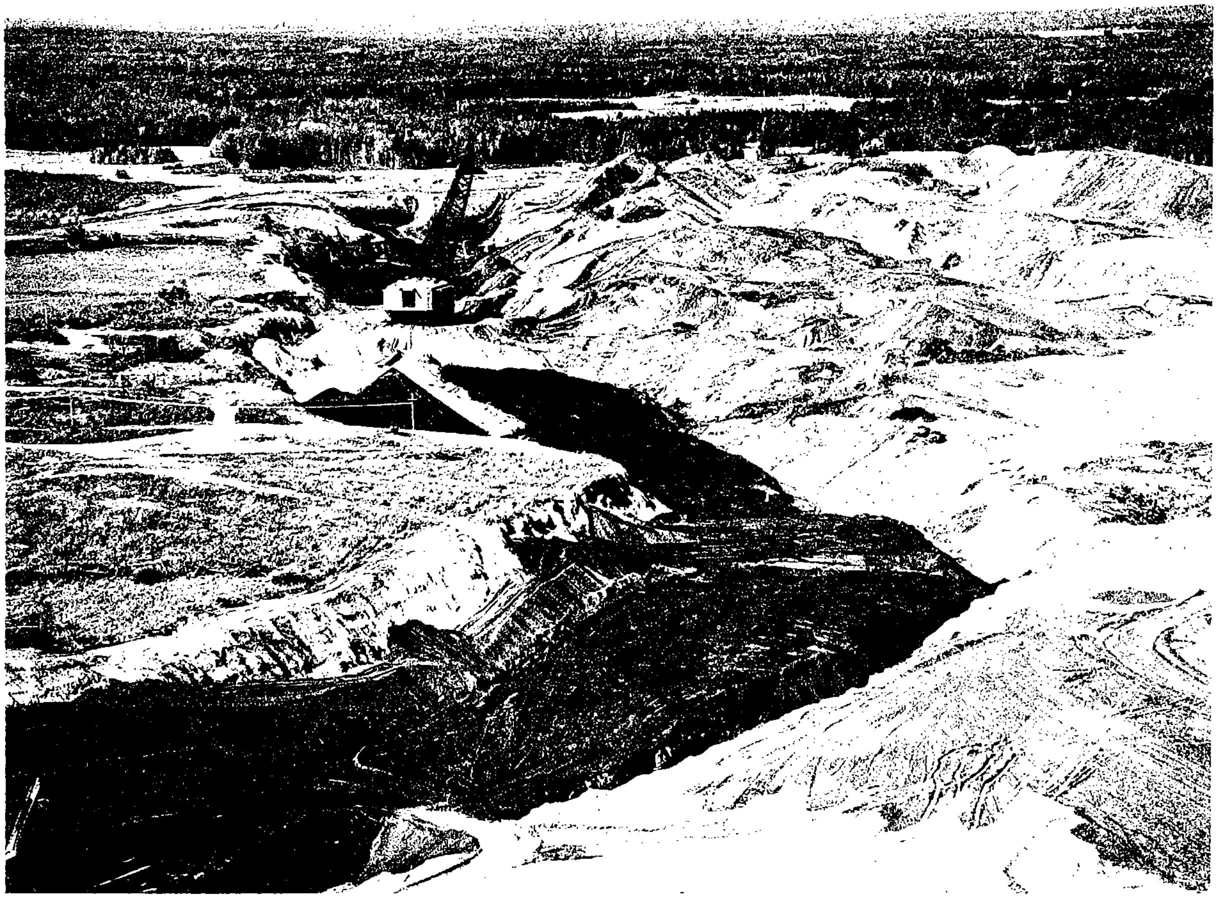
PPreliminary; – Nil.



(1) INDUSTRIAL USES INCLUDE IRON FOUNDRIES, NON-FERROUS SMELTING AND REFINING, NON-METALLIC MINERAL PRODUCTS AND MISCELLANEOUS.



GROWING OUTLET FOR WESTERN COAL: Calgary Power Limited's Wabamum thermal generating plant on north shore of Wabamum Lake, 44 miles west of Edmonton, began conversion from natural gas to coal in 1964. A fourth unit under construction in 1966 will be operational in 1967.



Coal is obtained from Alberta Coal Company's nearby strip mine.

Cobalt

G. P. WIGLE*

Canadian cobalt production in 1966 was 3.4 million pounds valued at $7.4 million compared with 3.6 million pounds valued at $7.5 million in 1965.[1] The decline is related to the year's reduced nickel production from which nearly all Canada's cobalt is recovered as a byproduct. Canada, one of the major cobalt producing countries, obtains cobalt as a byproduct of nickel-copper production and from the silver-cobalt ores of the Cobalt and Gowganda areas of Ontario.

The listed prices of cobalt remained unchanged (see prices) during 1966 but bids accepted for United States stockpile releases in September varied from $1.50 to $1.607 a pound.[2] Following an increase of 20 cents a pound by Union Minière du Haut-Katanga early in 1967, Canadian producers raised their prices accordingly.

World production and consumption of cobalt continued to increase in 1966 with most of the production increase coming from the Democratic Republic of the Congo (Kinshasa). In Finland, a new plant was expected to start up at Kokkola in 1967 with an initial capacity of 2.6 million pounds a year. Statistics issued by the United States Bureau of Mines for the first seven months of 1966 showed an increase of 24 per cent in United States cobalt consumption from that of the same period in 1965. Total metallic uses of cobalt increased 28 per cent for the period while non-metallic uses increased 11 per cent. The greatest increase occurred in high-temperature alloys and tool materials. In the non-metallic field, pigments showed no increase but salts and driers, ground-coat frit and other non-metallic uses showed varying increases, with an overall gain of 11 per cent during the seven-month period.[3]

CANADIAN PRODUCTION

ONTARIO

The International Nickel Company of Canada, Limited (Inco) produces cobalt oxide and electrolytic cobalt at its refining operations at Port Colborne. Cobalt oxide and cobalt salts are produced at Inco's refinery at Clydach, Wales, from cobalt oxides shipped from Canada. Production of 2 million pounds of cobalt from all operations, including the production at Clydach, was reported for 1966.

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

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*Mineral Resources Division.

[1]Source: Dominion Bureau of Statistics, excludes cobalt content of Inco shipments to Britain but includes Falconbridge shipments to Norway.

[2]Mineral Industry Surveys, U.S. Bureau of Mines, September 1966.

[3]COBALT – No. 34, March 1967, Cobalt Information Center, 35, rue des Colonies, Brussels, Belgium.

TABLE 1

Canadian Cobalt Production, Trade and Consumption, 1965-66

	1965		1966P	
	Pounds	$	Pounds	$
Production[1], all forms	3,648,332	7,529,143	3,427,926	7,404,276
Exports				
Cobalt metal				
United States	264,562	486,480	599,575	1,095,000
Britain	1,003	1,906	11,418	23,000
Republic of South Africa	5,400	44,216	8,435	75,000
Chile	—	—	6,613	5,000
Other countries	21,226	37,965	1,949	4,000
Total	292,191	570,567	627,990	1,202,000
Cobalt oxides and salts[2]				
Britain	1,364,400	1,897,358	1,265,400	2,153,000
United States	49,800	62,355	42,900	56,000
Total	1,414,200	1,959,713	1,308,300	2,209,000
Consumption[3], cobalt metal and cobalt contained in oxides and salts	366,036		392,177	

Source: Dominion Bureau of Statistics.

[1] Production (cobalt content) from domestic ores of cobalt metal and cobalt in alloys, oxides and salts. Excludes cobalt content of nickel-oxide sinter shipped to Britain by Inco but includes cobalt content of Falconbridge shipments of nickel-copper matte to Norway.[2] Gross weight.

[3] As reported by consumers.

P Preliminary; — Nil;.

TABLE 2

Canadian Cobalt Production, Trade and Consumption, 1957-66

(pounds)

	Production[1] (all forms)	Exports				Imports		Consumption[2]
		Cobalt in Ores and Concentrates	Metallic Cobalt	Cobalt Alloys[3]	Cobalt Oxide and Salts[3]	Cobalt Ores	Cobalt Oxides[3]	
1957	3,922,649	15,100	2,155,742	12,400	620,042	800	10,340	153,000
1958	2,710,429	—	1,024,667	9,712	522,144	—	16,230	260,000
1959	3,150,027	—	680,323	3,280	1,100,734	—	24,716	188,000
1960	3,568,811	—	844,293	1,938	1,175,206	—	20,227	182,000
1961	3,182,897	..	603,931	..	1,521,000	—	28,364	307,000
1962	3,481,922	..	542,565	..	1,629,900	—	40,936	299,000
1963	3,024,965	..	739,227	..	1,098,300	2,500	28,291	270,000
1964	3,184,983	..	593,607	..	1,654,900	..	..	276,000
1965	3,648,332	..	292,191	..	1,414,200	..	..	263,000
1966P	3,427,926	..	627,990	..	1,308,300	..	..	285,000

Source: Dominion Bureau of Statistics.

[1] Production from domestic ores of cobalt metal and cobalt contained in alloys, oxides and salts. Excludes cobalt content of nickel-oxide sinter shipped to Britain by Inco but includes cobalt content of Falconbridge shipments of nickel-copper matte to Norway.

[2] Refined metal only. Producers' domestic shipments 1956-59 and as reported by consumers for subsequent years.
[3] Gross weight.

P Preliminary; — Nil: .. Not available.

Cobalt Refinery Division of Kam-Kotia Mines Limited, formerly Cobalt Refinery Limited, produces cobalt oxide and speiss as a byproduct of smelting and refining complex silver-cobalt concentrates from mines in the Cobalt and Gowganda areas. Black cobalt oxide is sold to frit manufacturers in Canada, United States, Mexico and Europe. The intermediate product (speiss) is sold in Belgium. Oxide production in 1966 amounted to 134,559 pounds, up from 101,120 pounds in 1965. The company's total cobalt production in all forms was 249,000 pounds in 1966.

MANITOBA AND ALBERTA

International Nickel produces cobalt oxide at its Thompson, Manitoba, nickel refinery.

Sherritt Gordon Mines, Limited, produced 790,597 pounds of cobalt in 1966, up from 530,137 pounds in 1965. 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 from alloy grindings containing cobalt.

WORLD PRODUCTION

Non-communist world production of cobalt in 1966 was 20,300 short tons, up 3,250 tons from 1965.

The Democratic Republic of the Congo (Kinshasa) is the world's largest producer of cobalt. Its production in 1966 was 12,566 tons,[1] recovered as a byproduct of copper refining operations of Union Minière du Haut-Katanga. Canada, Morocco, Zambia and Germany each produce from 1,000 to 2,200 tons a year.

In the United States, cobalt is recovered in small quantities as a byproduct, principally from magnetite ores, and a smaller amount from zinc plant residues. Official production figures are not released but an estimate in COBALT No. 34, March 1967, places United States production for 1966 at about 320 tons. United States refiners and processors produce a wide range of cobalt products from duty-free imported ores, concentrates and metal.

TABLE 3

Non-Communist World Production of Cobalt 1964-66 (short tons)

	1964	1965	1966p
Congo (Kinshasa)	8,375r	9,147r	12,566e
Morocco	1,901	2,092	2,238
Canada	1,592	1,824r	1,714
Zambia	708	1,595r	1,618
Germany	1,527	1,385	1,152
United States ...	250e	300e	320e
Others	797e	707e	692e
Total	15,150	17,050	20,300

Source: Dominion Bureau of Statistics; Cobalt Information Center, Brussels, Cobalt No. 34, March 1967; 1965 Annual Report of Union Minière du Haut-Katanga.

p Preliminary; r Revised; e Estimated.

CONSUMPTION AND USES

The United States is the largest consumer of cobalt and in 1966 imported an estimated 9,878 tons and used 8,500 tons, 25 per cent more than in 1965.[2] The Cobalt Information Center in Brussels, Belgium, observed that the sharply rising trend of consumption in 1965 continued in 1966 both in the United States and in other large consumer-countries.

The important uses of cobalt are in high-temperature alloys, magnet materials, hard-facing rods, cemented carbides, high-speed tools and other ferrous and nonferrous alloys. Promising development has recently occurred in the production of strengthened cobalt alloys and improved permanent magnet materials. The metallic uses account for about 75 per cent of cobalt consumption. For non-metallic purposes, inorganic and organic cobalt salts are used as driers, 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.

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[1] COBALT – No. 34, March 1967, Cobalt Information Center, 35, rue des Colonies, Brussels, Belgium.

[2] Commodity Data Summaries, U.S. Bureau of Mines, January 1967.

TABLE 4

United States Consumption of Cobalt, by Uses, 1965-66

	1965[r]		1966 — 7 months	
	Short Tons	Per Cent	Short Tons	Per Cent
Metallic				
High speed steel	152	2.2	112	2.5
Other tool & alloy steel	459	6.7	315	7.2
Permanent-magnet alloys	1,368	20.1	803	18.2
Cutting & wear resisting materials	207	3.1	128	2.9
High-temperature high-strength materials	1,631	24.0	1,113	25.3
Alloy hard-facing rods & materials	528	7.8	318	7.2
Cemented carbides	265	3.9	179	4.1
Nonferrous alloys & other metallic uses	611	9.0	538	12.2
Total	5,221	76.8	3,506	79.6
Nonmetallic, exclusive of salts & driers				
Ground-coat frit	268	4.0	163	3.7
Pigments	129	1.9	57	1.3
Other materials	342	5.0	184	4.2
Total	739	10.9	404	9.2
Salts & driers: lacquers, varnishes, paints, inks, pigments, enamels, feeds, electroplating, etc.[e]	838	12.3	493	11.2
Grand Total	6,798	100.0	4,403	100.0

Source: COBALT No. 34, March 1967, Cobalt Information Center, Brussels, Belgium.

[e] Estimated; [r] Revised

TABLE 5

Cobalt Consumption in Canada, 1964-65
(pounds of contained cobalt)

	1964	1965
Cobalt metal	276,313	263,130
Cobalt oxide	52,991	86,463
Cobalt salt	36,547	16,443
Total	365,851	366,036

Source: Dominion Bureau of Statistics

PRICES

Prices in the United States according to *E & MJ Metal and Mineral Markets*, December 26, 1966 were

Cobalt Metal, per lb f.o.b. New York

Shot – 99%+	
less than 100–lb lots	$1.72
100–lb lots	1.67
500–lb lots	1.65
Powder – 99%+	
300 mesh, 100–lb lots	2.01
extra fine, 5 to 50–kilo lots	2.52
S grade, 10–ton lots	1.68
Fines – 95–96%	1.65
300 mesh	1.80
Briquettes, 10–ton lots	1.83

Cobalt oxide, per lb, contained, ceramic, delivered, 3¢ more west of Mississippi

70–71%	1.28
72½–73½%	1.32
Metallurgical – 75–76%	1.85

TARIFFS

	British Preferential (%)	Most Favoured Nation (%)	General (%)
Canada			
Ore	free	free	free
Cobalt metal: lumps, powder, ingots, blocks	free	10	25
Cobalt oxide	free	10	10
Cobalt bars	10	10	25

United States

Cobalt ore	free
Metal –	free
Cobalt oxide –	1.5¢ per lb
Cobalt sulphate –	1.5
Cobalt linoleate –	7.25
Other cobalt compounds and salts –	12% ad val.

Copper

A.F. KILLIN*

The copper industry from the producer to the ultimate consumer experienced a year of uncertainty in 1966. At the beginning of the year the major factor affecting copper supply was the unilateral declaration of independence by Rhodesia. This had a direct effect on the availability of copper supplies from Zambia because the disturbed political situation resulted in transportation and fuel supply difficulties. Labour strikes in many parts of the world cut copper supplies by an estimated 150,000 tons. In December, a dispute between the government of The Democratic Republic of the Congo and Union Minière du Haut-Katanga resulted in the stoppage of all copper shipments from the Congo.

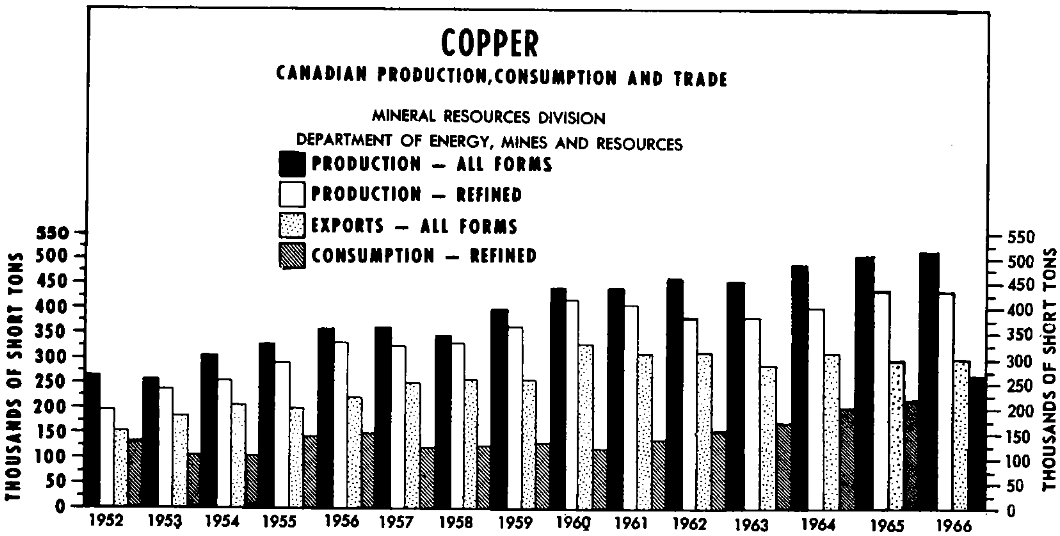
Consumption in the non-communist world increased in 1966, primarily as a result of the Vietnam war and a continued high level of industrial activity in North America. A major source of supply for defence orders in the United States was the release of 453,159 tons of copper from government stockpiles.

Prices on the commodity exchanges were extremely volatile, rising in the first part of the year and declining in the latter half. Price movements are discussed in detail later in this review and are illustrated by the graph "Copper Prices, 1966".

Government controls on the export of copper and copper-based scrap were continued in the United States, Britain, Australia and Canada. In Canada, controls were extended to cover the export of copper in ores and concentrates.

Mine production in Canada was hampered by strikes at mines in British Columbia, Ontario and Quebec. Production was 509,788 tons valued at $457,790,148 only 1,911 tons and $76,838,367 more than in 1965. Consumption of refined copper in Canada increased and exceeded fifty per cent of refined production for the second year. Total exports of primary copper (ore, matte and refinery shapes) decreased in 1966 because the increase in consumption reduced the amount of refined copper available for export. Exports of copper in ores and concentrates rose, primarily because of higher mine production in British Columbia. There was a moderate rise in the export of semifabricated products.

*Mineral Resources Division.


COPPER
CANADIAN PRODUCTION,CONSUMPTION AND TRADE
MINERAL RESOURCES DIVISION
DEPARTMENT OF ENERGY, MINES AND RESOURCES
PRODUCTION — ALL FORMS
PRODUCTION — REFINED
EXPORTS — ALL FORMS
CONSUMPTION — REFINED
THOUSANDS OF SHORT TONS
0
50
100
150
200
250
300
350
400
450
500
550
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966

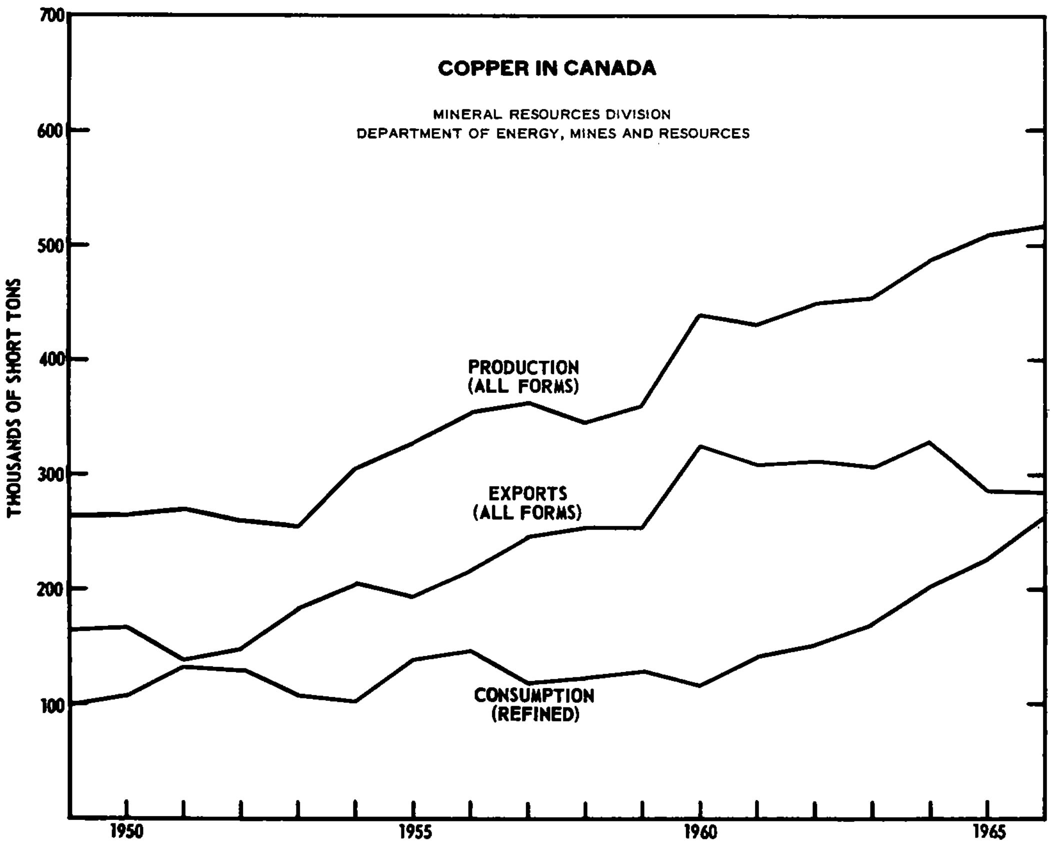

COPPER IN CANADA
MINERAL RESOURCES DIVISION
DEPARTMENT OF ENERGY, MINES AND RESOURCES
THOUSANDS OF SHORT TONS
100
200
300
400
500
600
700
PRODUCTION
(ALL FORMS)
EXPORTS
(ALL FORMS)
CONSUMPTION
(REFINED)
1950
1955
1960
1965

TABLE 1

Copper — Production, Trade and Consumption, 1965–66

	1965		1966P	
	Short Tons	$	Short Tons	$
Production[1]				
All forms				
Ontario	216,272	161,665,138	202,469	181,817,162
Quebec	173,938	130,801,096	172,717	155,100,021
British Columbia	42,565	32,008,933	57,962	52,050,177
Manitoba	30,807	23,167,131	30,900	27,747,938
Saskatchewan	18,732	14,086,297	19,417	17,436,814
Newfoundland	14,823	11,147,108	18,669	16,764,924
New Brunswick	10,082	7,581,283	6,553	5,884,840
Northwest Territories	471	354,342	809	726,429
Nova Scotia	187	140,453	292	261,843
Total	507,877	380,951,781	509,788	457,790,148
Refined	434,133r		433,921	
Exports				
Copper in ores, concentrates and matte				
Japan	52,555	32,940,477	56,456	51,796,000
Norway	15,525	8,530,287	16,611	14,733,000
United States	7,217	4,272,924	9,736	7,260,000
Sweden	4,645	4,864,256	8,509	9,716,000
Britain	1,664	1,109,493	1,342	1,124,000
Belgium & Luxembourg	2,653	1,114,687	1,227	799,000
Other countries	2,741	1,415,177	1,007	870,000
Total	87,000	54,247,301	94,888	86,298,000
Copper in slag, skimmings and sludge				
United States	277	189,124	216	181,000
Belgium & Luxembourg	234	150,474	167	112,000
Spain	163	125,353	—	—
Total	674	464,951	383	293,000
Copper scrap				
United States	4,201	3,823,985	22,795	26,832,000
West Germany	2,942	2,448,124	1,779	1,888,000
Spain	2,688	2,326,042	1,547	1,696,000
Japan	818	684,719	1,458	1,427,000
Britain	1,639	1,623,520	1,173	1,374,000
Netherlands	853	767,800	272	301,000
Belgium & Luxembourg	855	698,283	167	116,000
Yugoslavia	3,413	2,931,257	130	112,000
Other countries	2,475	2,016,426	85	80,000
Total	19,884	17,320,156	29,406	33,826,000
Brass and bronze scrap				
United States	2,099	1,221,015	8,313	6,853,000
Japan	4,250	2,556,356	3,745	2,596,000
Belgium & Luxembourg	341	175,946	323	252,000
West Germany	1,148	681,641	251	179,000
Italy	500	293,728	234	148,000
Other countries	954	588,108	338	305,000
Total	9,292	5,516,794	13,204	10,333,000
Copper Alloy scrap, n.e.s.				
United States	162	81,590	120	77,000
Japan	277	135,397	78	58,000
Sweden	—	—	28	7,000
Other countries	137	65,123	16	6,000
Total	576	282,110	242	148,000

Table 1 – continued

	1965		1966P	
	Short Tons	$	Short Tons	$
Copper refinery shapes				
Britain	106,098	78,264,114	91,881	102,187,000
United States	71,057	53,375,411	84,980	76,761,000
France	11,525	8,549,419	9,193	9,439,000
Switzerland	1,439	1,060,896	1,528	1,637,000
Netherlands	294	215,663	809	731,000
West Germany	3,680	2,751,596	700	623,000
Pakistan	–	–	450	364,000
Portugal	729	518,428	449	366,000
Sweden	2,421	1,777,225	448	381,000
Other countries	2,587	1,888,001	253	273,000
Total	199,830	148,400,753	190,691	192,762,000
Copper bars, rods and shapes, n.e.s.				
Norway	9,257	6,810,420	9,944	10,175,000
United States	7,214	5,924,260	2,946	3,275,000
Britain	2,376	1,808,583	2,150	2,136,000
Switzerland	3,189	2,371,491	1,972	1,746,000
Spain	1,834	1,380,638	1,835	1,706,000
Pakistan	2,980	2,036,475	1,505	1,274,000
Denmark	2,860	2,094,383	1,237	1,202,000
Colombia	471	413,988	750	870,000
Netherlands	582	465,147	616	534,000
France	1	1,123	548	726,000
Venezuela	565	499,460	504	549,000
Other countries	1,269	1,074,626	1,084	1,202,000
Total	32,598	24,880,594	25,091	25,395,000
Copper plates, sheet, strip and flat products				
United States	1,634	1,737,615	4,069	5,204,000
New Zealand	379	434,433	214	298,000
Venezuela	212	226,379	105	142,000
Puerto Rico	80	81,043	62	84,000
Korea	9	8,335	58	80,000
Colombia	18	18,007	43	54,000
Other countries	312	336,149	37	49,000
Total	2,644	2,841,961	4,588	5,911,000
Copper, pipe and tubing				
United States	2,950	3,260,624	11,525	18,476,000
New Zealand	2,047	2,596,638	1,562	2,462,000
Britain	798	866,262	646	923,000
Puerto Rico	242	277,523	437	629,000
Venezuela	530	570,939	391	583,000
Philippines	242	284,847	271	434,000
Other countries	1,562	1,864,727	1,842	2,680,000
Total	8,371	9,721,560	16,674	26,187,000
Copper, wire and cable, not insulated				
United States	852	897,649	2,826	3,552,000
New Zealand	30	35,085	48	64,000
Bolivia	139	129,481	43	58,000
Pakistan	857	833,281	36	46,000
Peru	...	699	36	47,000
Other countries	785	720,839	88	113,000
Total	2,663	2,617,034	3,077	3,880,000

Table 1 – continued

	1965		1966P	
	Short Tons	$	Short Tons	$
Copper alloy refinery shapes, sections and flat products				
United States	2,312	2,203,566	6,050	7,001,000
Britain	52	57,964	109	138,000
Venezuela	142	140,432	103	116,000
Hong Kong	62	44,006	63	73,000
Other countries	648	624,652	221	290,000
Total	3,216	3,070,620	6,546	7,618,000
Copper alloy pipe and tubing				
United States	1,039	1,346,399	1,015	1,533,000
Spain	4	4,421	258	371,000
New Zealand	117	150,350	237	347,000
Puerto Rico	18	19,326	130	171,000
India	86	83,028	118	110,000
Other countries	564	723,428	243	432,000
Total	1,828	2,326,952	2,001	2,964,000
Copper alloy wire and cable, not insulated				
United States	420	572,148	447	719,000
Australia	30	63,833	32	57,000
Britain	27	62,013	23	44,000
Other countries	18	23,599	13	30,000
Total	495	721,593	515	850,000
Copper and alloy fabricated materials, n.e.s.				
United States	115	179,033	289	402,000
Other countries	18	90,051	16	97,000
Total	133	269,084	305	499,000
Wire and cable, insulated[2]				
United States	9,014	12,990,759	7,856	11,920,000
Nigeria	588	712,202	1,661	2,641,000
Bahamas	189	211,610	557	784,000
Thailand	258	328,087	262	408,000
Venezuela	30	40,982	247	260,000
Trinidad-Tobago	10	14,469	228	252,000
Puerto Rico	86	127,633	217	332,000
New Zealand	190	266,575	190	303,000
Peru	82	119,078	168	214,000
Bermuda	56	56,397	165	190,000
Other countries	2,010	2,589,678	946	1,475,000
Total	12,513	17,457,470	12,497	18,779,000
Imports				
Copper in ores, concentrates and scrap	1,845	1,303,890	2,199	2,385,000
Copper refinery shapes	5,747	4,542,056	10,492	10,550,000
Copper bars, rods and shapes (sections) n.e.s.	1,272	1,501,885	1,218	1,264,000
Copper plates, sheet, strip and flat products	1,771	2,247,195	481	653,000
Copper pipe and tubing	1,240	1,937,815	479	892,000
Copper wire and cable except insulated	281	425,908	165	286,000
Copper alloy scrap	515	245,407	338	254,000
Copper alloy refinery shapes, bars, rods and sections	3,513	3,931,408	1,108	1,720,000

Table 1 – continued

	1965		1966p	
	Short Tons	$	Short Tons	$
Copper alloy plates, sheet, strip and flat products	3,963	4,993,050	2,163	2,973,000
Copper alloy pipe and tubing	1,145	1,984,284	1,062	2,058,000
Copper alloy wire and cable, except insulated	1,090	1,696,694	706	1,315,000
Copper and alloy fabricated materials, n.e.s.		3,660,959		3,886,000
Consumption[3]				
Refined	224,684r		262,557	

Source: Dominion Bureau of Statistics.
[1]Blister copper plus recoverable copper in matte and concentrate exported. [2]Includes also small quantities of noncopper wire and cable, insulated. [3]Producers' domestic shipments.
p Preliminary; – Nil; ... Less than one ton; r Revised.

TABLE 2

Copper – Production, Trade and Consumption, 1957–66

(short tons)

	Production		Exports			Imports	Consumption**
	All Forms*	Refined	In Ore and Matte	Refined	Total	Refined	Refined
1957	359,109	323,540	46,548	198,794	245,342	4,175	118,225
1958	345,114	329,239	30,316	224,638	254,954	1	122,893
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	117,637r
1961	439,088	406,359	42,894	266,247	309,141	3	141,808r
1962	457,385	382,862r	89,374	223,043	312,417	147	151,525
1963	452,559	380,075r	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	434,133r	87,000	199,830	286,830	5,747	224,684r
1966p	509,788	433,921	94,888	190,691	285,579	10,492	262,557

Source: Dominion Bureau of Statistics.
*Blister copper plus recoverable copper in matte and concentrate exported. **Producers' domestic shipments, refined copper.
p Preliminary; r Revised.

PRODUCTION AND DEVELOPMENT

Increased production in Newfoundland, Nova Scotia, Manitoba, Saskatchewan and British Columbia was offset to a great degree by decreased production in New Brunswick, Quebec and Ontario. Exploration for new properties and development of known deposits was proceeding vigorously in the year.

Details of individual mine production and development are given in Table 3. The following résumé outlines the production and developments by provinces.

NEWFOUNDLAND AND LABRADOR

Copper production increased in 1966 to 18,669 tons valued at $16,764,924. This was 3,846 tons and $5,617,816 more than in 1965.

Increased production is attributable to a number of factors, including: a full year's production from British Newfoundland Exploration Limited's Whalesback Pond mine at close to its 2,000-ton-a-day rated capacity; continued production from the Tilt Cove mine of First Maritime Mining Corporation Limited; higher grade ore mined at Atlantic Coast Copper Corporation Limited's Little Bay mine; and increased production at Consolidated Rambler Mines Limited's Baie Verte mines where the East Zone was gradually being phased into production in the latter part of the year. First Maritime started to tune-up its mill at the Gullbridge property at Gull Pond, near Badger.

NOVA SCOTIA

Copper production in Nova Scotia continued as a byproduct of the mining of lead-zinc ore at the Walton mine of Magnet Cove Barium Corporation. Production of 292 tons valued at $261,843 was 105 tons and $121,390 higher than in 1965. Several companies conducted reconnaissance exploration for base metal deposits.

NEW BRUNSWICK

Decreased production at the mines of Brunswick Mining and Smelting Corporation Limited and Cominco Ltd. (Wedge) accounted for the drop of 3,529 tons and $1,696,443 in 1966 from the 1965 output of 10,082 tons and $7,581,283. Brunswick completed the 2,250-ton mill, adjacent to the No. 12 mill that will treat the ore from the No. 6 open-pit mine. Mill tune-up started in the third quarter. Nigadoo River Mines Limited continued development of its mine at Robertville and was building a 1,000-ton-a-day mill. Production is scheduled for 1967.

The Anaconda Company (Canada) Ltd. continued underground development and exploration of its Caribou orebody. Several other companies including Mining Corporation of Canada (1964) Limited, New Jersey Zinc Exploration Company (Canada) Ltd. and Sullico Mines Limited were exploring properties in the Bathurst-Newcastle area.

QUEBEC

Copper production in Quebec at 172,717 tons was 1,221 tons less than in 1965, but, because of higher prices, was valued at $155,100,021, an increase of $24,298,925.

Gaspé Copper Mines, Limited continued expansion of its mill at Murdochville from 7,500 tons of ore a day to 11,000 tons. Exploration by Terra Nova Explorations Ltd., Wexford Mines Limited and others was continued in the Gaspé Provincial Park, west of Murdochville, where several interesting, low-grade copper discoveries have been made.

Production was hampered by a prolonged strike at the Stratford Place mine of Solbec Copper Mines, Ltd. Cupra Mines Ltd., 2½ miles from the Solbec mine, continued production but some ore was stockpiled while the Solbec mill was idle.

Mining, exploration and development continued at the mines in the Chibougamau district. Campbell Chibougamau Mines Ltd. obtained encouraging results from a surface diamond drill program on its extensive holdings. Bruneau Mines Ltd. shipped ore to the Merrill Island Mining Corporation, Ltd's mill on a custom basis. Opemiska Copper Mines (Quebec) Limited started shaft sinking at the Beaver Lake deposit about 1 mile east of the Perry shaft. The Patino Mining Corporation's Copper Rand Mines Division continued production from its 4 mines and completed the mining of known reserves at the property of Quebec Chibougamau Goldfields Limited.

Grandroy Mines Limited leased its copper property in Roy township to Campbell Chibougamau, who will mine the ore by open pit and truck it 15 miles to the mill at Campbell's Main mine. Production was scheduled for February 1967. Merrill Island Mining Corporation signed an agreement with the Icon Syndicate to mine and mill ore from Icon's copper orebody in O'Sullivan township. The initial mining will be by open pit and 600 tons of ore a day were scheduled to be trucked 38 miles to Merrill's mill.

Production continued at the 3 producing mines in the Matagami area. A zinc circuit was added to the custom section of the Orchan Mines Limited's mill to recover zinc from ore shipped by New Hosco Mines Limited. Bell Allard Mines Limited, a subsidiary of Orchan, was preparing to mine a zinc-copper orebody by open pit.

Mines de Poirier inc., about 60 miles north of Amos, completed a 700-ton-a-day addition to its mill to treat ore from the nearby mine of Joutel Copper Mines Limited. Joutel's mine was scheduled for production in the first quarter of 1967.

At Val d'Or, operations continued at the mines of Manitou-Barvue Mines Limited and Sullico Mines Limited. Ore reserves at Sullico's East Sullivan mine are nearly exhausted; the mine is scheduled to close in the first quarter of 1967.

Quebec's 2 nickel-copper mines, Lorraine Mining Company Limited at Belleterre and Marbridge Mines Limited at Malartic, continued to ship concentrates to domestic smelters.

Noranda Mines Limited continued production from its Horne mine at Noranda and was expanding its smelter to treat concentrates from the Kidd township, Ontario, mine of Texas Gulf Sulphur Company.

ONTARIO

Strikes at the Sudbury plants of The International Nickel Company of Canada, Limited (Inco) reduced Ontario's copper output to 202,469 tons valued at $181,817,162. This was 13,803 tons less than in 1965 but the value of production rose $20,152,024. International Nickel operated the Creighton, Frood-Stobie, Garson, Levack, Murray, Crean Hill, MacLennan and Totten mines and the MacLennan and Clarabelle open pits in 1966. Inco mines under development were: Copper Cliff North, production scheduled in 1967; Kirkwood, production scheduled for 1968; the Little Stobie and the Coleman both scheduled for production in 1969. Sinking of the No. 9 production shaft at the Creighton mine continued and had reached a depth of 2,337 feet at year-end. Shaft sinking at the Frood-Stobie mine was started in preparation for increased production. A 22,500-ton mill will be built to handle the ore from Frood-Stobie and from the Little Stobie mine.

Falconbridge Nickel Mines, Limited was preparing its Strathcona mine and mill, on the north rim of the Sudbury basin, for production in late 1967. The company was also exploring the Longvac South orebody north of the Strathcona.

In the Timmins area, Kam-Kotia Mines Limited and McIntyre Porcupine Mines Limited continued mining, exploration and development. Each company will increase its milling rate to 2,000 tons a day in 1967. Texas Gulf Sulphur Company started production from its open-pit mine in Kidd township. The first 3,000-ton-a-day section of the mill was put into operation in November and the full capacity of 9,000 tons a day was scheduled to be in operation by the end of February 1967. Copper concentrates from the Texas Gulf mill will be smelted at Noranda with the anodes being refined at Canadian Copper Refiners Limited, Montreal East. The mine, at scheduled capacity, is expected to produce 50,000 tons of copper a year. Canadian Jamieson Mines Limited started production in April from its copper-zinc orebody. Copper concentrates from the 450-ton-a-day mill were shipped to Sweden for processing.

Copperfields Mining Corporation Limited produced copper concentrates at its mine near Timagami. Concentrates were stockpiled at the mine from March until September pending the granting of an export licence by the federal government.

Rio Algom Mines Limited's Pater mine at Spragge, North Canadian Enterprises Limited's Point Mamainse mine and North Coldstream Mines Limited's mine at Kashabowie, produced steadily during the year. The North Coldstream mine was expected to close early in 1967 when ore reserves are exhausted.

Noranda Mines Limited's Geco Division at Manitouwadge completed the sinking of the No. 4 shaft and level development was started. Production continued from the developed sections of the orebody. Quarried waste rock was being dumped directly into the shrinkage stopes as ore was withdrawn. Dilution by caving of wallrock was kept to a minimum and there was very little mixing of ore and waste. Willroy Mines Limited treated 1,000 tons of ore a day from the orebody of Willecho Mines Limited developed in 1965, some three miles north of the Willroy mill. Production from the Willroy mine averaged 700 tons of ore a day.

Metal Mines Limited produced nickel-copper concentrates at its mine and mill near Werner Lake, for shipment to the Copper Cliff smelter of International Nickel.

Munro Copper Mines Limited, near Matheson, was developing a small copper orebody for production and building a 500-ton-a-day mill. Production was scheduled for the first quarter of 1967. Tribag Mining Co., Limited near Batchawana was building a 400-ton-a-day mill and has scheduled production for 1967.

MANITOBA

Production of copper increased to 30,900 tons valued at $27,747,938 from 30,807 tons valued at $23,167,131 in 1965. Hudson Bay Mining and Smelting Co., Limited operated 2 mines, a mill and a smelter at Flin Flon and 2 mines at Snow Lake. The company was developing 2 additional mines at Snow Lake, the Osborne, scheduled for production in 1967, and the Anderson, scheduled for 1968. Sherritt Gordon Mines, Limited at Lynn Lake produced nickel concentrates for shipment to its refinery at Fort Saskatchewan, Alberta, and copper concentrates that were custom smelted by Hudson Bay at Flin Flon. The company continued exploration for new ore at its Lynn Lake mine and started shaft sinking at its copper-zinc orebody at Fox Lake some 34 miles southwest of Lynn Lake.

SASKATCHEWAN

Anglo-Rouyn Mines Limited at Waden Bay and Hudson Bay Mining and Smelting Co., Limited at the Flin Flon mine were the 2 Saskatchewan copper producers in 1966. These mines turned out a total of 19,417 tons valued at $17,436,814, a small increase in tons and value from 1965. Hudson Bay was developing the Flexar mine, 8½ miles southwest of Flin Flon for production in 1967. At Hanson Lake, Share Mines & Oils Ltd. was preparing a small zinc-copper orebody for production and building a 350-ton-a-day mill. Production was scheduled for April 1967; the concentrates will be trucked to Flin Flon for smelting.

BRITISH COLUMBIA

Copper production in British Columbia increased to 57,962 tons valued at $52,050,177 which was 15,397 tons and $20,041,244 more than in 1965. With the advent of production from 3 new mines in 1967, production should exceed the record of 62,218 tons in 1963. Reduced production from the Merritt mine of Craigmont Mines Limited, due to a strike that lasted until April 18, was offset by increased production at the Britannia Beach mine of The Anaconda Company (Canada) Ltd. and the Highland Valley mine of Bethlehem Copper Corporation Ltd. Minoca Mines Ltd. shipped its first concentrates to Japan in January 1966 from the company's Yreka mine at Jeune Landing, Vancouver Island; the year's output was 2,162 tons of contained copper. Giant Mascot Mines, Limited produced steadily from its nickel-copper mine near Hope and was carrying out exploration and feasibility studies at the Canam property, 27 miles east of Hope, on the Hope-Princeton highway. The Granby Mining Company Limited continued production from its Phoenix open-pit mine near Greenwood. The company's Granisle mine, on an island in Babine Lake, started mill tune-up in November and will reach its rated 5,000-ton-a-day capacity in 1967. Noranda Mines Limited announced it will bring its Newman Peninsula orebody in the same area into production at 10,000 tons a day. No definite timetable for production has been announced.

On Vancouver Island, Cowichan Copper Co. Ltd.'s Sunro mine at Jordan River was reopened under the management of Aetna Investment Corporation Limited. Production continued until September when the mine was closed because of operating and financial difficulties. Cominco Ltd. produced from the Coast Copper mine at Benson Lake and was driving a 4,000-foot exploration heading to the south to explore for ore. At Myra Falls near the south end of Buttle Lake, Vancouver Island, Western Mines Limited started tuning-up its 750-ton-a-day mill in December. Production from an open pit at the Lynx orebody will start in 1967.

Falconbridge Nickel Mines, Limited was preparing its Tasoo Harbour, Queen Charlotte Islands, iron-copper mine for production in the first quarter of 1967. Granduc Mines, Limited was driving the 11.6-mile access tunnel from Tide Lake to the Leduc valley orebody. Production from the mine was scheduled for 1970.

Rio Algom Mines Limited has optioned the Highland Valley property of Lornex Mining Corporation Ltd. and was proceeding with an extensive exploration by trenching, drilling and geophysical surveying. A large, low-grade deposit of copper and molybdenum has been indicated. Rio Algom plans further exploration by shaft sinking, underground development and drilling. A pilot mill will be built to treat bulk samples from the underground development to test for grade and metallurgy. Brenda Mines Ltd., west of Peachland, was exploring an extensive, low-grade copper-molybdenum prospect by underground drifting, crosscutting, raising and diamond drilling. A pilot plant was built for bulk sampling and metallurgical testing. Kennco Explorations (Canada), Limited built a 29-mile tote road up the Scud River valley from the Stikine River to Galore Creek and into the Galore Creek basin. An adit was started to test ground and water conditions and to provide a bulk sample of the copper orebody.

Other companies exploring low grade copper deposits included: Cariboo-Bell Copper Mines Limited at Bootjack Lake, Cariboo District; Copper Giant Mining Corporation Limited at Poison Creek, Bridge River District; Highmont Mining Corp. Ltd., Highland Valley and Falconbridge Nickel Mines, Limited at Catface Mountain, Bedwell Sound, Vancouver Island.

YUKON TERRITORY

New Imperial Mines Ltd. was stripping overburden from the Little Chief orebody in preparation for open-pit mining. Mill and plant construction will be completed in the first quarter of 1967 when production will start. Diamond drilling from surface has indicated an extension of the orebody below the limits of the open pit.

TABLE 3

Producing Companies, 1966

Company and Location	Mill Capacity (tons ore/day)	Ore Produced 1966 (1965) (short tons)	Grade (%)			Developments
			Copper	Zinc	Nickel	
Newfoundland						
American Smelting and Refining Company (Buchans Unit), Buchans	1,250	355,000 (366,000)	1.05	12.80	–	Routine exploration and development.
Atlantic Coast Copper Corporation Limited, Little Bay	1,150	318,735 (292,023)	1.30	–	–	Shaft deepened to 2,083 feet below the collar. Level development on the 1,650 and 1,850 horizons. Exploration of north zone by crosscutting on the 700-foot level.
British Newfoundland Exploration Limited, Whalesback mine, Springdale	1,500	644,128 (165,000)	1.10	–	–	Exploration in the area of the mine for new orebodies. Routine mine development.
Consolidated Rambler Mines Limited, Main mine,	1,500 (central mill)	148,737 (128,625)	1.37	2.04	–	Modest surface exploration program. Routine mine development.
East mine, Baie Verte		34,059 (–)	0.94	–	–	Development of East orebody 95 per cent completed. Mill expansion to 1,500 tons of ore a day completed at Main mine.

Table 3 (continued)

Company and Location	Mill Capacity (tons ore/day)	Ore Produced 1966 (1965) (short tons)	Grade (%) Copper	Zinc	Nickel	Developments
First Maritime Mining Corporation Limited, Tilt Cove mine, Tilt Cove	2,350	656,250 (713,662)	0.70	–	–	Exploration for new ore continued. Mining from pillars and low grade extensions of the known orebodies.
First Maritime Mining Corporation Limited, Gullbridge mine, Gull Pond.	2,000	Tune-up	–	–	–	Mill and initial mine development completed in December, 1966.
Nova Scotia						
Magnet Cove Barium Corporation, Walton	125	50,213 (48,594)	0.61	1.60	–	Extensive exploration for new sulphide orebodies. Routine mine development.
New Brunswick						
Brunswick Mining and Smelting Corporation Limited, No. 12 mine, Bathurst	4,500	1,650,120 (1,657,519)	0.22	9.26	–	Routine mine development. Underground exploration of hangingwall zone by drifting and diamond drilling.
Brunswick Mining and Smelting Corporation Limited, No. 6 mine, Bathurst.	2,250 (at No. 12 plant)	300,676 (–)	0.35	6.19	–	Open-pit mine developed to production. Mill completed adjacent to the No. 12 mill.
Cominco Ltd., Wedge mine, Bathurst	750 (trucked to Heath Steele)	269,295 (271,649)	..	–	–	Exploration by lower level drifting and diamond drilling.
Heath Steele Mines Limited, Bathurst – Newcastle	1,500	287,515 (211,000)	1.04	5.90	–	Sinking new production shaft to 1,750 feet below the collar. Routine exploration and development.
Quebec						
Campbell Chibougamau Mines Ltd. (Main, Henderson, Kokko Creek and Cedar Bay mines), Chibougamau	3,500	966,027 (941,198)	1.82	–	–	Shaft sinking and level development at the Henderson "B" zone. Routine exploration and development at the Main mine. Shaft deepening and exploration drilling at the Cedar Bay Mine, Kokko Creek mine on salvage basis. Surface exploration and diamond drilling in the Chibougamau area.
Cupra Mines Ltd., Stratford Place	700 (trucked to Solbec mill)	158,130 (82,427)	3.40	4.25	–	Routine exploration and development.
Gaspé Copper Mines, Limited, Murdochville	7,500	2,831,800 (2,602,900)	1.12	–	–	Routine exploration and development at Needle Mountain mine, stripping of waste and preparation for open-pit mining at Copper Mountain mine. Concentrator expansion to 11,000 tons of ore a day continued.

Table 3 (continued)

Company and Location	Mill Capacity (tons ore/day)	Ore Produced 1966 (1965) (short tons)	Grade (%)			Developments
			Copper	Zinc	Nickel	
Lake Dufault Mines, Limited, Noranda	1,300	489,387 (475,007)	4.84	9.48	—	Routine development and exploration of producing orebody. On-property exploration by diamond drilling for new orebodies.
Lorraine Mining Company Limited, Belleterre	400	186,362 (162,533)	1.24	—	0.57	Routine exploration and development.
Manitou-Barvue Mines Limited, Val d'Or	1,300	299,875 (283,875)	0.93	—	—	Routine mine development.
		173,130 (168,895)	—	3.72	—	
Mattagami Lake Mines Limited, Matagami	3,850	1,411,100 (1,406,154)	0.62	12.40	—	Routine exploration and development.
Marbridge Mines Limited, Malartic	300 (milled at Canadian Malartic Gold Mines Limited)	129,000 (119,304)	..	—	3.22	Routine development of No. 1 and No. 2 orebodies. On-property exploration for new orebodies.
Merrill Island Mining Corporation, Ltd., Chibougamau	650	85,798 (90,176)	2.10	—	—	Routine exploration and development of Merrill Island and Chib-Kayrand orebodies.
New Hosco Mines Limited, Matagami	900 (trucked to Orchan mill)	315,083 (324,131)	2.66	0.96	—	Routine exploration and development of known ore. Exploration at depth by diamond drilling from lower levels. Zinc circuit added to Orchan mill to recover zinc from New Hosco ore.
Noranda Mines Limited, Horne mine, Noranda	3,200	774,719 (771,400)	1.96	—	—	Routine exploration and development.
Normetal Mining Corporation, Limited, Normetal	1,000	335,666 (350,693)	1.53	7.60	—	Shaft deepening program completed. Lateral development on the 6955, 7155, 7355, and 7955 levels continued. Exploration by drifting and diamond drilling.
Opemiska Copper Mines (Quebec) Limited, Chapais	2,000	766,128 (745,976)	3.00	—	—	Perry shaft deepened 1,300 feet. Robitaille shaft sinking started.
Orchan Mines Limited, Matagami	1,900 (mills 900 tons of ore a day from New Hosco)	368,030 (368,877)	1.25	10.83	—	No. 1 orebody explored by underground diamond drilling. Development of this ore started, for mining in 1967. Zinc circuit added to custom section of the mill.
The Patino Mining Corporation, Copper Rand Mines Division, (Machin Point, Chibougamau Jaculet, Portage Island,	1,800	651,210 (663,251)	1.97	—	—	Deepening shaft at Machin Point mine. Routine exploration and development.

Table 3 (continued)

Company and Location	Mill Capacity (tons ore/day)	Ore Produced 1966 (1965) (short tons)	Grade (%) Copper	Zinc	Nickel	Developments
Quebec Chibougamau Goldfields and Bouzan Mines), Chibougamau						
Quemont Mining Corporation, Limited, Noranda	2,300	578,171 (657,307)	1.08	1.93	–	Routine exploration and development.
Rio Algom Mines Limited, Mines de Poirier mine, Poirier township	2,500	575,907 (–)	1.06	3.49	–	Routine exploration and development. Mill expanded to treat 700 tons of ore a day from the Joutel mine.
Rosario Mining Explorations Ltd., Bruneau mine, Chibougamau	480 (treated at Merrill Island mill)	44,302 (–)	1.43	–	–	Routine exploration and development.
Solbec Copper Mines, Ltd., Stratford Place	1,000	154,795 (403,869)	1.41	6.23	–	Mine closed by labour dispute September 9, 1966. Routine exploration and development.
Sullico Mines Limited, East Sullivan mine, Val d'Or	3,000	652,412 (993,321)	0.61	–	–	Ore reserves are virtually depleted. Mine scheduled to close in 1967.
Ontario						
Canadian Jamieson Mines Limited, Timmins	350	92,685 (–)	2.75	4.15	–	Mine and mill put into operation. Routine development.
Copperfields Mining Corporation Limited (Temagami mine), Timagami	200	.. (55,922)	5.27	–	–	Shaft deepening to the 2175-foot level. Routine development and exploration.
Falconbridge Nickel Mines, Limited (Falconbridge, East, Hardy, Fecunis and North mines,) Falconbridge	3,000 (Falconbridge) 1,500 (Hardy) 2,400 (Fecunis)	1,998,860 (2,246,918)	0.78	–	1.55	Routine development at the producing mines. Preparation of Strathcona mine for production in 1967, building of mining plant and mill. Exploration of Longvac South orebody.
The International Nickel Company of Canada, Limited (Creighton, Frood-Stobie, Garson, Levack, Crean Hill, Murray, MacLennan and Totten mines and MacLennan and Clarabelle open pits), Copper Cliff	30,000 (Copper Cliff) 12,000 (Creighton) 6,000 (Levack)	14,625,200 (16,704,143)	0.8[e]	–	1.0[e]	Creighton shaft sinking continued. MacLennan and Totten underground mines brought to production. Expansion of Frood-Stobie mine, and preparation of Copper Cliff North, Coleman, Kirkwood and Little Stobie mines for production.
Kam-Kotia Mines Limited, Timmins	1,500	464,726 (597,623)	1.67	1.97	–	Shaft deepening to 2000 feet below collar, four new levels established. Development of orebodies being mined and exploration and development of new ore.

Table 3 (continued)

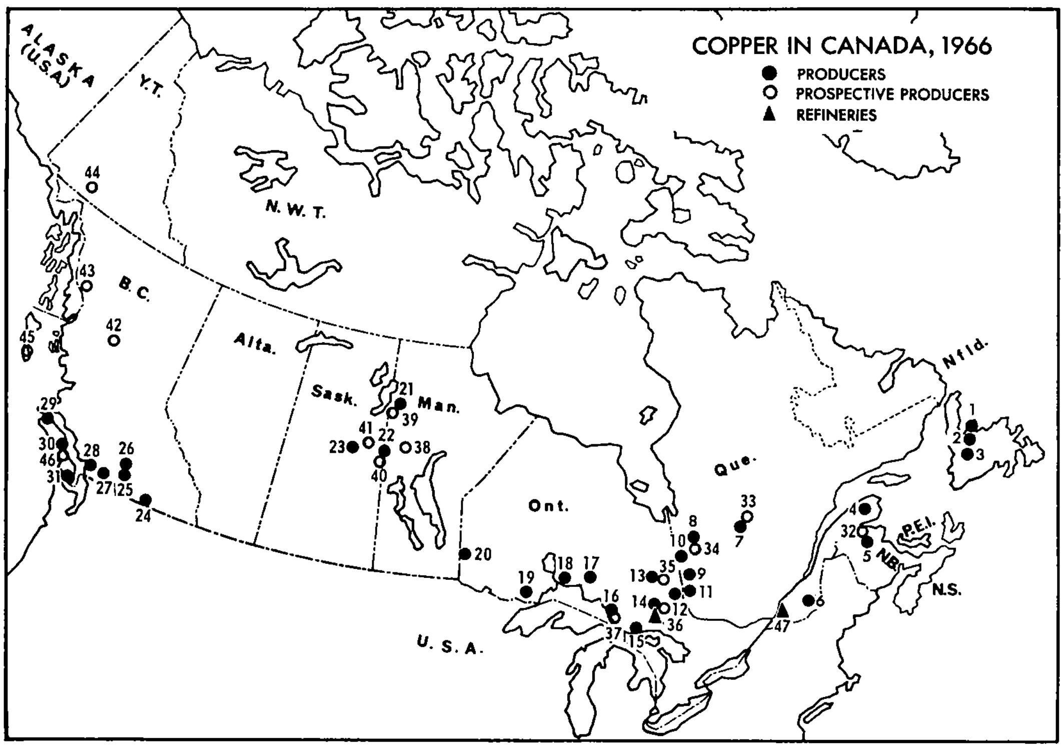
Company and Location	Mill Capacity (tons ore/day)	Ore Produced 1966 (1965) (short tons)	Grade (%) Copper	Zinc	Nickel	Developments
Kidd Copper Mines Limited, Aer Nickel mine, Sudbury	1,000	– (–)	–	–	–	Mill tune-up in December.
McIntyre Porcupine Mines Limited, Schumacher	2,000	665,545 (549,310)	0.85	–	–	Copper circuit increased from 1,500 tons a day to 2,000 tons a day in June. Routine development and exploration.
Metal Mines Limited, Werner Lake Division, Gordon Lake.	750	..	..	–	..	Routine exploration and development.
Noranda Mines Limited, Geco division, Manitouwadge	3,300	1,459,586 (1,326,400)	1.95	4.15	–	Routine development of 2,650–, 2,850–, 3,050–, 3,450–, 3,650–, and 3,850–foot levels. Preparation for installation of crusher above the 3,850–foot level.
North Canadian Enterprises Limited, Coppercorp mine, Point Mamainse	500	.. (29,867)	..	–	–	Routine exploration and development.
North Goldstream Mines Limited, Kashabowie	1,100	343,835 (365,082)	1.67	–	–	Reserves depleted, mine expected to close in 1967.
Rio Algom Mines Limited, Pronto division, Spragge	750	240,828 (248,613)	2.00	–	–	No. 2 shaft deepened to 3,934 feet below the collar. Four new levels under development.
Texas Gulf Sulphur Company, Kidd Creek mine, Timmins	3,000	..	..	..	–	First 3,000-ton-a-day unit of 9,000-ton-a-day mill started production November 16, 1966. Second and third units scheduled for production first quarter 1967. Stripping of overburden and mining of ore from open pit.
Upper Beaver Mines Limited, Dobie	150 (milled at Upper Canada Mines Limited)	60,397 (..)	1.14	–	–	Routine exploration and development.
Willecho Mines Limited, Manitouwadge	1,000 (treated at Willroy mill)	330,000[e] (..)	0.48	4.29	–	Routine development and exploration.
Willroy Mines Limited, Manitouwadge	1,500	219,400 (293,989)	0.60	2.80	–	Crusher enlarged to handle Willecho and Big Nama Creek ore. Routine exploration and development.
Zenmac Metal Mines Limited, Zenith mine, Schreiber	100	29,839 (–)	0.40	22.6	–	Expansion of mill to 200 tons a day. Routine exploration and development.
Manitoba						
Hudson Bay Mining and Smelting Co., Limited, (Flin Flon, Schist Lake, Chisel Lake and Stall Lake mines), Flin Flon	6,000	1,689,550 (1,640,328)	2.49	3.80	–	Routine exploration and development at producing mines. Preparation of Osbome Lake and Anderson Lake mines for production. Automation of mill feed circuits.

Table 3 (continued)

Company and Location	Mill Capacity (tons ore/day)	Ore Produced 1966 (1965) (short tons)	Grade (%) Copper	Zinc	Nickel	Developments
Sherritt Gordon Mines, Limited, Lynn Lake	3,500	1,205,318 (1,363,583)	..	–	..	Routine development of known ore. Extensive underground exploration for extensions of known ore and for new orebodies.
Saskatchewan						
Hudson Bay Mining and Smelting Co., Limited, Flin Flon mine.	(see Manitoba)					Flexar mine developed to production.
Rio Algom Mines Limited Anglo-Rouyn mine, Waden Bay.	900	230,586 (–)	1.76	–	–	Routine exploration and development.
British Columbia						
The Anaconda Company (Canada) Ltd., Britannia Beach Division, Britannia Beach	4,000 (operating rate 2,000)	505,433 (226,005)	1.00	0.58	–	Routine development of known ore. Extensive exploration underground and on surface for new orebodies and for extensions to known orebodies.
Bethlehem Copper Corporation Ltd., Highland Valley	9,000	3,027,281 (1,964,042)	0.61	–	–	Mill expansion continued. Capacity scheduled to be increased to 12,000 tons a day. Surface exploration of ore zones adjacent to producing open pit.
Cominco Ltd., Coast Copper mine, Benson Lake	750	282,832 (292,196)	..	–	–	Routine exploration and development of producing orebodies. Development of newly discovered orebodies.
Cowichan Copper Co. Ltd., Sunro mine, River Jordan, V.I.	1,500	.. (–)	..	–	–	Mine reopened in January but closed in September because of financial difficulties.
Craigmont Mines Limited, Merritt	5,000	989,144 (1,616,615)	1.54	–	–	Extensive underground exploration and development to prepare mine for sub-level caving method of mining in 1967. Open pit expected to be phased out in first quarter of 1967.
Giant Mascot Mines, Limited, Hope	1,250	327,164 (330,954)	0.33	–	0.66	Exploration and development of high-grade 1500 orebody. Exploration of orezone, by geological, geochemical and geophysical surveys.
The Granby Mining Company Limited, Phoenix Copper Division, Greenwood.	2,000	.. (703,420)	0.80	–	–	Routine expansion and mining of open pit.
Minoca Mines Ltd., Yreka mine, Jeune Landing, V.I.	200	73,959 (..)	3.12	–	–	Routine exploration and development
Mt. Washington Copper Co. Ltd., Courtenay, V.I.	1,000	179,502 (..)	1.06	–	–	Exploration by diamond drilling to extend open-pit ore.

Source: Company reports

.. Not available – nil [e] Estimated



MINERAL RESOURCES DIVISION
DEPARTMENT OF ENERGY, MINES AND RESOURCES

PRODUCERS

(numbers refer to numbers on map)

1. Atlantic Coast Copper Corp. Ltd.
   British Newfoundland Expl. Ltd. (Whalesback Pond)
   Consolidated Rambler Mines Ltd.
   First Maritime Mining Corp. Ltd. (Tilt Cove)
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.
6. Cupra Mines Ltd.
   Solbec Copper Mines, Ltd.
7. Campbell Chibougamau Mines Ltd. (4 mines)
   Merrill Island Mining Corp. Ltd.
   Opemiska Copper Mines (Quebec) Ltd.
   The Patino Mining Corp., Copper Rand Mines Division (5 mines)
   Rosario Mining Explorations Ltd. (Bruneau)
8. Mattagami Lake Mines Ltd.
   New Hosco Mines Ltd.
   Orchan Mines Ltd.
   Rio Algom Mines Ltd. (Mines de Poirier)
9. Lake Dufault Mines, Ltd.
   Manitou-Barvue Mines Ltd.
   Noranda Mines Ltd.
   Quemont Mining Corp. Ltd.
   Sullico Mines Ltd. (East Sullivan)
   Marbridge Mines Ltd.
10. Normetal Mining Corp. 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.
    Texas Gulf Sulphur Co.
    Upper Beaver Mines Ltd.
14. Falconbridge Nickel Mines, Ltd. (5 mines, 1 smelter)
    The International Nickel Company of Canada, Ltd. (10 mines, 2 smelters, 1 refinery)
    Kidd Copper Mines Ltd. (Aer nickel)
15. Rio Algom Mines Ltd. (Pronto Division)
16. North Canadian Enterprises Ltd. (Coppercorp)

17. Noranda Mines Ltd. (Geco Division)
    Willecho Mines Ltd.
    Willroy Mines Ltd.
18. Zenmac Metal Mines Ltd.
19. North Coldstream Mines Ltd.
20. Metal Mines Ltd.
21. Sherritt Gordon Mines, Ltd.
22. Hudson Bay Mining and Smelting Co., Ltd. (4 mines, 1 smelter)
23. Anglo-Rouyn Mines Ltd.
24. The Granby Mining Company Ltd. (Phoenix Division)
25. Craigmont Mines Ltd.
26. Bethlehem Copper Corp. Ltd.
27. Giant Mascot Mines, Ltd.
28. The Anaconda Company (Canada) Ltd. (Britannia Division)
29. Cominco Ltd. (Coast Copper)
30. Mt. Washington Copper Co. Ltd.
31. Cowichan Copper Co. Ltd. (Sunro)

PROSPECTIVE PRODUCERS

32. Nigadoo River Mines Ltd.
33. Grandroy Mines Ltd.
    Icon Syndicate
34. Joutel Copper Mines Ltd.
35. Munro Copper Mines Ltd.
36. Falconbridge Nickel Mines, Ltd. (Strathcona)
    The International Nickel Company of Canada, Ltd. (4 mines, 1 mill)
37. Tribag Mining Co., Ltd.
38. Hudson Bay Mining and Smelting Co., Ltd. (Osborne, Anderson Lake)
39. Sherritt Gordon Mines, Ltd. (Fox Lake)
40. Hudson Bay Mining and Smelting Co., Ltd. (Flexar)
41. Share Mines & Oils Ltd.
42. The Granby Mining Co. Ltd. (Granisle)
    Noranda Mines Ltd. (Newman Peninsula)
43. Granduc Mines Ltd.
44. New Imperial Mines Ltd.
45. Falconbridge Nickel Mines, Ltd. (Wesfrob)
46. Western Mines Ltd.

REFINERIES

14. The International Nickel Company of Canada, Ltd.
47. Canadian Copper Refiners Ltd.

TABLE 4

Prospective Producing Companies*, 1966

Company and Location	Type of Ore	Mill Capacity (tons ore/day)	Production to Start	Destination of Concentrates
New Brunswick				
Nigadoo River Mines Limited, Robertville	Zn, Cu	1,000	1967	Export market
Quebec				
Grandroy Mines Limited, Chibougamau	Cu	575 (ore trucked to Campbell Chibougamau mill).	1967	Ore to Campbell Chibougamau
Icon Sydicate, Chibougamau	Cu	600 (ore trucked to Merrill Island mill).	1967	Ore to Merrill Island.
Joutel Copper Mines Limited, Joutel Township	Cu, Zn	700 (ore trucked to Mines de Poirier mill).	1967	Ore to extension of Mines de Poirier mill.
Ontario				
Falconbridge Nickel Mines, Limited, Strathcona mine, Sudbury.	Ni, Cu	6,000	1967	Own smelter
The International Nickel Company of Canada, Limited, Sudbury				
Copper Cliff North mine	Ni, Cu	Treated at central mill	1967	Own smelter

TABLE 4 (continued)

Company and Location	Type of Ore	Mill Capacity (tons ore/day)	Production to Start	Destination of Concentrates
Frood–Stobie expansion	Ni, Cu	22,500	1968	Own smelter
Kirkwood mine		Treated at central mill	1968	Own smelter
Little Stobie and Coleman mines	Ni, Cu	Treated at Frood-Stobie mill	1969	Own smelter
Munro Copper Mines Limited, Matheson	Cu, Zn	500	1967	Export market
Tribag Mining Co., Limited, Batchawana Bay	Cu	400	1967	Noranda
Manitoba–Saskatchewan				
Hudson Bay Mining and Smelting Co., Limited, Flin Flon, Manitoba				
Flexar mine, Saskatchewan	Cu, Zn	Treated at Flin Flon mill	1967	Own smelter
Osborne Lake mine, Man.	Cu, Zn		1967	
Anderson Lake mine, Man.	Cu, Zn		1968	
Share Mines & Oils Ltd., Hanson Lake, Saskatchewan	Zn, Cu	350	1967	Hudson Bay smelter at Flin Flon
British Columbia				
Falconbridge Nickel Mines, Limited, Wesfrob mine, Tasoo Harbour, Q.C.I.	Fe, Cu	10,000	1967	Japan
Granduc Mines, Limited, Unuk River	Cu	7,000	1969	Tacoma, U.S.A.
The Granby Mining Company Limited, Granisle mine, Babine Lake	Cu	5,000	1967	Japan
Noranda Mines Limited, Newman Peninsula, Babine Lake	Cu	10,000	..	Export market
Western Mines Limited Buttle Lake, V.I.	Zn, Cu Pb	750	1967	Export market
Yukon Territory				
New Imperial Mines Ltd., Whitehorse	Cu, Fe	2,000	1967	Japan

Source: Company reports
*Includes only companies with announced production plans
.. not known

SMELTERS AND REFINERIES

Salient statistics on Canada's 6 copper smelters and 2 refineries are given in Tables 5 and 6. The International Nickel Company of Canada, Limited at Copper Cliff, Ontario, continued the changeover from multi-hearth to fluid-bed roasters and was improving its matte-cooling facilities. These changes will enable the plant to treat the increased production from the planned mine expansion.

Noranda Mines Limited has made changes and additions to its smelter at Noranda, Quebec, to enable it to treat an anticipated 250,000 tons of concentrates a year from the Texas Gulf mine. Canadian Copper Refiners Limited at Montreal East, added an extension to the copper refinery that will raise its capacity from 284,000 tons of refined copper a year to 342,000 tons.

TABLE 5

Canadian Copper and Copper-Nickel Smelters

Operator and Location	Product	Rated Annual Capacity (short tons)	Remarks	Ore and Concentrate Treated, 1966 (short tons)	Blister or Anode Copper Produced, 1966 (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.	437,216	..
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.	266,800 (of which 75,100 were custom concentrates)	47,169
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.	398,363 (of which 26,548 were custom concentrates)	38,881
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, then by sintering to make sintered-nickel products for refining and marketing. Electric-furnace melting of copper sulphide and conversion to blister copper.	.. ..	.. ..

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Table 5 (continued)

Operator and Location	Product	Rated Annual Capacity (short tons)	Remarks	Ore and Concentrate Treated, 1966 (short tons)	Blister or Anode Copper Produced, 1966 (short tons)
Noranda Mines Limited, Noranda, Que.	Copper anodes	2,200,000e (ore and concentrates and scrap)	Roasting furnaces, 2 hot-charge reverberatory furnaces, 1 green-charge reverberatory furnace, 5 converters. Also smelts custom material.	1,648,000 (of which 679,300 were custom material)	184,510

Source: Company reports.

.. Not available; e Estimated.

TABLE 6

Copper Refineries in Canada, 1966

Refinery	Products
1) Canadian Copper Refiners Limited, Montreal East, Quebec. (subsidiary of Noranda Mines Limited)	Rated annual capacity: 342,000 tons. Refines anode copper from Noranda and Gaspé smelters, blister copper from Flin Flon smelter and purchased scrap. Copper sulphate recovered by vacuum evaporation. Precious metals, selenium and tellurium recovered from anode slimes. CCR brand electrolytic copper wire bars, ingot bars, ingots, cathodes, cakes and billets.
2) 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

Copper production in the non-communist world was hampered in 1966 by strikes, slowdowns and supply interruptions. Mine output was 4,655,000* tons compared with 4,578,000 tons in 1965. The major supply interruptions were in Zambia where transportation difficulties and a shortage of metallurgical coal reduced deliveries to 75 per cent of normal. Canada, Chile, Peru and Zambia had production losses because of strikes at mines or smelters.

Non-communist world capacity for copper production will increase by an estimated 350,000 tons in 1967. Canada's capacity is expected to increase by 100,000 tons to 625,000 tons a year by the end of 1967.

TABLE 7

Consumption of Primary Copper in Manufacture of Semifabricated Products, 1964, 1965

(short tons)

	1964	1965
Copper mill products, sheet, strip,bars, rolls, pipe, tube, etc.	63,076	62,993
Brass mill products – plate, sheet, strip, rods, bars, rolls, pipe, tubes, etc	10,350	11,279
Wire and rod mill products	109,474	114,546
Miscellaneous	2,144	1,918
Total	185,044	190,736

CONSUMPTION AND USES

World demand for copper continued to exceed consumption. A high level of industrial activity in the United States and increased military needs for the Vietnam conflict offset a slump in demand in Europe. Consumers continued to build inventories as a hedge against the possibility of production losses by strikes in mid-1967 as labour contracts at most of the large United States mines expire in June.

*U.S. Bureau of Mines.

The major use of copper is in the manufacture of wire. Other uses include tube, sheet and strip, and in alloying for brass and bronze.

Canadian consumption of refined copper in 1966 at 262,557 tons was 37,873 tons more than in 1965. More than half of this copper was used in the manufacture of wire and rod mill products; the rest was used in copper and brass mill products and in miscellaneous uses. Exports of semi-fabricated products from Canada increased 6,833 tons to 71,294 tons in 1966.

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 Cables Limited, St. Johns, and Northern Electric Company, Limited, Montreal.

PRICES

Canadian and United States producers' domestic prices were stable at 45 cents (Can.) and 36 cents (US) a pound, in 1966. The world producers' European price was raised to 42 cents a pound on January 3, at which level it remained until April 13. The London Metal Exchange price continued to react to the variations in supply and reached a high of 97.5 cents (US) a pound on April 5 as a result of strikes in Chile and interruption of supplies from Zambia. When the strikes were settled and copper shipments from Zambia were resumed, the London Metal Exchange (LME) price declined. In April, Chile raised the selling price of its copper in Europe to 62 cents (US) a pound shortly after which the Zambian producers announced that their European price would be based on the London Metal Exchange 3-month price. This announcement depressed the LME spot price to 63.75 cents. Minor supply difficulties in May raised the spot price to 83 cents but resumption of deliveries and a seasonal slump in demand lowered the price to 44.50 cents in August. The London price was reasonably stable for the rest of the year, fluctuating between 50 and 60 cents a pound.

Producers' European prices were very confused after April, as evidenced in the following table.

Copper Producer Prices in Europe, 1966

Seller(s)	From	To	Price ¢US /lb
All major producers	Jan. 3	April 13	42
Chile	April 14	July 14	62
	July 15	Aug. 12	70
	Aug. 13	Dec. 31	LME
Zambia	Apr. 14	April 24	42
	Apr. 25	Dec. 31	LME
Canada	April 14	April 26	42
	April 27	May 5	61.25
	May 6	June 30	65
	July 1	Dec. 31	LME
Union Minière du Haut-Katanga	April 14	April 27	42
	April 28	May 5	61
	May 6	May 16	65
	May 17	Dec. 31	LME

Source: American Metal Market
LME — London Metal Exchange, 3-month seller price.

GOVERNMENT REGULATIONS

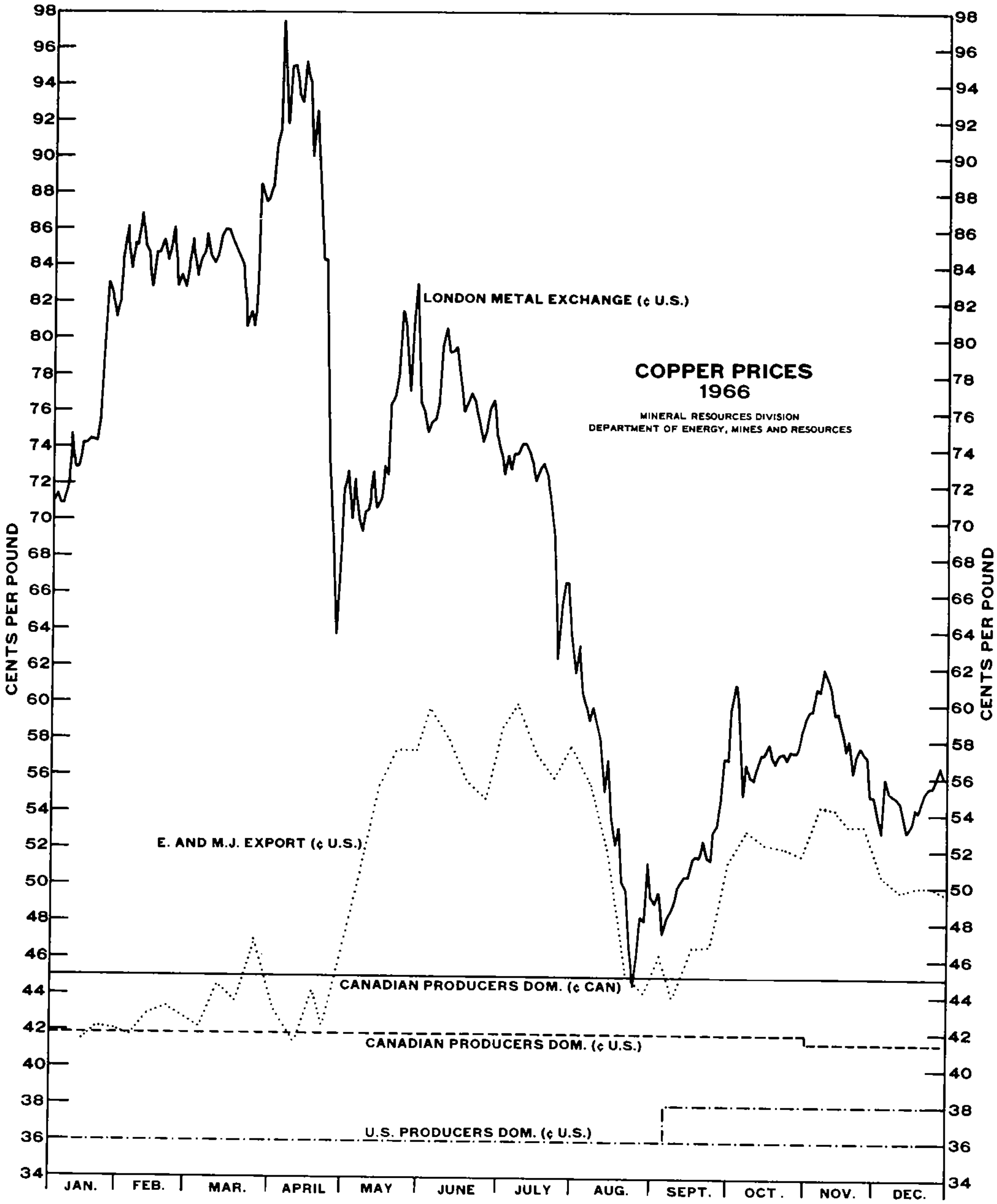
The pricing, marketing and supply difficulties that have beset the copper industry in the last three years have brought about varying degrees of government intervention in several countries.

CANADA

The Canadian government imposed a permit system to regulate offshore export of ores and concentrates. The measure was designed to ensure an adequate supply of copper, and to prevent the diversion of concentrates from domestic smelters. The ban on scrap exports imposed in 1965 was relaxed in that a quota system was set up to allow some offshore exports.

UNITED STATES OF AMERICA

The United States government established set-asides for domestic primary copper producers. At year-end the producers were required to reserve 18 per cent of their domestic production for delivery to plants with defence-rated orders. The government also suspended



SOURCE: AMERICAN METAL MARKET.

until June 30, 1968, the 1.7-cent-a-pound import duty on copper entering the United States. A total of 453,159 tons was released from the strategic stockpile and a further 150,000 tons will be released in 1967 for use in defence-rated industries.

United States Copper Stockpile, 1966

(short tons)

		Beginning of Year	End of Year
Stocks*	National Stockpile	897,375	444,416
	Defence Production Act Stockpile	2,010	1,811
	Supplemental Stockpile	6,328	6,327
		905,713	452,554**
	Net change in stocks		–453,159
	Stockpile objective	770,440	770,440
	Excess of stocks over stockpile objective	83,364	–317,886

Source: Report of Joint Committee on Reduction of Nonessential Federal Expenditures, Congress of the United States.

*Includes brass, bronze and oxygen free high conductivity copper; ** Release of 150,000 short tons authorized for 1967.

OTHER

The Chilean government passed a bill authorizing the government to enter into partnership with the large, American-owned copper mining companies. The first company to be 'Chilenized' will be the Braden Copper Corporation, a subsidiary of Kennecott Copper Corporation. The government hopes to double the production of copper in Chile by 1971. Both the Zambian and Chilean governments have exerted strong pressure on the pricing policies of the copper producers in their respective countries and are exploring the possibility of setting up an agency for mutual co-operation in the marketing and production of copper.

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, rods, wire, semi-fabricated forms and fully processed products entering the country. Table 8 summarizes the Canadian tariff rates on copper and its products.

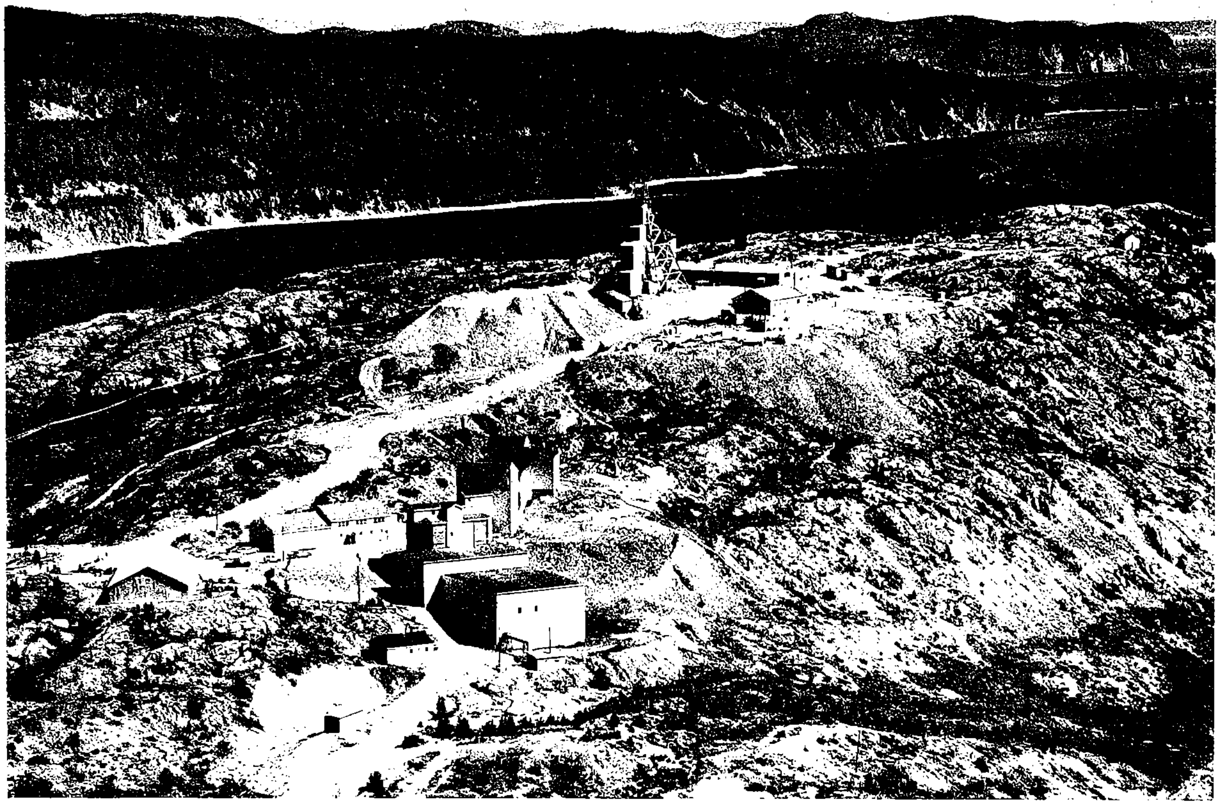
The United States tariff on copper entering the country in ores, concentrates and primary shapes is 1.7 cents a pound on copper content*. On fabricated products an ad valorem duty that varies with the type of product is added to the tariff of 1.7 cents a pound on copper content.

TABLE 8

Canadian Tariffs

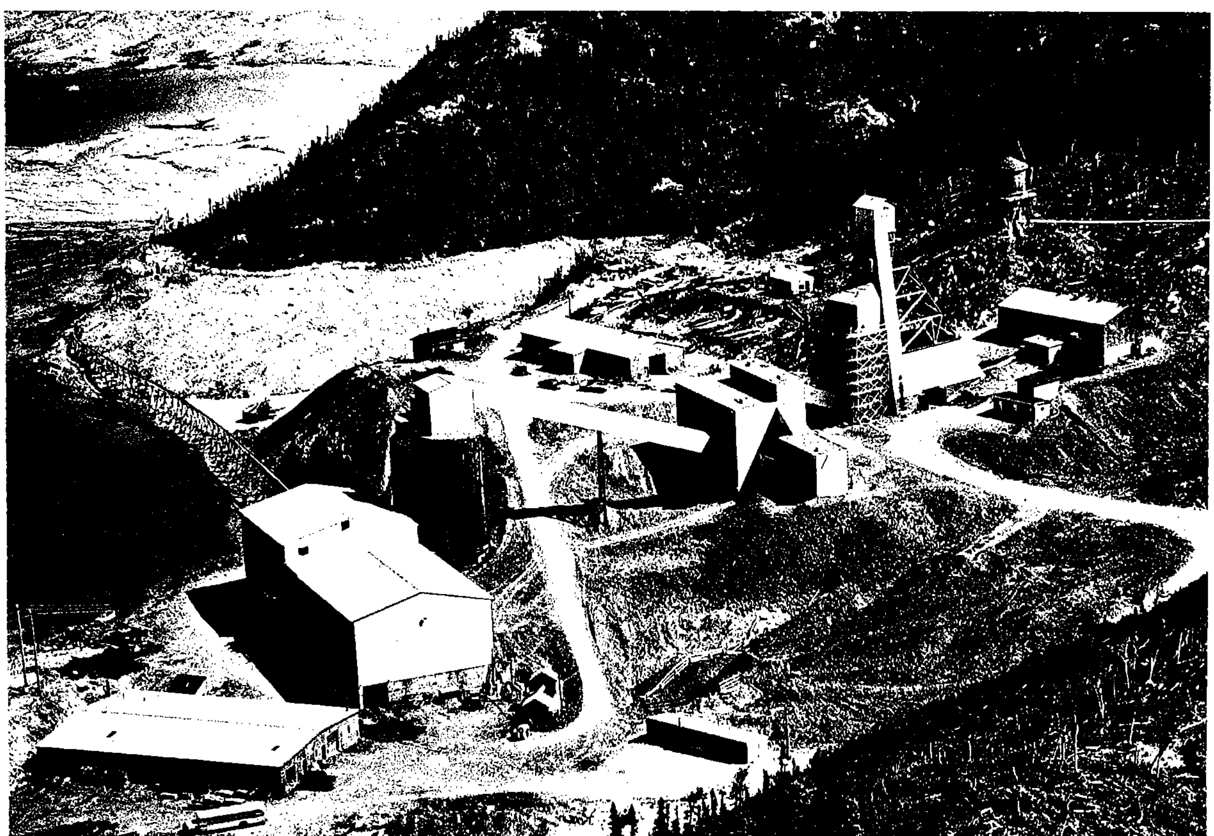
	British Preferential	Most Favoured Nation	General
Ores, concentrates	free	free	free
Pigs, blocks, ingots, cathodes	¾¢ lb	¾¢ lb	1½¢ lb
Scrap	¾¢ lb	¾¢ lb	1.5¢ lb
Anodes	5%	7.5%	10%
Oxides	free	15%	15%
Bars or rods; tubing not less than 6 ft. long, unmanufactured; copper in sheets, strips or plates, not polished, planished or coated	5%	10%	10%
Bars and rods for manufacture of wire and cable	free	10%	10%
Tubing not more than ½ in. in dia. and not less than 6 ft. long	5%	10%	10%
Alloys of copper consisting 50% or more by weight of copper in sheets, plates, bars, rods, tubes	7.5%	15%	15%

*Suspended until June 30, 1968.



TWO OF NEWFOUNDLAND'S FIVE COPPER PRODUCERS: Atlantic Coast Copper Corporation Limited's mine at Little Bay on the north coast, which went into operation in 1961.

Nearby Whaleback Mine of British Newfoundland Exploration Limited which has its first full year of production in 1965.



Feldspar

J.E. REEVES*

The Canadian feldspar industry experienced little change in 1966. Shipments of ground feldspar by International Minerals & Chemical Corporation (Canada) Limited, the sole producer, were at about the same level as in 1965. The source is a large, very coarse-grained granitic pegmatite in Derry Township, Quebec, from which hand-cobbed feldspar is trucked to the company's grinding plant at Buckingham. The principal market is the ceramics industry in southern Ontario and northwestern New York State. Exports declined slightly. Some feldspar is imported from the United States into western Canada, but is no longer recorded as a separate trade item.

For several years, the feldspar industry in Canada has operated in the shadow of the thriving nepheline syenite industry. Principally because of its higher alumina content, nepheline syenite gradually won the favour of glass makers and, within the last decade, completely replaced feldspar in the Canadian glass industry. Unless some special set of circumstances arises, the Canadian feldspar industry is unlikely to recapture the glass market and will remain relatively small.

TECHNOLOGY

Feldspar is the general term for a group of related aluminum silicates of potassium, sodium and calcium. Feldspar containing potassium and sodium is of value to the ceramics industry as a source of alumina (Al_2O_3), potash (K_2O) and soda (Na_2O), and for its relatively low firing temperature; it is of some use to manufacturers of cleaning compounds because it is moderately abrasive. High-calcium feldspar, in the form of anorthosite or as pieces of labradorite, is in some demand for building and decorative purposes but is not included in Canadian feldspar statistics.

Potash and soda feldspar occur widely in many types of rock, but commercial deposits are restricted to a very few with a high content of feldspar that can be suitably extracted. Very coarse-grained granitic pegmatites, with the feldspar concentrated in zones, have been the most common sources. The feldspar from such sources is hand-cobbed to remove excess quartz and various other unwanted minerals, and is ground and classified. Nearly all Canadian feldspar has been mined from such pegmatites, which are relatively common in southeastern Ontario and southwestern Quebec.

Elsewhere, the depletion of many of these deposits and the need for mechanized high-tonnage operations have led to the development of pegmatites or other highly feldspathic rocks in which the feldspar is finer-grained and more intimately mixed with quartz and small quantities of other minerals. The feldspar is concentrated mechanically, usually by flotation.

* Mineral Processing Division.

TABLE 1

Feldspar — Production, Trade and Consumption, 1965-66

	1965		1966	
	Short Tons	$	Short Tons	$
Production (shipments)	10,904	252,868	10,924	254,714
Exports				
United States	3,746	86,815	3,419	78,000
	1964		1965	
Consumption, available data				
Whiteware	6,715		7,607	
Porcelain enamel	189		309	
Cleaning compounds	548		356	
Other	41		66	
Total	7,493		8,338	

Source: Dominion Bureau of Statistics

The acceptance of feldspathic substitutes by the consumers has adversely affected the growth of the feldspar industry. Nepheline syenite from Ontario has been substituted by glass manufacturers because of its comparatively higher content of alumina; aplite, a feldspathic byproduct of titanium mineral operations in Virginia, is also used in some types of glass as a relatively cheap source of alumina; and controlled feldspar-silica mixtures have become acceptable in glass and certain clay ware.

USES AND SPECIFICATIONS

Feldspar is important as a flux in the firing of whiteware bodies and glazes, and is used principally in Canada in the manufacture of electric porcelain and vitreous sanitary ware. It must be essentially minus 325 mesh, have a very low quartz and iron-mineral content and, in many cases, contain a high potash-soda ratio. An iron content of less than 0.1 per cent (in terms of ferric oxide, Fe_2O_3) is specified to ensure a white fired product.

In the manufacture of porcelain enamels, feldspar is a source of alumina, potash and silica. It must be at least minus 120 mesh, have a very low iron content and fire white.

For cleaning compounds, feldspar should be white and free of quartz.

Where it can compete economically with nepheline syenite, feldspar is still used extensively as a source of alumina, soda and potash in the manufacture of glass. A relatively coarse particle size, generally with an upper limit of 20 mesh, is required. The iron content should be less than 0.1 per cent Fe_2O_3.

TABLE 2

Feldspar, Production and Trade, 1957-66
(short tons)

	Production	Imports	Exports
1957	20,450	241	4,047
1958	20,387	1,140	9,956
1959	17,953	1,161	7,552
1960	13,862	1,338	3,183
1961	10,507	1,721	2,626
1962	9,994	1,901	3,698
1963	8,608	2,600	3,282
1964	9,149	..	3,386
1965	10,904	..	3,746
1966	10,924	..	3,419

Source: Dominion Bureau of Statistics
.. Not available.

PRICES AND TARIFFS

According to *E & MJ Metal and Mineral Markets* of December 26, 1966, some prices in the United States, per short ton, f.o.b. mine or mill, in bulk and carload lots, were:

North Carolina

200 mesh, dry ground	$ 18.50 – 21.00
325 mesh, dry ground	18.50 – 23.00
20 mesh, dry ground	10.00 – 12.50
200 mesh, flotation concentrate	18.50
20 mesh, flotation concentrate	9.00

Connecticut

200 mesh	$ 19.50
325 mesh	21.50
30 mesh, granular	12.00
20 mesh, granular	12.00

TARIFFS

Canadian and United States feldspar tariffs in effect at the time of writing were:

	British Preferential	Most Favoured Nation	General
Canada			
Crude only	free	free	free
Ground but not further manufactured	free	15%	30%

United States
Crude 12½¢ per long ton
Ground 7½% ad val.

Fluorspar

J. E. REEVES*

In 1966, production of fluorspar in Canada declined. Imports from Mexico, the principal supplier, increased. A small amount of optical-grade fluorspar was exported to Great Britain.

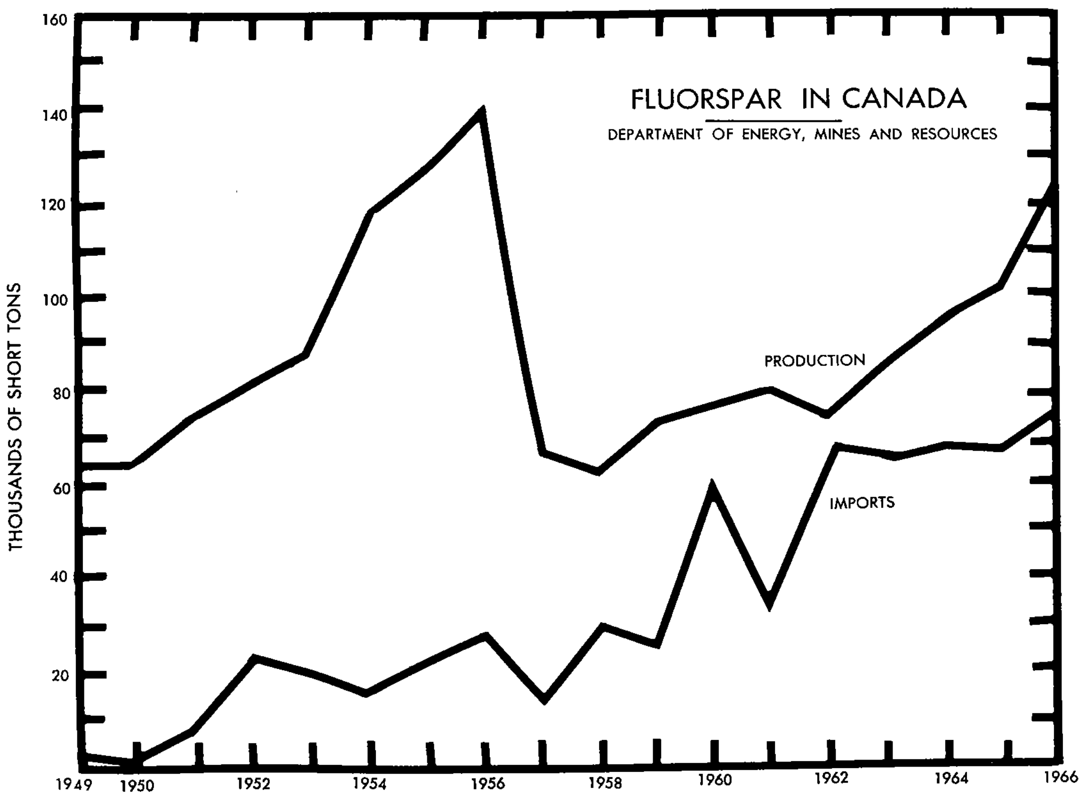
Consumption of fluorspar in Canada is continuing to increase, particularly in the manufacture of aluminum and fluorine chemicals. The demand is bound to continue growing and should eventually result in increased Canadian production.

THE CANADIAN INDUSTRY

Newfoundland Fluorspar Limited, a subsidiary of Alcan Aluminium Limited, mines fluorspar near St. Lawrence, on the Burin Peninsula of Newfoundland, and ships a partly concentrated product to another subsidiary, Aluminum Company of Canada, Limited, at Arvida, Quebec. Aluminum Company upgrades the concentrate and produces artificial cryolite (sodium aluminum fluoride) for use in the reduction of alumina to aluminum. Pacific Silica Limited produces a small amount of metallurgical-grade fluorspar as a byproduct of its silica operation near Oliver, British Columbia.

Allied Chemical Canada, Ltd., imports acid-grade fluorspar and produces hydrofluoric acid at Valleyfield, Quebec. It uses some of this acid in a new plant at Amherstburg, Ontario, in the manufacture of fluorocarbons for use as aerosol propellants and refrigerants. At North Brook, Ontario, Huntingdon Fluorspar Mines Limited produces 5-pound briquettes from imported metallurgical-grade fluorspar, for use in foundries. At Port Maitland, Ontario, Electric Reduction Company of Canada, Ltd., produces fluosilicic acid as a byproduct of processing phosphate rock to make fertilizers, and sells it for use in fluoridating water.

*Mineral Processing Division, Mines Branch.



CANADIAN RESOURCES

Newfoundland is the only significant commercial source at present, although fluorspar has also been produced from deposits in Ontario, British Columbia and Nova Scotia. The deposits near St. Lawrence, Newfoundland, consisting of veins of various widths in a granitic rock, have been a source of nearly 2 million tons of fluorspar. Newfoundland Fluorspar has operated continuously since 1940. St. Lawrence Corporation of Newfoundland Limited produced metallurgical and acid grades from 1933 until forced by competition from Mexican fluorspar to close in 1957. Newfoundland Fluorspar now controls all the deposits in the St. Lawrence area.

Near Madoc, Ontario, veins were mined on a small scale for metallurgical-grade fluorspar almost continuously from 1910 to 1961, producing as much as 11,000 tons a year. Total production is estimated at 120,000 tons. The several small mines were operated to only shallow depths and probably did not exhaust the fluorspar reserves.

From 1940 to 1949, about 1,400 tons of fluorspar were produced from veins near Lake Ainslie on Cape Breton Island, for metallurgical use. Recent drilling on two veins has indicated more than 2½ million tons containing an average of about 46 per cent barite and 14 per cent fluorite, allowing for 10 per cent dilution.

The Rock Candy mine, near Grand Forks, British Columbia, was a source of fluorspar on three occasions between 1918 and 1942, and probably still contains substantial reserves. It is controlled by Cominco Ltd. The property of Rexspar Minerals & Chemicals Limited, beside the Canadian National Railways line at Birch

TABLE 1

Fluorspar — Production, Trade and Consumption

	1965		1966P	
	Short Tons	$	Short Tons	$
Production (shipments)				
Newfoundland	..	2,677,443	..	2,187,500
British Columbia	..	2,419	..	3,850
Total		2,679,862		2,191,350
Exports				
Britain	..	9,575*	12	6,000*
Imports				
Mexico	54,785	1,587,655	60,287	1,572,000
United States	11,776	390,873	11,403	412,000
Britain	3,287	121,907	3,634	159,000
Total	69,848	2,100,435	75,324	2,143,000
	1964		1965	
Consumption (available data)				
Metallurgical flux (steel, magnesium, foundries)	45,600		44,666	
Glass	2,851		2,751	
Enamels	250		291	
Other (including aluminum and chemicals)	107,127		119,829	
Total	155,828		167,537	

Source: Dominion Bureau of Statistics.
* Shipments of clear crystal for optical use.
P Preliminary; .. Not available.

TABLE 2

Fluorspar — Production, Trade and Consumption, 1957-66
(short tons)

	Production[1]	Exports	Imports	Consumption
1957	66,245	23,630	14,547	70,761
1958	62,000[2]	7	30,408	89,933
1959	74,000[2]	3,774	26,588	96,016
1960	77,000[2]	10,312	59,690	111,835
1961	78,600[3]	2,048	32,769	111,542
1962	77,700[3]	4	67,847	123,694
1963	85,000[3]	4	66,798	142,840
1964	96,000[3]	..	69,986	155,828
1965	112,000[3]	..	69,848	167,537
1966P	..	12	75,324	..

Source: Dominion Bureau of Statistics except where otherwise indicated.

[1] Producers' shipments. Tonnage statistics after 1957 not available for publication. [2] Estimates reported by U.S. Bureau of Mines. [3] Shipments reported in annual reports of Aluminium Limited.
P Preliminary; .. Not available.

TABLE 3

World Production of Fluorspar
(short tons)

	1964	1965	1966e
Mexico	708,644	801,066	775,000
USSR	330,000	385,000	..
France	215,119	275,578	..
Spain	164,995	244,795	..
United States	217,137	240,932	247,000
China, mainland	220,000	240,000	..
Britain	131,175	190,000	..
Italy	136,724	162,990	160,000
Canada	96,000	107,000	..
Other countries	510,206	522,639	..
Total	2,730,000	3,170,000	3,247,000

Source: U.S. Bureau of Mines Preprint, Fluorspar, 1965 and U.S. Bureau of Mines Commodity Data Summaries, January, 1967.
e Estimate; .. Not available.

Island, British Columbia, contains a large medium-grade fluorite deposit that could be mined at low cost. The fluorite is fine grained and difficult to concentrate, but increased prices and the growing acceptance of pelletized metallurgical-grade fluorspar could provide the impetus for development. Shallow, flat-lying deposits along the Liard River in northern British Columbia appear to contain a large amount of fluorite, but their remote location makes them currently uneconomic.

WORLD REVIEW

The steadily increasing demand for aluminum, steel, and fluorine chemicals and their derivatives has meant a rising demand in many parts of the world for fluorspar. Consumption in the United States rose to an estimated 1 million short tons in 1966, compared with 930,127 tons in 1965 and 831,561 tons in 1964. Most producing countries have experienced increases in production of fluorspar. The world total rose from 2.73 million short tons in 1964 to 3.17 million short tons in 1965, and probably to a higher level in 1966.

Mexico is the leading producer, but several countries have actively growing fluorspar industries. The Republic of South Africa, which is only a modest producer, recently announced that it has substantial reserves of fluorspar that can be tapped to supply future world demand. No present shortage of fluorspar exists on a world-wide basis, but, as the need continues to grow, attendant price increases and local shortages should result in the development of lower-grade deposits in many countries.

TECHNOLOGY

'Fluorspar' is an archaic mineralogical term that is still the common commercial term for the mineral fluorite, which is calcium fluoride, CaF_2. Fluorite is widely distributed, occurring in a variety of colours in many different geological environments. It is important economically because it is an active flux and the principal source of fluorine.

Processing methods vary considerably. Hand cobbing is still common for producing metallurgical-grade lump. To produce higher grades and to process fine-grained ores, flotation is generally used. The pelletizing of fluorspar is providing the steel industry with an acceptable alternative to lump fluorspar, and may lead to the development of some deposits not currently of commercial value because the fluorspar is too fine grained to yield metallurgical lump or is not amenable to concentration to higher grades. Newfoundland Fluorspar Limited upgrades its ore using a heavy media process; the product is concentrated to acid grade by flotation at Arvida.

Phosphate rock normally contains 2 to 4 per cent fluorine and is being processed in large quantity by the fertilizer industry. The recovery of byproduct fluorine has long been recognized as a possibility, but thus far is only being done on a small scale or for captive use.

USES AND SPECIFICATIONS

Fluorspar is used as a flux by the steel industry, to assist the melting of the furnace charge and to improve the separation of metal and slag. Metallurgical-grade fluorspar is usually specified by steelmakers on the basis of a minimum of 75 to 80 per cent effective CaF_2 (which is computed by subtracting 2½ times the silica content from the total content of CaF_2), a maximum of about 5 per cent silica (SiO_2), a very small content of sulphur and lead, and in lump form essentially between 2 inches and 3/8 inch, with a maximum of about 15 per cent finer. Fluorspar is also used as a flux in foundries and in the reduction of dolomite to magnesium.

Ceramic-grade fluorspar is used as a flux and opacifier in enamels and opal glass. It is also used in transparent glass because it is an active flux, contributes to the gloss and acts as a decolourizer. Specifications generally require at least 94 to 95 per cent CaF_2 and not more than 3 per cent SiO_2, 1 to 3 per cent calcium carbonate ($CaCO_3$) and 0.1 per cent iron (as ferric oxide, Fe_2O_3).

Acid-grade fluorspar is the most suitable source material for the flux used in the Hall electrolytic process for producing aluminum. It is converted to hydrofluoric acid, which is used to make artificial cryolite, the principal flux for melting alumina in the Hall cell. A small amount of fluorspar is added directly to the melt.

Acid-grade fluorspar is the principal raw material for the making of fluorine chemicals. Fluorine chemicals are used for uranium processing, the alkylation of gasoline and the production of high-energy missile fuels. Hydrofluoric acid is used for the manufacture of fluorocarbon aerosol propellants, refrigerants, plastics and solvents. The remarkable growth of the fluorocarbons, borne on a variety of useful characteristics – they are inert, odourless, non-toxic, non-corrosive and non-flammable – seems bound to continue.

Acid-grade fluorspar must contain a minimum of 97 per cent CaF_2 and not more than 1 per cent SiO_2, and be of fine particle size.

Fluosilicic acid, sodium fluoride and to a slight extent calcium fluoride are used to fluoridate public water supplies.

PRICES

According to *E & MJ Metal and Mineral Markets* of December 26, 1966, prices were as follows:

United States, in bulk, f.o.b.	
Illinois and Kentucky, per short ton	
Metallurgical	
72½% CaF_2	\$37 – \$39
70% CaF_2	35 – 37
60% CaF_2	32 – 34
Pellets, 70% CaF_2	44
Acid, dry basis, 97% CaF_2	
Carload	49*
Less than carload	54*
Bags, extra \$4	
Wet filter cake, 8-10% moisture, sold dry content, subtract approx. \$2.50	
Pellets, carload lots	
No. 1	55
No. 2	47
No. 3	44
Less than carload lots, add \$5	
Ceramic, calcite and silica variable	
Fe_2O_3 max. 0.14%	
88–90% CaF_2	44*
93–94% CaF_2	46*
95–96% CaF_2	47*
In 100-lb paper bags, extra \$4	

*Indicates an increase of \$3 a ton for 88–90% ceramic grade and \$4 a ton for other grades, effective January 1, 1967

Europe, c.i.f. U.S. ports, duty paid, per short ton	
Acid, wet filter cake, 8–10% moisture, sold by dry content	\$42.50 – \$43.50
Mexico, per short ton	
Metallurgical 72½% CaF_2, f.o.b., per short ton	
Border, all rail, duty paid	\$30.10
Brownsville, barge, duty paid	32.90
Tampico, vessel, cargo lots	22.90
Acid, 97% CaF_2 min., Eagle Pass, in bulk	38.00

TARIFFS

Canada – free

United States

Fluorspar, by weight of calcium fluoride, per long ton	
containing over 97%	\$2.10
containing not over 97%	8.40

Gold

W.J. BEARD*

Gold production in Canada in 1966 declined for the sixth successive year. Production is estimated at 3,317,488 ounces valued at $125,102,472. In comparison with the 1965 production of 3,606,031 ounces worth $136,051,943, the 1966 production is down about 8 per cent in weight and in value. The highest production since World War II was achieved in 1960 when 4,628,911 ounces valued at $157,151,527 were produced.

The 1966 decrease is directly attributable mainly to the closure of auriferous-quartz or lode gold mines. In 1966 the lode gold mines produced 2,693,974 ounces as compared with 2,958,874 ounces in 1965. Six lode mines closed in 1966 while only one lode mine began operation.

Ontario continued as the leading producing province in 1966 by a wide margin as it produced 49.6 per cent of the total. Quebec was in second place with 28.4 per cent. The Northwest Territories produced 12.7 per cent and British Columbia 3.6 per cent.

World production in 1965 totalled 47.7 million ounces as estimated by the United States Bureau of Mines. In 1964, world production was 46.2 million ounces. About 64 per cent of the 1965 total, or 30.56 million ounces, was produced by The Republic of South Africa. The USSR produced an estimated 6.1 million ounces in 1965.

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 180.8 million ounces worth about $5,839 million to the end of 1966. Although most provinces have been contributors to the total, Ontario, Quebec, British Columbia, the Yukon Territory and the Northwest Territories, in that order, are the leaders.

Since 1948, production by the gold mining industry has been maintained in large part by financial assistance from the Government of Canada under the provisions of the Emergency Gold Mining Assistance Act. In 1966 there were 39 lode gold mines in receipt of assistance. Seven lode mines did not apply for assistance for various reasons. The legislation, under which payments based on the cost of production are made, is due to expire at the end of 1967.

The rapid closure of gold mines in 1965 and 1966 is due basically to the exhaustion of economic ore brought about by ever-increasing costs for supplies and higher wage scales. One or two of the mines that closed may have been able to continue production but the shortage of miners adversely affected operations to the point where the rate of production was uneconomical.

Production is expected to continue to decline as at least four more mines are slated for closure in 1967 and a further three are experiencing above-normal problems. Placer gold production will decrease substantially in 1967 as The Yukon Consolidated Gold Corporation, Limited, Canada's largest placer operator, ceased production at the end of the 1966 season.

*Mineral Resources Division.

TABLE 1

Production of Gold, 1965-66
(troy ounces)

	1965	1966[p]
Newfoundland		
Base-metal mines	23,657	24,912
New Brunswick		
Base-metal mines	1,659	1,768
Quebec		
Auriferous-quartz mines		
Bourlamaque - Louvicourt	246,249	268,136
Malartic	203,528	235,870
Chibougamau	40,399	35,096
Noranda	36,436	56,906
Total	526,612	596,008
Base-metal mines	378,326	352,963
Placer operations	442	–
Total	905,380	948,971
Ontario		
Auriferous-quartz mines		
Kirkland Lake	187,308	149,104
Larder Lake	222,969	188,554
Matachewan	1,511	1,162
Porcupine	899,530	751,747
Red Lake & Patricia	451,390	400,146
Sudbury	36,642	38,306
Thunder Bay	80,963	59,704
Kenora-Rainy River	302	1,395
Miscellaneous	–	1,280
Total	1,880,615	1,591,398
Base-metal mines	65,388	60,881
Total	1,946,003	1,652,279

	1965	1966[p]
Manitoba-Saskatchewan		
Auriferous-quartz mines	25,132	21,000
Base-metal mines	88,726	85,015
Total	113,858	106,015
Alberta		
Placer operations	200	182
British Columbia		
Auriferous-quartz mines	73,080	63,740
Base-metal mines	44,020	54,189
Placer operations	664	1,217
Total	117,764	119,146
Yukon Territory		
Base-metal mines	783	600[e]
Placer operations	43,292	41,787
Auriferous-quartz mines	956	612
Total	45,031	42,999
Northwest Territories		
Auriferous-quartz mines	452,479	421,216
Canada		
Auriferous-quartz mines	2,958,874	2,693,974
Base-metal mines	602,559	580,328
Placer operations	44,598	43,186
Total	3,606,031	3,317,488
Total value	$136,051,943	$125,102,472
Average value per ounce	$37.73	$37.71

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

OPERATIONS AT PRODUCING MINES

ATLANTIC PROVINCES

Gold production in the provinces of Newfoundland, New Brunswick and Nova Scotia was 26,680 ounces in 1966 as compared with 25,316 ounces in 1965. Production is derived mainly as a byproduct of base-metal mining, principally 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. Prince Edward Island does not produce gold.

QUEBEC

Gold production increased in 1966 by 4.8 per cent to 948,971 ounces due to Camflo Mines Limited and Wasamac Mines Limited, both of which began production in 1965, and Chimo Gold Mines Limited which started in January, 1966. Twelve gold mines, including the three above, operated in the province in 1966.

Two of the 12 closed during the year. Lode gold production was substantially higher than in 1965 while byproduct gold from the base-metal mines decreased. In 1966 the base-metal mines produced about 37.4 per cent of the provincial gold total as against 41.8 per cent the year before. The principal producers of byproduct gold are the base-metal mines of the Chibougamau and Noranda districts.

Auriferous-Quartz Mines

Bourlamaque-Louvicourt District — Four gold mines operated in 1966. Chimo Gold Mines Limited began production in January at its property in Vauquelin Township near Louvicourt. Chimo's ore is trucked about 14 miles to the mill formerly owned and operated by Bevcon Mines Limited. Production at Sigma Mines (Quebec) Limited and Lamaque Mining Company Limited (Lamaque Division) was practically the same as in 1965. Because economic ore reserves are being depleted, Sullivan Consolidated Mines, Limited, produced less and the mine is scheduled to close in 1967.

Malartic District — Five mines operated in 1966 but the Norlartic mine closed in November. Little Long Lac Gold Mines Limited produced a small amount of gold from its property adjoining Marban Gold Mines Limited. The ore is mined through the extension of the Marban workings. Production decreased at Barnat Mines Ltd. and Marban while East Malartic Mines, Limited, produced about the same as in 1965. Camflo Mines Limited, which completed its first full year of production, increased its output by 126 per cent.

Chibougamau District — Norbeau Mines (Quebec) Limited, the only operator of a lode gold mine in this area, completed its second full year of production. Production declined from the 1965 total.

Noranda District — Production increased about 56.1 per cent in this district due to the efforts of Wasamac Mines Limited during its first full year of operation. Peel-Elder Limited, a gold-quartz producer since 1946, ceased operations in June.

TABLE 2

World Gold Production, 1964-65
(troy ounces)

	1964	1965
North America		
Canada	3,835,454	3,606,031
United States	1,456,308	1,705,190
Mexico	209,976	215,796
Nicaragua	225,581	198,152
Other countries	14,681	12,831
Total	5,742,200	5,738,000
South America		
Colombia	364,991	319,362
Brazil	142,492	161,044
Peru	92,503	96,863
Chile	64,993	57,068
Other countries	117,021	128,663
Total	782,000	763,000
Europe		
USSR	5,600,000	6,100,000
Sweden	117,500	118,000
Yugoslavia	106,773	112,500
Other countries	575,727	569,500
Total	6,400,000	6,900,000
Asia		
Philippines	425,770	435,545
Japan	253,300	264,408
Korea (including North Korea)	235,779	222,823
India	148,504	130,628
Other countries	101,647	111,596
Total	1,165,000	1,165,000
Africa		
Republic of South Africa	29,111,524	30,553,874
Ghana	864,917	755,191
Southern Rhodesia	575,386	544,100
Republic of the Congo	188,693	66,327
Other countries	219,480	210,508
Total	30,960,000	32,130,000
Oceania		
Australia	965,113	877,139
Fiji	100,493	109,095
New Guinea	38,934	32,439
Other countries	8,991	12,191
Total	1,113,531	1,030,864
World total (estimate)	46,200,000	47,700,000

Source: US Bureau of Mines Mineral Trade Notes. For Canada, Dominion Bureau of Statistics.

GOLD PRODUCERS AND PROSPECTIVE PRODUCERS, 1966

(Numbers refer to numbers on the map)

Newfoundland

1. Atlantic Coast Copper Corporation Limited (a)
   Consolidated Rambler Mines Limited (a)
   First Maritime Mining Corporation 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. The Coniagas Mines, Limited (a)
9. *Noranda-Rouyn District*
   Lake Dufault Mines, Limited (a)
   Noranda Mines Limited (a)
   Peel-Elder Limited (b)
   Quemont Mining Corporation, Limited (a)
   Wasamac Mines Limited (b)
   Wasamac Mines Limited (Francoeur) (b) (d)
   Malartic District
   Barnat Mines Ltd. (b)
   Camflo Mines Limited (b)
   East Malartic Mines Limited (b)
   Little Long Lac Gold Mines Limited (b)
   Marban Gold Mines Limited (b)
   Willroy Mines Limited (Norlartic Mine) (b)
   Bourlamaque-Louvicourt District
   Chimo Gold Mines Limited (b)
   Lamaque Mining Company Limited (b)
   Manitou-Barvue Mines Limited (a)
   Sigma Mines (Quebec) Limited (b)
   Sullico Mines Limited (a)
   Sullivan Consolidated Mines, Limited (b)
   Duparquet District
   Normetal Mining Corporation, Limited (a)
10. *Matagami District*
    Mattagami Lake Mines Limited (a)
    New Hosco Mines Limited (a)
    Orchan Mines Limited (a)
11. *Belleterre District*
    Lorraine Mining Company Limited (a)

Ontario

12. *Larder Lake District*
    Kerr Addison Mines Limited (b)
    Kirkland Lake District
    Lamaque Mining Company Limited (Teck Mining Division) (b)
    Macassa Gold Mines Limited (b)
    Oakdale Mines Limited (b) (d)
    Upper Beaver Mines Limited (a)
    Upper Canada Mines Limited (b)
13. *Porcupine District*
    Aunor Gold Mines Limited (b)
    Dome Mines Limited (b)
    Hallnor Mines, Limited (b)
    Hollinger Consolidated Gold Mines, Limited (Hollinger) (b)
    Hollinger Consolidated Gold Mines, Limited (Ross) (b)
    McIntyre Porcupine Mines Limited (a) (b)
    Pamour Porcupine Mines, Limited (b)
    Porcupine Paymaster Limited (b)
    Preston Mines Limited (b)
    Texas Gulf Sulphur Company (a)
    Matachewan District
    Stairs Exploration & Mining Company Limited (b)
14. *Sudbury Mining Division*
    Falconbridge Nickel Mines, Limited (a)
    The International Nickel Company of Canada, Limited (a)
15. Renabie Mines Limited (b)
    Surluga Gold Mines Limited (b) (d)
16. *Port Arthur Mining Division*
    Noranda Mines Limited (Geco Mine) (a)
17. Consolidated Mosher Mines Limited (b)
    MacLeod-Cockshutt Gold Mines Limited (b)
18. North Coldstream Mines Limited (a)
19. *Fort Frances Mining Division*
    Sapawe Gold Mines Limited (b)
20. *Patricia Mining Division*
    Pickle Crow Gold Mines, Limited (b)
21. *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)
    McKenzie Red Lake Gold Mines Limited (b)
    Robin Red Lake Mines Limited (b) (d)
    Wilmar Mines Limited (b) (d)

Manitoba

22. Hudson Bay Mining and Smelting Co., Limited (a)
23. Hudson Bay Mining and Smelting Co., Limited (Snow Lake) (a)
    The International Nickel Company of Canada, Limited (Thompson Mine) (a)
24. San Antonio Gold Mines Limited (b)
25. Sherritt Gordon Mines, Limited (a)

Saskatchewan

22. Hudson Bay Mining and Smelting Co., Limited (a)
26. Anglo-Rouyn Mines Limited (a)

British Columbia

27. Cominco Ltd. (a)
28. The Granby Mining Company Limited (Phoenix Copper Division) (a)
29. Bethlehem Copper Corporation Ltd. (a)
30. The Anaconda Company (Canada) Ltd. (Britannia Mine) (a)
    Texada Mines Ltd. (a)
31. Coast Copper Company, Limited (a)
32. Bralorne Pioneer Mines Limited (b)
33. The Cariboo Gold Quartz Mining Company, Limited (b)

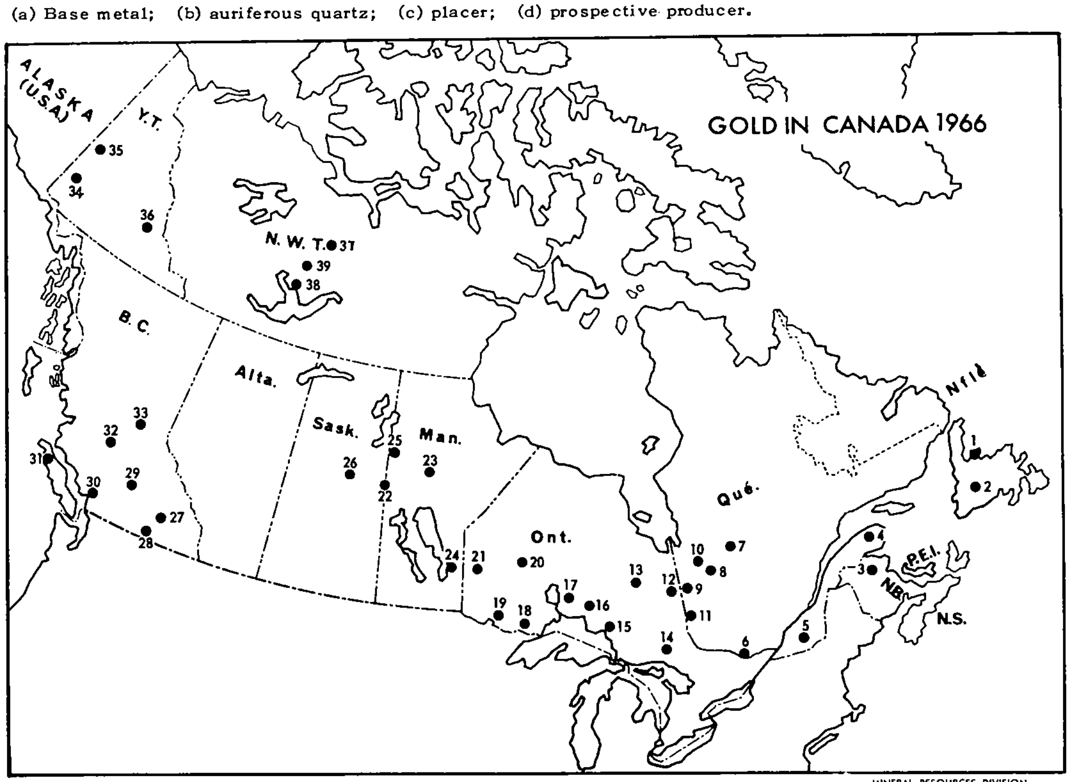
Yukon Territory

34. Small placer operations (c)
35. The Yukon Consolidated Gold Corporation, Limited (c)
    Small placer operations (c)
36. Discovery Mines Limited (LaForma Mine) (b)

Northwest Territories

37. Tundra Gold Mines Limited (b)
38. Cominco Ltd. (Con, Rycon and Vol mines) (b)
    Giant Yellowknife Mines Limited (b)
39. Discovery Mines Limited (b)

(a) Base metal; (b) auriferous quartz; (c) placer; (d) prospective producer.



MINERAL RESOURCES DIVISION
DEPARTMENT OF ENERGY, MINES AND RESOURCES

TABLE 3

Canadian Gold Production, 1957-66

Year	Auriferous-Quartz Mines (troy ounces)	%	Placer Operations (troy ounces)	%	From Base-Metal Ores (troy ounces)	%	Total Production (troy ounces)	Total Value ($ Can.)	Average Value per Ounce ($ Can.)	Gold as % of All Mineral Production Value
1957	3,766,285	85.0	76,303	1.7	591,306	13.3	4,433,894	148,757,143	33.55	6.8
1958	3,928,187	85.9	71,955	1.6	571,205	12.5	4,571,347	155,334,370	33.98	7.4
1959	3,852,074	85.9	72,974	1.6	558,368	12.5	4,483,416	150,508,275	33.57	6.2
1960	3,930,366	84.9	80,804	1.7	617,741	13.4	4,628,911	157,151,527	33.95	6.3
1961	3,774,522	84.4	69,240	1.5	629,937	14.1	4,473,699	158,637,366	35.46	6.1
1962	3,494,821	83.6	57,760	1.4	625,815	15.0	4,178,396	156,313,794	37.41	5.5
1963	3,324,907	83.1	57,905	1.4	620,315	15.5	4,003,127	151,118,045	37.75	5.0
1964	3,151,593	82.2	58,512	1.5	625,349	16.3	3,835,454	144,788,388	37.75	4.3
1965	2,958,874	82.1	44,598	1.2	602,559	16.7	3,606,031	136,051,943	37.73	3.6
1966P	2,693,974	81.2	43,186	1.3	580,328	17.5	3,317,488	125,102,472	37.71	3.1

Source: Dominion Bureau of Statistics.
P Preliminary

ONTARIO

Twenty-five lode gold mines operated in the province in 1966 as compared to 31 in 1965. Production from one operator was small and intermittent. Four of the 25 mines closed during the year. Production was about 15.3 per cent lower than in 1965.

Auriferous-Quartz Mines

Kirkland Lake District — Three gold mines operated in this district in 1966. In addition, Lake Shore Mines, Limited, recovered gold from the re-treatment of old tailings. Oakdale Mines Limited produced some gold from development work and Upper Beaver Mines Limited recovered considerable gold from its gold-copper mine. Production at Macassa Gold Mines Limited suffered a decrease while the Teck-Hughes Mining Division of the Lamaque Mining Company Limited operated on a salvage basis and produced slightly less gold than in 1965. The Teck-Hughes mine is scheduled to close in 1967. Production at Upper Canada Mines, Limited, was slightly lower.

Larder Lake District — Kerr Addison Mines Limited continued a planned reduction in the scale of operations and, as a result, production in 1966 declined approximately 15 per cent from that in 1965.

Porcupine District — Porcupine Paymaster Limited ceased production during 1966 when operating conditions became completely uneconomic. Hollinger Consolidated Gold Mines, Limited, operated throughout 1966 on a salvage basis at its main mine and production was substantially lower. Production is expected to continue throughout 1967. McIntyre Porcupine Mines Limited reduced the tonnage of gold ore treated as a greater tonnage of copper ore was milled. Aunor Gold Mines Limited, Dome Mines Limited and Pamour Porcupine Mines, Limited, maintained production in 1966 at about the 1965 levels. Production was lower at Hallnor Mines, Limited, Preston Mines Limited and the Ross mine of Hollinger Consolidated Gold Mines, Limited. The nine mines, including Porcupine Paymaster, produced about 16.4 per cent less gold than the 11 mines which were in operation in 1965.

Sudbury Mining Division – Renabie Mines Limited near Missinabie produced slightly more gold in 1966 than in the previous year.

Port Arthur Mining Division – Production decreased substantially at both Consolidated Mosher Mines Limited and MacLeod-Cockshutt Gold Mines Limited near Geraldton. The two mines, which work as a combined operation, produced about 26.3 per cent less gold in 1966 than the three mines which operated in the division in 1965. Consolidated Mosher and MacLeod-Cockshutt will operate on salvage basis for the next two years.

Red Lake and Patricia Mining Division – Seven mines operated in 1966; the same as in the year previous. However, McKenzie Red Lake Gold Mines Limited at Red Lake and Pickle Crow Gold Mines, Limited, at Pickle Crow closed during the year. Due to the two closures and sharp drops in production at Cochenour Willans Gold Mines, Limited, and Madsen Red Lake Gold Mines Limited, combined production in 1966 was close to 11.4 per cent lower than in 1965. Campbell Red Lake Mines Limited, Dickenson Mines Limited and Annco Mines Limited, controlled and operated by Cochenour Willans, increased output.

Matachewan District – Stairs Exploration & Mining Company Limited ceased operation in 1966 after recording a small production.

Fort Frances Mining Division – Sapawe Gold Mines Limited, after a shaft-deepening program in 1965, resumed intermittent production in 1966.

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 Limited near Timmins also recovered gold from its copper ore and Upper Beaver Mines Limited near Kirkland Lake produced appreciable gold from its gold-copper ores. Late in 1966 Texas Gulf Sulphur Company began production at its large copper-zinc mine near Timmins and it is anticipated byproduct gold will be produced.

PRAIRIE PROVINCES

San Antonio Gold Mines Limited at Bissett, Manitoba, continued production in 1966 but output declined. This operation is the only lode gold mine in the prairie provinces.

Hudson Bay Mining and Smelting Co., Limited, produced byproduct gold from its base-metal operations at Flin Flon and Snow Lake. Sherritt Gordon Mines, Limited, at Lynn Lake, Manitoba, and Anglo-Rouyn Mines Limited near Lac La Ronge in Saskatchewan also produced byproduct gold. The International Nickel Company of Canada, Limited produced a small amount of gold from its nickel-copper ores at Thompson, Manitoba.

Byproduct gold in small amounts is recovered annually by gravel-producing operations on the North Saskatchewan River near Edmonton.

BRITISH COLUMBIA

Production in 1966 was substantially lower at Bralorne Pioneer Mines Limited and slightly higher at the province's second lode gold mine operated by The Cariboo Gold Quartz Mining Company, Limited. Cariboo Gold has announced that it will probably close in 1967. Total output in 1966 from all sources in the province was slightly higher than in 1965. The recovery of placer gold, although still small, improved over 1965.

Byproduct gold production from base-metal mines rose sharply in 1966, an increase of about 22.9 per cent. The Phoenix Copper Division of The Granby Mining Company Limited, Coast Copper Company, Limited, and Cominco Ltd. were the three largest contributors. Western Mines Limited began production late in 1966 and expects to turn out a relatively large amount of byproduct gold annually.

NORTHWEST TERRITORIES

Discovery Mines Limited increased production sizably in 1966 while the Con mine of Cominco Ltd. produced slightly more than in 1965. Output declined sharply at Giant Yellowknife Mines Limited and Tundra Gold Mines Limited and the Rycon mine of Cominco Ltd. produced less than in 1965. A small amount of gold was produced by the Vol mine of Cominco Ltd. In total, production declined about 6.9 per cent from 1965.

YUKON TERRITORY

The LaForma lode gold mine of Discovery Mines Limited ceased operations near Carmacks in early 1966. This was the only lode gold mine in the territory.

Placer gold production was slightly lower in 1966 when compared with 1965. The Yukon Consolidated Gold Corporation, Limited, the largest placer operator in Canada, terminated operations near Dawson at the end of 1966. As this operator produced 75 to 80 per cent of the territory's annual placer gold, production in future years will decline markedly.

NEW PROPERTY DEVELOPMENTS

QUEBEC

In 1966 Wasamac Mines Limited began a shaft-sinking program on the gold property formerly owned by Francoeur Mines Limited. Plans are to bring the property into production in 1968 at a rate of at least 400 tons of ore per day. The ore will be trucked to the Wasamac mill, about five miles distant. The Wasamac mine is situated a short distance west of Noranda.

Equity Explorations Limited has formulated plans for shaft sinking and development at its gold property in the Joutel area of Quebec. The program was scheduled to commence in early 1967.

ONTARIO

Oakdale Mines Limited, formerly Tegren Gold Mines, Limited, continued underground development in 1966 on its gold property at Kirkland Lake. The program is being conducted through the extension of the workings from the adjoining Macassa Gold Mines Limited.

In 1966 Surluga Gold Mines Limited completed shaft sinking on its gold property near Wawa. Plans are to eventually proceed to production at a milling rate of at least 600 tons per day if underground development proves that indicated ore reserves are up to expectations.

Robin Red Lake Mines Limited continued underground exploration and development in 1966 on its gold property in the Red Lake area. The work is being carried out by Dickenson Mines Limited from the extension of the workings from its adjoining gold mine. Finances for the program are furnished by Dickenson, Noranda Mines Limited and Dome Mines Limited.

Also near Red Lake, Wilmar Mines Limited proceeded with an underground exploration and development program in 1966. The work is done by Cochenour Willans Gold Mines, Limited, from the adjoining Cochenour workings.

MANITOBA

Surface drilling was carried out in 1966 by Agassiz Mines Limited on a gold property near Lynn Lake. The company was considering shaft sinking and underground work in early 1967.

NORTHWEST TERRITORIES

In 1966 near Yellowknife, Lolor Mines Limited began production. Lolor, a subsidiary of Giant Yellowknife Mines Limited, is developed through the extension of the Giant Yellowknife workings and the ore is treated in Giant Yellowknife's mill.

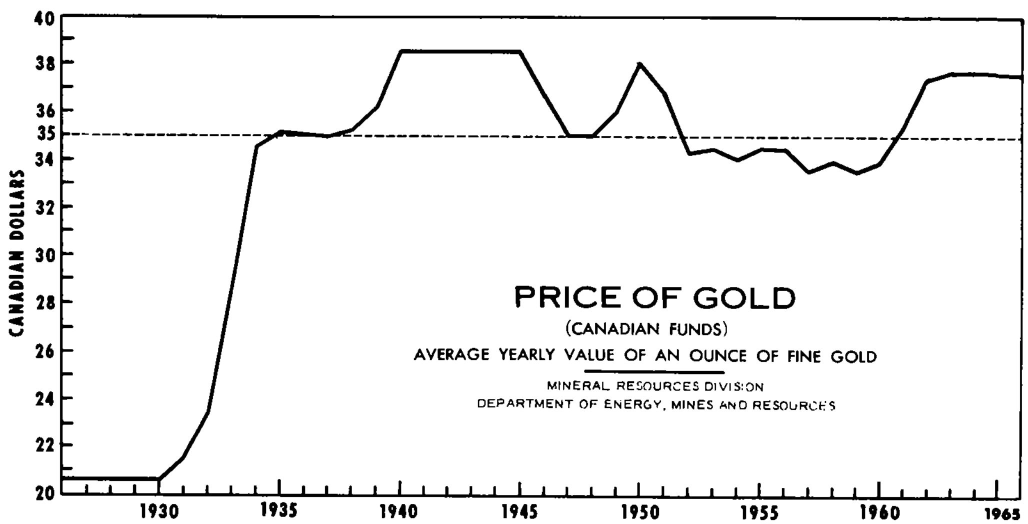
Giant Yellowknife also carried out underground exploration and development on the adjoining property owned by Supercrest Mines Limited. This property was formerly held by Akaitcho Yellowknife Gold Mines Limited. Giant Yellowknife and Akaitcho each have a 50 per cent interest in Supercrest.

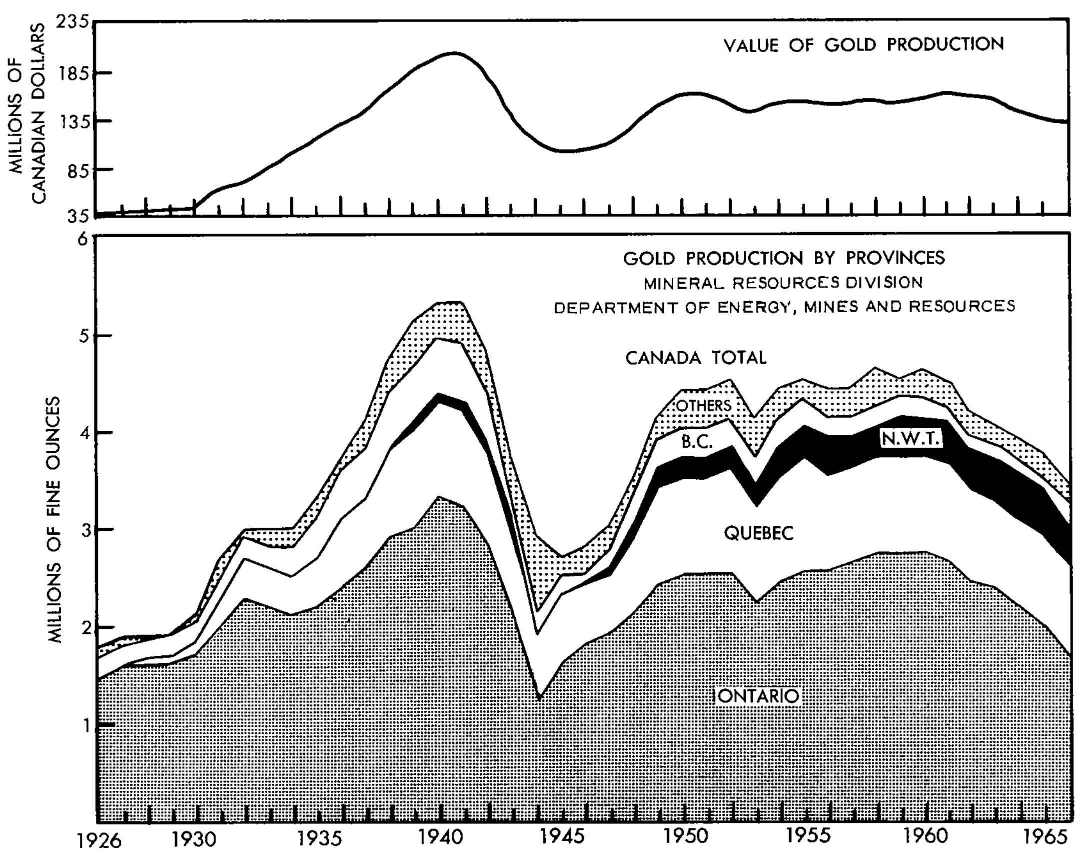
USES

Today, gold is principally used as a monetary reserve by governments and central banks to give stability to paper currencies and to assist in the settlement of international trade balances.

However, the demand for gold for industrial uses, including the arts and jewelry manufacture, has greatly increased in recent years. Industrial uses are estimated to have consumed gold valued in excess of $500 million in 1966 or approximately one-third of the world's new production. This compares with about $450 million and $400 million in 1965 and 1964, respectively.

About 75 per cent of the industrial uses consist of the manufacture of jewelry and objects of art. The remainder is consumed in the electrical and electronic, chemical, glass-making and textile fields and in various aerospace applications.


PRICE OF GOLD
(CANADIAN FUNDS)
AVERAGE YEARLY VALUE OF AN OUNCE OF FINE GOLD
MINERAL RESOURCES DIVISION
DEPARTMENT OF ENERGY, MINES AND RESOURCES
CANADIAN DOLLARS
40
38
36
35
34
32
30
28
26
24
22
20
1930
1935
1940
1945
1950
1955
1960
1965


VALUE OF GOLD PRODUCTION
MILLIONS OF CANADIAN DOLLARS
235
185
135
85
35
GOLD PRODUCTION BY PROVINCES
MINERAL RESOURCES DIVISION
DEPARTMENT OF ENERGY, MINES AND RESOURCES
CANADA TOTAL
OTHERS
B.C.
N.W.T.
QUEBEC
ONTARIO
MILLIONS OF FINE OUNCES
6
5
4
3
2
1
1926
1930
1935
1940
1945
1950
1955
1960
1965

PRICES

The average price paid by the Royal Canadian Mint in 1966 for gold was $37.71 per fine ounce. This compares with $37.73 in 1965 and $37.75 in 1964. During 1966, the price fluctuated between a low of $37.58 and a high of $37.92. 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.

Gypsum and Anhydrite

R.K. COLLINGS*

Canada is well endowed with large, well located gypsum deposits, many of which contain gypsum of high purity. Deposits are known in all provinces except Prince Edward Island and Saskatchewan, and gypsum is produced in each of the remaining provinces with the exception of Quebec and Alberta. Nova Scotia, the chief producer, annually accounts for 75 to 80 per cent of the total domestic production and ships most of its output to gypsum-product plants located along the eastern coast of the United States.

Canada dropped to third place as a world producer of gypsum in 1966 and now follows France as well as the United States. Domestic production declined for the second consecutive yeai to slightly under 6 million tons in 1966 as a direct result of reduced activity in the building construction industry, particularly with respect to the construction of apartment buildings and individual houses. Exports of crude gypsum, all to the United States in 1966, totalled 4.67 million tons, slightly less than 1965. Imports, on the other hand, showed a slight increase – from 75,433 tons in 1965 to 85,913 tons. Mostly from Mexico, this gypsum was largely to supply a gypsum-products plant in the Vancouver area.

Although reduced output in 1965 and again in 1966 would appear to indicate a trend towards decreased consumption of gypsum, increased activity in the building construction industry over the next few years is expected to reverse this trend. Drywall construction utilizing gypsum wallboard, because it is rapid and relatively inexpensive, is the common method of finishing interior walls and ceilings in private dwellings and in many apartment and office buildings. This application for gypsum wallboard continues to expand despite increased use of other panel building materials such as masonite and plywood.

Although many domestic gypsum deposits are well located and reserves adequate, this is not the case in all areas of Canada, notably Quebec, Alberta and, to a lesser degree, British Columbia. The two gypsum-products plants in Montreal bring in crude from Nova Scotia, while the two plants in Calgary obtain crude from British Columbia and Manitoba. Although gypsum deposits occur in Alberta, several of the more interesting deposits are in national parks and, under present legislation, are not available for mining. One of the two gypsum-products plants in Vancouver obtains gypsum from a company-operated quarry in the

*Mineral Processing Division, Mines Branch.

southeastern part of the province; 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.

A development of interest during 1966 was the decision of British-American Construction & Materials Limited, a Winnipeg firm, to enter the gypsum-products field. This company has under construction a fully-automated gypsum wallboard plant in Saskatoon and is developing a mine near Amaranth, Manitoba, as a source of crude gypsum. A 15° incline shaft is being sunk to the gypsum which is 125 feet below surface in this area. The mine, to be operated on a room and pillar system, will have an initial capacity of 400 tons per shift.

TABLE 1

Gypsum — Production and Trade, 1965-66

	1965		1966P	
	Short Tons	$	Short Tons	$
Production (shipments)				
Crude gypsum				
Nova Scotia	4,862,485	8,619,989	4,542,851	8,587,505
Ontario	531,918	1,444,293	550,000	1,508,000
Newfoundland	442,655	1,088,531	457,408	1,166,390
British Columbia	207,705	648,221	215,789	631,380
Manitoba	159,854	521,242	108,649	278,211
New Brunswick	101,012	211,108	107,232	231,470
Total	6,305,629	12,533,384	5,981,929	12,402,956
Imports				
Crude gypsum				
Mexico	74,341	241,677	85,000	276,000
United States	1,066	24,323	894	32,000
Britain	26	1,348	19	1,000
Total	75,433	267,348	85,913	309,000
Plaster of paris and wall plaster				
United States	4,344	180,029	7,967	407,000
Britain	365	17,796	160	8,000
Other countries	13	1,065	10	1,000
Total	4,722	198,890	8,137	416,000
Gypsum lath, wallboard and basic products				
United States	2,585	174,822	641	17,000
Total imports		641,060		742,000
Exports				
Crude gypsum				
United States	4,716,202	8,268,167	4,672,518	8,327,000
Bahamas	30,436	67,008	—	—
Total	4,746,638	8,335,175	4,672,518	8,327,000

Source: Dominion Bureau of Statistics.
P Preliminary; — Nil

TABLE 2

Gypsum Production, Trade and Consumption, 1957-66
(short tons)

	Production[1]	Imports[2]	Exports[2]	Apparent Consumption[3]
1957	4,577,492	92,139	3,410,684	1,258,947
1958	3,964,129	108,038	2,898,230	1,173,937
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
1966P	5,981,929	85,913	4,672,518	1,395,324

Source: Dominion Bureau of Statistics.
[1] Producers' shipments, crude gypsum. [2] Includes crude and ground but not calcined. [3] Production plus imports minus exports.
P Preliminary

TABLE 3

World Production of Gypsum, 1965-66
(thousand short tons)

	1965	1966e
United States	10,035	10,090
Canada	6,306	5,982
France	5,401	6,200
Britain	4,911	5,000
USSR	4,740	..
Spain	3,147	..
Italy	2,646	3,100
Other countries	14,514	..
Total	51,700	52,770

Source: Canada, Dominion Bureau of Statistics; all other countries, US Bureau of Mines Preprint, Gypsum, 1965 and US Bureau of Mines Commodity Data Summaries, January 1967.
e Estimate; .. Not available

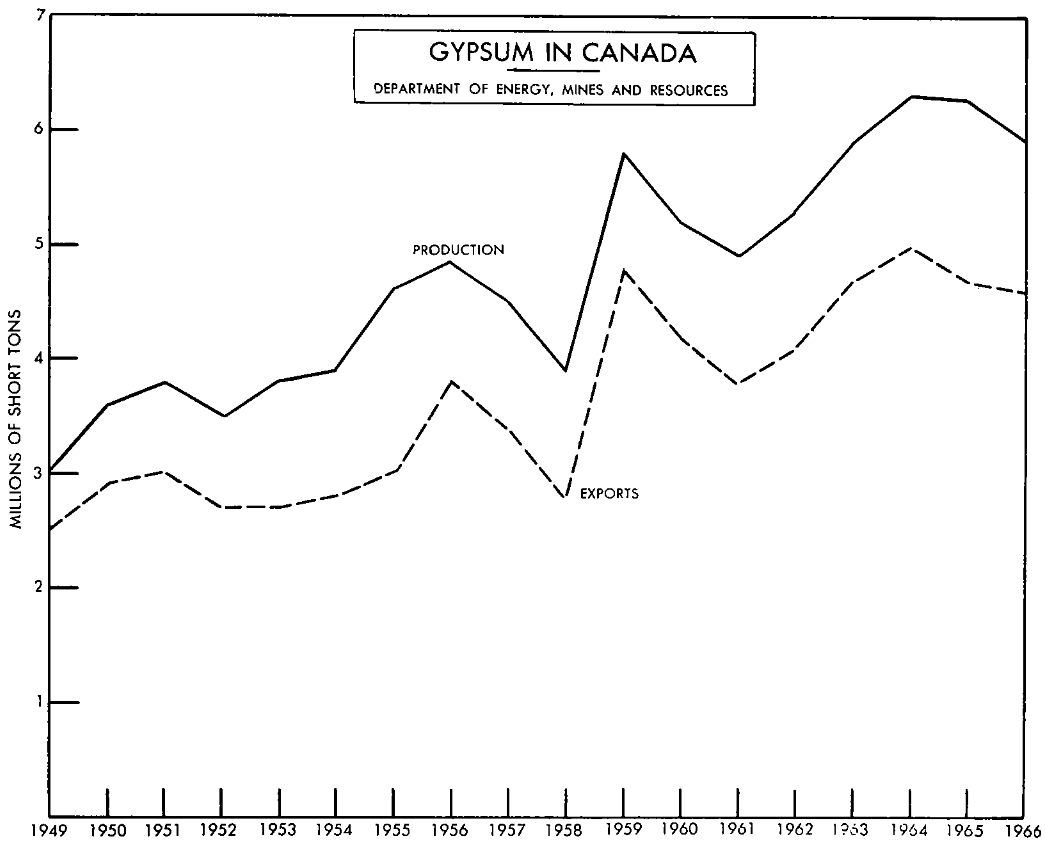
The rapid expansion of Canada's phosphate fertilizer industry is resulting in the accumulation of large tonnages of by-product, synthetic gypsum. Produced during the manufacture of phosphoric acid by the action of sulphuric acid on phosphate rock, this gypsum is finely divided and relatively impure. It is now produced in British Columbia, Alberta, Manitoba, Ontario and Quebec, and will soon be produced in New Brunswick. Production currently is in the order of 2 million tons per year. Although essentially a waste material in Canada and the United States, by-product, 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.

OCCURRENCES

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 extensive 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 are 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; at Amaranth, where 40 feet of gypsum occurs at a depth of 100 feet; and at Silver Plains, 30 miles south of Winnipeg, where high-quality 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 occurs along the banks of the Slave and Salt rivers north and west of Fort Fitzgerald and as narrow seams interbedded with anhydrite at a depth of 500 feet at McMurray in the northeastern section of the province. 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 Territory and, in the Northwest 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.

CURRENT OPERATIONS

NOVA SCOTIA

There are 5 companies actively producing gypsum in Nova Scotia. Production totalled 4.5 million tons in 1966, 75 per cent of the Canadian total. Over 90 per cent of the production of this province was exported to the United States in 1966.

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 Montreal.

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. 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 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 quarries at Flat Bay Station, 60 miles southwest of Humbermouth, which are operated by The Flintkote Company of Canada Limited. The bulk of the 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 Products 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 Products 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.

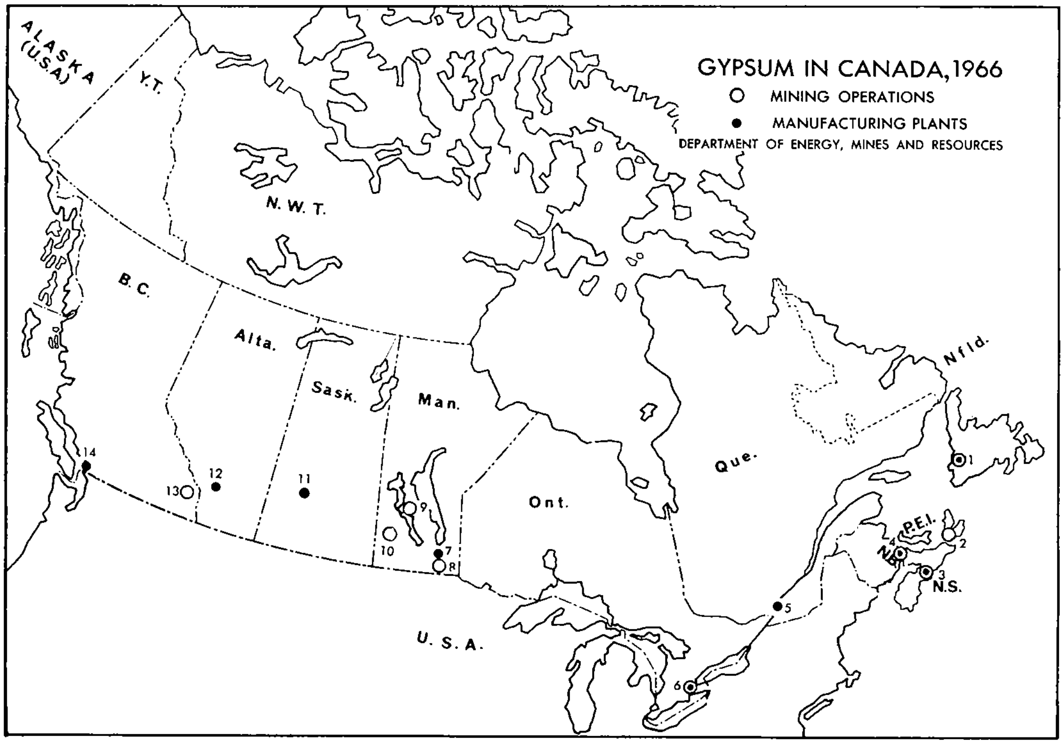
NEW BRUNSWICK

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.

OTHER PROCESSING PLANTS

QUEBEC

Domtar Construction Materials Ltd. and Canadian Gypsum Company, Limited operate gypsum-products plants in Montreal East. Crude gypsum is obtained from Nova Scotia.



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 Products Limited, Silver Plains (underground)
9. Domtar Construction Materials Ltd., Gypsumville
10. British-American Construction & Materials Limited, Amaranth (underground, under construction during 1966)
13. Western Gypsum Products Limited, 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 Products Limited, Clarkson
7. Domtar Construction Materials Ltd., Winnipeg
   Western Gypsum Products Limited, Winnipeg
11. British-American Construction & Materials Limited, Saskatoon (under construction during 1966)
12. Domtar Construction Materials Ltd., Calgary
    Western Gypsum Products Limited, Calgary
14. Domtar Construction Materials Ltd., Port Mann
    Western Gypsum Products Limited, Vancouver

*Surface operations except where noted otherwise.

ONTARIO

Western Gypsum Products Limited produces gypsum products at Clarkson, southwest of Toronto. Crude gypsum is obtained from mines in southern Ontario.

ALBERTA

Domtar Construction Materials Ltd. and Western Gypsum Products Limited produce plaster and wallboard in Calgary. Gypsum is obtained from British Columbia and Manitoba.

BRITISH COLUMBIA

Domtar Construction Materials Ltd. and Western Gypsum Products Limited have plants in Vancouver for gypsum plaster and wallboard production. The former obtains crude gypsum from Mexico, the latter from its Windermere deposit.

USES

Calcined gypsum, or plaster of paris, 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. These products are used by the building-construction industry for sheeting interior walls and ceilings.

Crude uncalcined gypsum is used in the manufacture of portland cement. The gypsum acts as a retarder to control set. Crude gypsum, reduced to 100 mesh or finer, 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, as a soil conditioner, offsets the effect of black alkali; aids in restoring impervious, dispersed soil; and is a fertilizer for peanuts and other legumes.

ANHYDRITE*

Anhydrite, an anhydrous calcium sulphate, 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 1966 was about 280,000 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 coproduct cement. The gases are then converted into sulphuric acid.

*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.

TARIFFS

	British Preferential (%)	Most Favoured Nation (%)	General (%)
Canada			
Gypsum, crude	free	free	free
Gypsum, ground, not calcined	10	12½	15
Gypsum wallboard and lath	15	20	35
Plaster of paris and prepared wall plaster, per 100 lb	free	11¢	12½¢
United States			
Gypsum, crude	free		
Gypsum, ground or calcined, per long ton	$1.19		
Gypsum wallboard and lath	12½		

Indium

D.B. FRASER*

Indium is a silvery-white, soft metal which resembles tin in its physical and chemical properties. It occurs in minute quantities in certain ores of zinc, lead, tin, tungsten and iron. It is most commonly associated with sphalerite, the most abundant zinc mineral. Like many of the rare metals, indium becomes concentrated in residues and slags formed during the recovery of other metals, principally zinc and lead. The metal is produced commercially at only a few of the world's zinc and lead smelters.

Statistics on the output 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 also in the United States, 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, B.C., 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) of indium. The metal is cast in ingots varying in size from 10 ounces to 10 kilograms. Also pro-

*Mineral Resources Division.

duced 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

The chief characteristics of indium are its extreme softness, its low melting point and high boiling point. It is easily scratched with the fingernail and can be made to adhere to other metals by hand-rubbing. It has a melting point of 156°C. Like tin, a rod of indium will emit a high-pitched sound if bent quickly. The metal has an atomic weight of 114.8; its specific gravity at room temperature is 7.31, which is about the same as that 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. 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 U.S. and Britain, and smaller amounts go to a number of countries in Europe.

PRICES

Prices of indium as quoted in *E & MJ Metal and Mineral Markets* remained during 1966 at the levels that became effective on October 5, 1965:

Sticks, 30-90 troy oz	– $2.75 a troy oz
Ingot	
100 troy oz	– $2.30 a troy oz
10,000+ troy oz	– $2.00 a troy oz

Iron Ore

V.B. SCHNEIDER*

Iron ore shipments reached an all-time high of 36.2 million tons** in 1966, valued at $419 million. This was the fifth consecutive year that shipments increased but the increase of slightly less than 2 per cent was the smallest of any of the previous five years and reflected reduced exports to Belgium-Luxembourg, Britain, West Germany and Japan. Shipments to Italy, the United States and to domestic consumers increased to more than offset reductions in some offshore exports. Labour strikes during 1966 interrupted production of six companies; most were of short duration but that in British Columbia of Brynnor Mines Limited, which began in July, remained unsettled at the year's end.

Annual iron ore production capacity in Canada at the end of 1966 was 46 million tons, which includes 15.6 million tons of pellet capacity. Iron ore shipments via the St. Lawrence Seaway extended from April 15 to December 15 and from the head of the Great Lakes from April 4 to December 12. Iron ore shipments via the St. Lawrence section of the Seaway amounted to 13.8 million tons, all upbound; iron ore shipments via the Welland Canal section were 12.5 million tons upbound and 3.2 million tons downbound.

Wabana Mines Division, Dosco Industries Limited, closed its Bell Island, Newfoundland, mine on June 30 after 72 years of continuous operation. Shipments from the Wabana mine reached a high of 2.81 million tons in 1960 but had decreased to 1.2 million tons in 1965. Shipments from the mine since 1892 totalled 78,989,412 tons of which 34,578,326 tons were used in Canada and 44,411,086 tons were exported, mainly to West Germany, Britain, the United States, Belgium and Holland.

In Labrador, Iron Ore Company of Canada (IOC) commenced an expansion program that includes increasing the capacity of its Carol concentrator from 7 million to 10 million tons annually and the Carol pellet plant from 5.5 million tons to 10 million tons by November 1967. Beginning in 1968, with the Carol expansion completed, there will be an increase in total sales from the Carol and the Schefferville (Labrador-Quebec) operations to participating partners from 13 million to 16 million tons a year. Including sales to non-participants that could range up to 3 million tons a year, annual production by IOC from the two areas will be higher. The Schefferville operations, which first started shipping ore in 1954 together with the completion

*Mineral Resources Division.

**The long or gross ton (2,240 pounds) is used throughout unless otherwise noted.

of the present Carol expansion will represent a total investment in excess of $550 million. A fire on February 7 at Wabush Mines' concentrator reduced production through April. The concentrating plant at Wabush Lake, Labrador, and the pellet plant at Pointe Noire, Quebec, are each being expanded to 6 million tons a year from 5.3 million and 4.9 million tons a year.

TABLE 1

Canada, Iron Ore Production and Trade, 1965-66

	1965		1966P	
	Long Tons	$	Long Tons	$
Production (shipments)				
Newfoundland	12,946,870	156,888,970	14,492,522	186,665,832
Quebec	13,230,196	140,469,624	12,336,935	128,707,024
Ontario	7,567,159	94,209,236	7,369,087	82,969,491
British Columbia	1,933,396	21,497,031	1,959,666	20,765,430
Total	35,677,621	413,064,861	36,158,210	419,107,777
Byproduct iron ore*	1,136,546		1,003,487	
Imports				
United States	4,503,804	58,130,495	3,937,149	52,442,000
Brazil	259,225	2,419,220	327,853	3,145,000
Venezuela	–	–	36,999	320,000
India	–	–	21,120	117,000
Total	4,763,029	60,549,715	4,323,121	56,024,000
Exports				
Iron ore direct shipping				
United States	7,181,726	73,669,321	6,033,833	61,887,000
Italy	45,243	436,142	548,898	5,296,000
Britain	278,134	2,684,844	274,859	2,612,000
Netherlands	44,234	441,454	–	–
West Germany	27,913	278,571	–	–
Total	7,577,250	77,510,332	6,857,590	69,795,000
Iron ore concentrates				
United States	8,741,972	96,953,234	8,865,778	96,146,000
Japan	1,773,012	19,734,258	1,689,409	18,145,000
Britain	1,940,608	18,814,649	1,424,793	13,287,000
West Germany	636,244	5,170,618	532,353	3,225,000
Netherlands	242,499	2,392,004	372,522	3,826,000
Italy	342,831	3,630,156	272,975	2,387,000
Belgium and Luxembourg	531,046	4,594,497	83,885	674,000
Sweden	–	–	35,797	378,000
Total	14,208,212	151,289,416	13,277,512	138,068,000
Iron ore, agglomerated				
United States	7,223,323	105,922,538	8,896,733	135,203,000
Britain	695,898	10,303,260	521,820	7,880,000
Italy	180,205	2,730,319	311,925	5,175,000
Netherlands	163,660	2,432,225	161,132	2,329,000
West Germany	111,394	1,655,681	118,970	1,795,000
France	29,710	435,548	62,399	931,000
Other countries	1,500	21,990	16	1,000
Total	8,405,690	123,501,561	10,072,995	153,314,000

Table 1 – continued

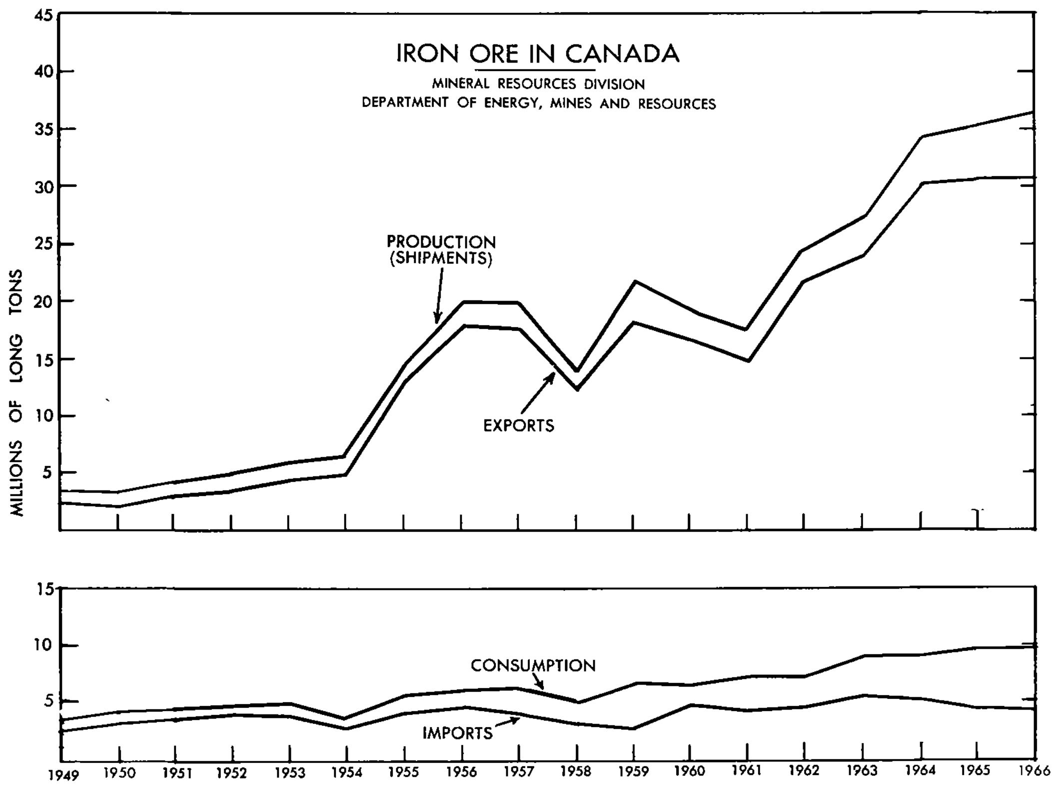
	1965		1966P	
	Short Tons	$	Short Tons	$
Iron ore, not elsewhere specified including byproduct iron ore				
United States	608,082	8,516,980	485,605	7,831,000
Netherlands	18	216	–	–
Other countries	–	–	43	1,000
Total	608,100	8,517,196	485,648	7,832,000
Total exports, all classes				
United States	23,755,103	285,062,073	24,281,949	301,067,000
Britain	2,914,640	31,802,753	2,221,472	23,779,000
Japan	1,773,012	19,734,258	1,689,409	18,145,000
Italy	568,279	6,796,617	1,133,798	12,858,000
West Germany	775,551	7,104,870	651,323	5,020,000
Netherlands	450,411	5,265,899	533,654	6,155,000
Belgium and Luxembourg	532,546	4,616,487	83,885	674,000
France	29,710	435,548	62,399	931,000
Sweden	–	–	35,797	378,000
Other countries	–	–	59	2,000
Total	30,799,252	360,818,505	30,693,745	369,009,000

Source: Dominion Bureau of Statistics.
*Total shipments of byproduct iron ore compiled by Mineral Resources Division from data supplied by individual companies. Total iron ore shipments include shipment of byproduct iron ore.
P Preliminary; – Nil.

In Ontario, Steep Rock Iron Mines Limited and The Algoma Steel Corporation, Limited signed a joint venture agreement whereby Algoma acquired title to ore reserves at the Roberts and Hogarth open pits in the middle arm of Steep Rock Lake. In co-operation with Algoma, Steep Rock Iron Mines will develop the properties, mine the ore and produce pellets grading 64 per cent iron. Construction of the pellet plant commenced mid-year and by the end of 1966 construction of the plant buildings was nearing completion with installation of machinery and the relocation of screening and other facilities under way. The agreement between Algoma and Steep Rock covers a minimum period of 20 years and involves the supply of 1.1 million tons of pellets a year to Algoma. As the reserves that Algoma acquired at Steep Rock are used, Algoma acquires an increasing interest in Steep Rock's large magnetite property at Lake St. Joseph, 165 miles north of Steep Rock Lake. The pelletizing plant will have an initial annual capacity of 1.35 million tons of pellets and is designed for expansion to 2 million tons. Steep Rock also signed a contract to supply Detroit Steel Co. with 250,000 tons of pellets a year for a minimum of ten years.

Work on The Steel Company of Canada, Limited's (Stelco) Griffith Mine on the west shore of Bruce Lake, Ontario, proceeded on schedule; projected startup of operations is for the spring of 1968. The new mine, concentrator and pellet plant, costing $60 million, will be capable of producing 1.5 million tons of pellets a year. To transport the pellets to Stelco's Hilton Works in Hamilton via Port Arthur, the Canadian National Railway is building a 68-mile branch line from Amesdale on its mainline to the Griffith Mine. The pellets will be shipped from the Lakehead to Hamilton from new bulk-handling facilities being prepared by The Valley Camp Coal Company of Canada, Limited. Valley Camp is spending $5 million on a 45-acre site leased from Canadian National Railways. Terminal loading capacity will be 5,000 tons an hour.

Stripping operations to remove 2 million cubic yards of overburden and rock commenced at Sherman Mine, five miles from Timagami,



Ontario. The mine, which is owned by Dominion Foundries and Steel, Limited (Dofasco) (90%) and a subsidiary of The Cleveland-Cliffs Iron Company (10%), is expected to produce pellets by the end of 1967 and capacity production of from 1 million to 1.2 million tons is expected in 1968. Mining will be by open-pit methods, with about 3.5 tons of crude ore being processed to make one ton of pellets grading better than 65 per cent iron. The pellets will be shipped year-round by rail, 320 miles to Dofasco's Hamilton steel plant.

Lowphos Ore Limited, a wholly-owned subsidiary of National Steel Corporation, changed its name to National Steel Corporation of Canada, Limited (effective July 14, 1966). The Hanna Mining Company operates the Moose Mountain mine near Capreol, Ontario, for National Steel.

In British Columbia, a fire that destroyed the concentrator of Empire Development Company, Limited in January held up production for six months. Orecan Mines Ltd. suspended mining and milling operations in September at its property on Vancouver Island. Wesfrob Mines Limited continues to prepare its mine at Tasu Harbour, Moresby Island, for production with the first shipment, amounting to some 55,000 tons of sinter feed, scheduled for June 1967. The plant will be capable of producing in excess of one million tons of magnetite concentrate grading 60% iron, a year; forty per cent will be for sinter feed and the remainder will be pellet feed.

TABLE 2

Canada, Iron Ore Production, Trade and Consumption, 1957-66
(long tons)

	Production (shipments)	Imports	Exports	Consumption* (indicated)
1957	19,885,870	4,052,704	17,972,769	5,965,805
1958	14,041,360	3,047,301	12,391,314	4,697,347
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
1966p	36,158,210	4,323,121	30,693,745	9,787,586

Source: Dominion Bureau of Statistics
*Shipments plus imports less exports with no account taken of changes in stocks at consuming plants.
p Preliminary.

TABLE 3

World Production of Iron Ore* by Country, 1963-66
(thousand long tons)

	1963	1964	1965	1966p
USSR	135,304	143,695	151,272	160,000
United States	73,599	84,836	87,430	92,000
France	56,978	59,971	59,166	57,000
Canada	26,914	34,219	35,678	36,158
China	34,400	36,400	30,510	..
Sweden	23,259	26,116	29,019	27,535
India	14,690	14,646	20,963	18,000
Venezuela	11,562	15,403	17,863	19,500
Liberia	6,453	10,291	17,420	16,800
Britain	14,912	16,068	15,413	12,500
Brazil	11,042	14,763	14,369	19,000
Chile	8,373	9,697	11,791	12,038
West Germany	12,694	11,430	10,676	9,000
Total	430,180	477,535	501,570	..
Other countries	83,481	88,878	89,187	..
World total	513,661	566,413	590,757	624,000

Source: For 1963-65, American Iron and Steel Institute Statistical Report, 1965. For 1966, United States Bureau of Mines Commodity Data Summaries, January 1967.
*Direct shipping, concentrates and agglomerates.
p Preliminary; .. Not available

WORLD PRODUCTION, MARKETS AND TRADE

World production of iron ore in 1966 exceeded 624 million tons, an increase of slightly more than 5 per cent from 1965. There was higher steel production in nearly all industrial countries, particularly in the United States, Japan, Italy, the Netherlands and the USSR. Steel production was lower in Britain, West Germany and France.

The steel industry in Canada and the United States obtains about 90 per cent of its iron ore requirements from 'captive' iron mines in that the steel companies receive iron ore nearly entirely from mines in which they participate or by 'trading' ores. There is relatively little 'merchant' ore used by the North American steel industry. On the other hand, most iron ore consumed by the steel industries of the other industrial nations of the non-communist world is obtained under contract from merchant iron ore companies. Steel companies in those countries have only recently been major participants in the financing of iron ore projects in foreign lands.

Changes in the production and marketing or iron ore are directly related to the ease of beneficiation, which upgrades and improves the physical properties of ores, so that they become more desirable as furnace feed. This trend toward beneficiation of iron ore to as high a degree as practicable for blast furnace feed continued and is becoming more pronounced each year. Pelletizing is the preferred method for agglomeration of iron ore concentrates from low-grade ores in North America. The rising trend toward greater use of pellets is due to economic, transportation, engineering and probably metallurgical factors. Many steel plants maintain high rates of pig iron production from efficient operations using sized, good-grade sinter, sometimes self-fluxing with rate of blast furnace output being comparable to that obtained by using pellets. Sinter is not transported long distances but is usually made at the blast furnace location using screened fines from good-grade direct-shipping ore or concentrate. Pellet capacity in Canada and the United States at the end of 1966 was 53 million tons a year; world capacity was about 65 million tons. Pellet capacity under construction or planned in the United States and Canada was nearly 21 million tons a year and in the rest of the world an estimated 11 million tons a year. Long-range projections of the growth of pellet capacity are uncertain and subject to much questioning and speculation though the trend toward using high-grade, sized feed for blast furnaces remains strong.

Trends in international iron ore trading patterns are important to the Canadian iron ore industry because of its dependence on exports for the bulk of its sales. United States, Britain, Japan and Western Europe constitute Canada's largest present and potential export markets. The domestic market presently about 10 million tons a year, supplied mostly by Canada and the United States is also a very important market. The participation of Canada's largest steel producer in United States iron ore mines predates the modern iron ore industry in Canada, which started in 1939 with the revival of operations at the site of the Helen Mine at Michipicoten, Ontario. This was followed by the opening of the deposit at Steep Rock Lake, Ontario, in 1944.

From a small exporter in 1950 Canada became the world's leading exporter of iron ore in 1963, a position maintained through 1966. 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.

Although West Germany is the largest iron ore importer in Western Europe, the steel industries of Belgium, Italy and Netherlands depend almost totally on imports for their ore needs. In 1966, Italy for the first time imported more iron ore from Canada than did West Germany. France and Luxembourg produce relatively low grade iron ore but France is the only significant exporter, mainly to Belgium and West Germany. Historically, France has never been a major iron ore importer but in recent years, because of the trend to construction of steel plants near the coast and because the iron ore mined in France is of relatively low grade, imports by France of high-grade ores have increased significantly.

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 with Australia promising to become Japan's major supplier by 1970 or shortly thereafter. The present leaders are India (including Goa), Malaysia, Chile and Peru. In 1966, Australia exported 1.9 million tons, of which 1.8 million tons went to Japan. According to the Bureau of Mineral Resources Geology and Geophysics, Department of National Development, Australia, the various projects under way have export contracts amounting to some 338 million tons to be fulfilled during the next 20 years. Some contracts are of long duration and others are as short as 3 years, but the average exports from 1970 on, based on existing contracts, could well increase to 26 million tons a year.

TABLE 4

Consumption of Iron Ore in Canadian Iron and Steel Plants, by Type of Furnace, 1965-66
(tons)

	1965	1966
In blast furnaces direct...........	7,835,208	8,001,746
In steel furnaces direct...........	254,675	256,515
In sintering plants before ore is charged to blast or steel furnaces....	1,188,084	1,104,562
Miscellaneous......	148	388
Total.........	9,278,115	9,363,211

Source: American Iron Ore Association compiled from company submissions

DOMESTIC CONSUMPTION

Iron ore is used primarily as a raw material in the making of iron and steel. Small amounts of iron oxide, not properly iron ore, are used in the manufacture of paint and cement, for heavy aggregate in concrete, as heavy media in some beneficiation plants and for agriculture. Most iron ore is made into pig iron, some of which is used by iron foundries. Most pig iron, however, along with steel scrap, fluxes, additive agents, etc., goes into the production of crude steel. Some iron ore is also used in the steelmaking furnaces. Canadian iron ore consumption between 1956 and 1965 increased 4½ per cent a year. This rate is based on tonnage only and does not reflect the better grade and quality used.

TABLE 5

Consumption and Stocks of Iron Ore at Canadian Iron and Steel Plants, by Source, 1965-66
(tons)

	1965	1966
Receipts imported ...	4,781,777	4,282,295
Receipts from domestic sources..	4,679,184	5,293,265
Total receipts at iron and steel plants...	9,460,961	9,575,560
Consumption of iron ore..............	9,278,115	9,363,211
Stocks of ore at iron and steel plants, December 31......	3,814,534	4,065,764
Change from previous year.............	+ 296,153	+ 251,230

Source: American Iron Ore Association compiled from company submissions.

TABLE 6

Production and Capacity of Pig Iron and Crude Steel at Canadian Iron and Steel Plants, 1965-66
(short tons)

	1965	1966p
Pig iron		
Production	7,064,880	7,212,543
Capacity at Dec. 31	7,643,000	7,764,000
Steel ingots and castings		
Production	10,028,899	10,002,868
Capacity at Dec. 31	11,797,770	12,261,226

Source: Dominion Bureau of Statistics.
p Preliminary

CANADIAN DEVELOPMENTS IN 1966

NEWFOUNDLAND AND LABRADOR

Dosco Industries Limited, Wabana Mines Division: Dosco was unsuccessful in its efforts to find economic methods for upgrading its Wabana iron ore and because of deteriorating sales outlook the mine ceased production in June. Shipments from stockpiled material continued throughout the year.

Iron Ore Company of Canada, Labrador City: Production of pellets and concentrates at the Carol Operation was almost at capacity. Shipments reached 6.5 million tons, made up of 1.3 million tons of concentrates and 5.2 million tons of pellets. Expansion of the concentrator from 7 million tons to 10 million tons annually and of the pellet plant from 5.5 million tons to 10 million tons commenced and should be completed late in 1967.

Wabush Mines (Scully Mine): A fire in February in the company's concentrator reduced production through April. Some concentrates were purchased from IOC for conversion to pellets at Arnaud Pellet's pellet plant at Pointe Noire, Quebec. Shipments amounted to 3.8 million tons made up of 136,179 tons of concentrate and 3.7 million tons of pellets. Mannesmann Canadian Iron Ores Ltd. and Hoesch Iron Ores Ltd. were expected to sell their interest in Wabush to the remaining eight owner companies. The company's concentrating plant at Wabush Lake is being expanded to 6 million tons a year from 5.3 million tons. The pellet plant of Arnaud Pellets is being expanded to 6 million tons a year from 4.9 million tons.

LABRADOR-QUEBEC

Iron Ore Company of Canada, Schefferville: Shipments of direct-shipping ore from the Schefferville, Quebec operations in Labrador and Quebec were 6.7 million tons, slightly lower than in 1965.

QUEBEC

Quebec Cartier Mining Company: Quebec Cartier shipped 8.32 million tons of concentrate, about the same as in 1965.

Hilton Mines, Ltd.: Hilton Mines shipped 815,712 tons of pellets; down slightly from 1965. The reduced output is attributable to a labour strike that stopped production in June and July.

Quebec Iron and Titanium Corporation: Quebec Iron and Titanium Corporation mines ilmenite, a titanium-iron oxide, at Lac Tio, Quebec, and smelts it in electric furnaces at Sorel, Quebec, to produce titania slag (TiO_2) and pig iron. Consumption of ilmenite at Sorel was 1,264,683 tons from which 524,773 tons of slag and 353,479 tons of pig iron were produced.

ONTARIO

Algoma Ore Division of The Algoma Steel Corporation, Limited: Algoma Ore shipped 1,793,394 tons of which 1,788,546 tons were sinter and 4,848 were low-grade direct shipping ore. Of the sinter a total of 1.5 million tons were shipped to Algoma Steel's works at Sault Ste. Marie and its blast furnace works at Port Colborne; 252,568 tons were exported to the United States. Algoma Ore continued to investigate possible new iron ore sources and entered into a 20-year contract with Steep Rock Iron Mines Limited to take 1.1 million tons of pellets a year.

Caland Ore Company Limited: Caland shipped 1,454,961 tons of which 452,696 tons were pellets, 172,842 tons were direct shipping ore and the remainder concentrates. Shipments were down about 5 per cent from 1965, reflecting the effects of an eight-week labour strike. The company commenced production of pellets in its $15-million plant, which is designed to produce one million tons of pellets a year.

Adams Mine (Jones & Laughlin Mining Company, Ltd.): shipments of pellets at 984,960 tons were up some 30% from 1965. It was the first full year of operations for the pellet plant which made its first trial shipment in December 1964 but did not commence regular shipments until February 1965. Pellets are shipped the year round by rail to the parent company's steel plants in the United States.

Marmoraton Mining Company, Ltd.: Shipments of pellets amounted to 495,684 tons of which 492,652 tons were shipped to Lackawanna, New York via the company's ore dock at

Picton, Ontario, where the shipping season extended from April 19 to December 3. All-rail shipments from Marmora to Lackawanna were 3,052 tons.

National Steel Corporation of Canada, Limited. (formerly Lowphos): Shipments of pellets in 1966 at 630,289 tons were down slightly from 1965.

Steep Rock Iron Mines Limited: Shipments in 1966 at 1,236,453 tons were down slightly from 1965. Of the shipments, 494,380 tons were run-of-mine crushed to minus 2½" and 742,073 tons were concentrates. Steep Rock commenced the construction of a 1.35-million-ton-a-year capacity pellet plant which it is building and operating as part of a joint venture agreement with The Algoma Steel Corporation, Limited.

The Griffith Mine (Stelco): Construction of the new concentrator and pelletizing plant continued on schedule at this property near Bruce Lake. The plant will have an initial annual capacity of 1.35 million tons of pellets, which will be shipped by rail to Port Arthur and then by boat to the parent company's Hilton Works in Hamilton, Ontario.

Sherman Mine: This project is owned 90 per cent by Dofasco of Hamilton, Ontario, and 10 per cent by Tetapaga Mining Company Limited, a wholly-owned subsidiary of The Cleveland-Cliffs Iron Company. It is being developed to produce 1.2 million tons of pellets a year with production scheduled for January 1968. Cliffs of Canada is developing the project and will operate it. Cost of the development is expected to exceed $40 million.

BRITISH COLUMBIA

Brynnor Mines Limited: A labour strike, still in effect at year's end, closed this operation in July. In 1966, until the strike, 335,488 tons of dry ore were mined from which 259,809 dry tons of concentrate containing 63.73 per cent iron was produced. Shipments for the year were 286,747 tons, all to Japan.

Coast Copper Company, Limited: Shipments of magnetite concentrate amounted to 65,600 tons. The magnetite concentrate is recovered at the company's Benson Lake property as a byproduct of copper recovery operations. All shipments were to Japan.

Empire Development Company, Limited: A fire in January that destroyed the company's concentrating plant held up production for 6 months. Shipments for the year totalled 59,489 tons of concentrate, all of which was shipped to Japan.

Jedway Iron Ore Limited: Jedway shipped 477,586 tons of sinter feed to Japan, up 37% from 1965.

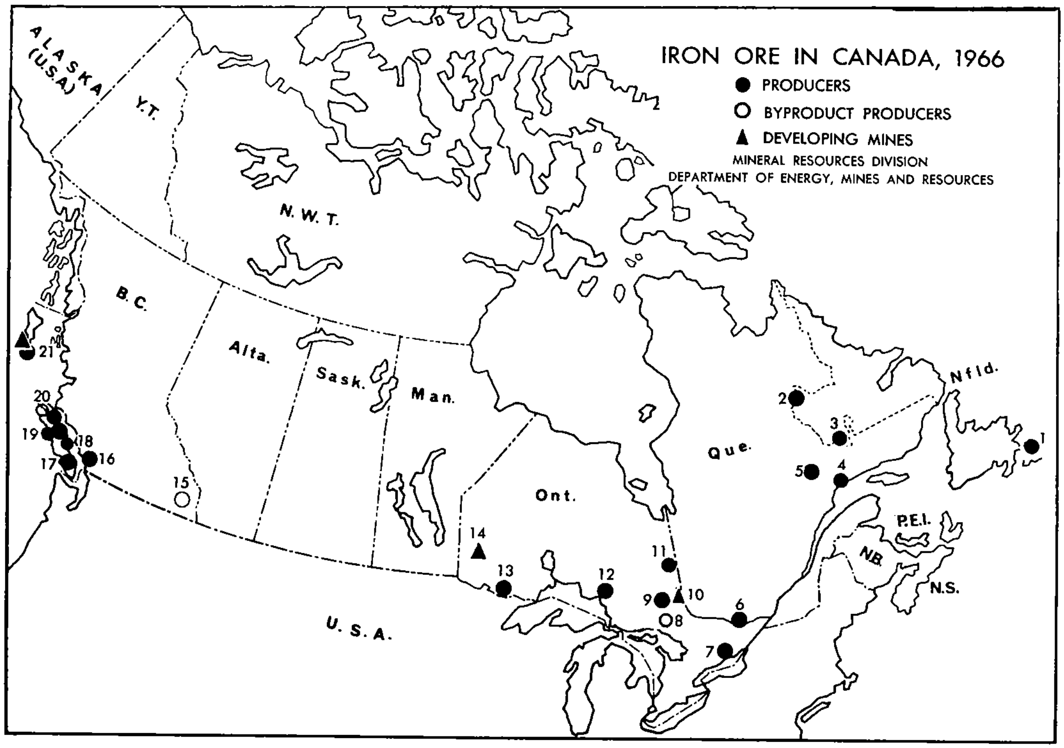
Orecan Mines Ltd.: Orecan suspended operations in September and "an assignment in Bankruptcy was filed on November 1, 1966". Shipments for the year are estimated at 113,000 tons.

Texada Mines Ltd.: Texada shipped 515,117 tons of concentrates to Japan, down about 2.8 per cent from 1965. Approximately 75,000 tons of a total of 1.1 million tons of crude ore mined came from an open-pit operation, the remainder came from underground operations.

Wesfrob Mines Limited: This company's plant which will be capable of producing more than one million tons of iron ore concentrates a year, was about 75 per cent completed by year's end. Forty per cent of the concentrate will consist of sinter feed, the remainder will be pellet feed. First shipment is expected in June 1967 and total shipments for 1967 should approach the half-million ton mark.

The plant will consist of an underground primary crusher; a secondary crushing and cobbing plant; a concentrator; concentrate stockpile complex; a concentrate reclaiming, shiploading complex including deep sea berth; a 11,000 H.P. diesel generating plant; and water supply. A permanent townsite of 88 homes and commercial and recreational facilities was completed.

Zeballos Iron Mines Limited: Shipments totalled 289,093 tons, all to Japan.



PRODUCERS

(numbers refer to numbers on map)

1. Dosco Industries Limited, Wabana Mines Division.
2. Iron Ore Company of Canada
3. Iron Ore Company of Canada Wabush Mines
4. Arnaud Pellets
5. Quebec Cartier Mining Company
6. Hilton Mines, Ltd.
7. Marmoraton Mining Company, Ltd.
9. National Steel Corporation of Canada, Limited.
11. Jones & Laughlin Mining Company, Ltd. (Adams Mine)
12. The Algoma Steel Corporation, Limited, Algoma Ore Division.
13. Caland Ore Company Limited Steep Rock Iron Mines Limited
16. Texada Mines Ltd.
17. Brynnor Mines Limited
18. Orecan Mines Ltd.
19. Zeballos Iron Mines Limited
20. Empire Development Company, Limited
21. Jedway Iron Ore Limited,

BYPRODUCT PRODUCERS

8. Falconbridge Nickel Mines, Limited The International Nickel Company of Canada, Limited
15. Cominco Ltd.
20. Coast Copper Company, Limited

PROSPECTIVE PRODUCERS

10. The Sherman Mine (1968)
14. Griffith Mine (1968)
21. Wesfrob Mines Limited (1967)

TABLE 7

Canadian Producers of Iron Ore During 1965 and 1966

Company and Property Location	Participating Companies	Product mined (Average natural grade, % Fe)	Product shipped (Average natural grade % Fe)	Shipments[1] ('000 long tons) 1965	1966
The Algoma Steel Corp., Ltd., Algoma Ore Division; mines and sinter plant near Wawa, Ont.	Wholly owned	Siderite, open-pit and underground mines (32.23)	Ore beneficiated by sink-float, sintered (50.37% Fe 2.9% Mn)	1,825	1,793
Arnaud Pellets; Pointe Noire, Que.	All participants of Wabush Mines.	Operated by Pickands Mather & Co. to process Wabush Mines' concentrate	Pellets (65% Fe)	1,880	3,702
Brynnor Mines Ltd.; near Ucluelet, Vancouver Island, B.C.	Noranda Mines Ltd.	Magnetite, open-pit mine (51.88)	Magnetite concentrate (64.23% Fe)	575	287
Caland Ore Co. Ltd; E. Arm of Steep Rock Lake, N. of Atikokan, Ont.	Inland Steel Co.	Hematite and goethite, open-pit mines (53.57)	Direct-shipping ore (52.3% Fe) and concentrate (57.3% Fe) (pellets 62.2)	1,800	1,445
Canadian Charleson Mine; S. of Steep Rock Lake, near Atikokan, Ont.	Oglebay Norton Co.	Hematite-bearing gravels (12-20)	Jig and spiral concentrate (55% Fe)	35	–
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 (64.40% Fe)	5,325	5,214
Coast Copper Co., Ltd.; Benson L., northern Vancouver Is., B.C.	Cominco Ltd.	Copper ore, magnetite by-product underground mine, containing 32.95% Fe.	Magnetite concentrate (63.49% Fe)	90	66
Empire Development Co., Ltd.; Benson R., 25 miles S.W. of Port McNeill, Vancouver Is., B.C.	Loram Ltd., Quatsino Copper-Gold Mines, Ltd.	Magnetite, underground mine (31.3)	Magnetite concentrate (55.69% Fe)	–	59
Hilton Mines, Ltd., near Shawville, Que., 40 miles N.W. of Ottawa	The Steel Co. of Canada, Ltd.; Jones & Laughlin Steel Corp.; Pickands Mather & Co.	Magnetite, open-pit mine (approx. 32.92)	Iron oxide pellets (66.64% Fe)	894	816

TABLE 7 (cont'd)

Canadian Producers of Iron Ore During
1965 and 1966

Company and Property Location	Participating Companies	Product mined (Average natural grade % Fe)	Product shipped (Average natural grade % Fe)	Shipments[1] ('000 long tons) 1965	1966
Iron Ore Company of Canada; Schefferville, Que.	The Hanna Mining Co.; Hollinger Consolidated Gold Mines, Ltd.; Armco Steel Corp.; Bethlehem Steel Corp.; National Steel Corp.; Republic Steel Corp.; Wheeling Steel Corp.; The Youngstown Sheet and Tube Co.	Goethite-limonite, open-pit mines (53.6)	Direct-shipping ore (54.27% Fe)	7,025	6,653
Labrador City, Nfld.	Same as above	Specular hematite open-pit mine (38.4)	Specular hematite concentrate (62.75% Fe)	1,505	2,017[2]
Jedway Iron Ore Ltd.; Moresby Island, Queen Charlotte Is., B.C.	The Granby Mining Co. Ltd.	Magnetite, open-pit mine (36.6)	Magnetite concentrate (59.95% Fe)	350	478
Jones & Laughlin Mining Co., Ltd. (Adams Mine) Boston tp., near Kirkland Lake, Ont.	Jones & Laughlin Steel Corp.	Magnetite, open-pit mine (20.11)	Pellets (64.32% Fe)	750	985
National Steel Corporation of Canada, Ltd., Sudbury area, 20 miles N. of Capreol, Ont.	National Steel Corp.; The Hanna Mining Co. (managing agents)	Magnetite, open-pit mine (31.0)	Pellets (63.27% Fe)	650	630
Marmoraton Mining Co., Ltd.; near Marmora, in southern Ont.	Bethlehem Steel Corp.	Magnetite, open-pit mine (44.51)	Pellets (65.03% Fe)	455	496
Orecan Mines Ltd., Menzies Bay, Vancouver Is. B.C.	Public Stock Company	Magnetite, open-pit mine (45)	Magnetite concentrate (+62% Fe)	–	113[e]
Quebec Cartier Mining Co.; Gagnon, Que.	United States Steel Corp.	Specular hematite-magnetite, open-pit mine (33.9)	Specular hematite-magnetite concentrate (64.34% Fe)	8,230	8,319
Steep Rock Iron Mines Ltd.; Steep Rock Lake, N. of Atikokan, Ont.	Premium Iron Ores Ltd., The Cleveland-Cliffs Iron Co., and others.	Hematite-goethite, open-pit and underground mines (54.1)	Direct shipping ores and gravity concentrates (54.28% Fe)	1,265	1,236

TABLE 7 (cont'd)

Texada Mines Ltd.; Texada Island, B.C.	Private company	Magnetite, open-pit and underground mines (38.6)	Magnetite concentrate (60.22% Fe)	530	515
Dosco Industries Limited, Wabana Mines Division; Bell Island, Conception Bay, E. Coast of Nfld.	Wholly owned	Hematite-chamosite underground mine, (48.82)	Heavy-media concentrate (50.30% Fe)	1,190	792
Wabush Mines; Pickands Mather & Co. Managing agents, Wabush, near Labrador City, Lab., 190 miles N. of Sept-Iles.	The Steel Co. of Canada, Ltd.; Dom. Foundries and Steel, Ltd.; Wabush Iron Co. Ltd. (The Youngstown Sheet and Tube Co.; Inland Steel Co.; Interlake Steel Corp.; Pittsburgh Steel Co.; Finsider of Italy and Pickands Mather & Co.)	Specular hematite-magnetite, open-pit mine (33.99)	Concentrate (64.24% Fe)	130	136[3]
Zeballos Iron Mines Ltd., near Zeballos, Vancouver Is., B.C.	Falconbridge Nickel Mines, Ltd.	Magnetite, underground mine (47.68)	Magnetite concentrate (62.83% Fe)	240	289
Byproduct Producers					
Cominco Ltd.; Kimberley, B.C.	Wholly owned	Pyrrhotite flotation concentrates roasted for acid production. Calcine sintered.	Iron oxide sinter (62.3% Fe) is further processed into pig iron at the plant.	143	136
Falconbridge Nickel Mines, Ltd.;Falconbridge, Ont.	Wholly owned	Pyrrhotite flotation concentrates treated.	Iron oxide calcine (about 67% Fe)	90	90
The International Nickel Co. of Canada, Ltd.; Copper Cliff, Ont.	Wholly owned	Pyrrhotite flotation concentrates treated.	Iron oxide pellets (67.9% Fe)	890	687
Cutler Acid Limited, Copper Cliff, Ont.	Canadian Industries Limited	Plant formerly treated iron sulphide concentrates	Iron oxide calcine (about 66% Fe)	14	–
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, open-pit mine (40% Fe, 35% TiO_2)	TiO_2 slag, and various grades of desulphurized pig iron or remelt iron	1,177	1,129[4]

Source: Company reports, personal communication and other.

[1]Statistics supplied by companies to Mineral Resources Division. [2]Does not include concentrate pelletized by Carol Pellet Company. [3]Does not include concentrate pelletized by Arnaud Pellets. [4]Ilmenite consumed.

– Nil; [e] Estimate

TABLE 8

Companies Under Development with Announced Plans for Production

Company and Production or Expansion Date	Property Location	Participating Companies	Product to be Mined or Processed	Product to be shipped	Designed Annual Capacity (long tons)
Carol Pellet Company (1967)	Labrador City, Labrador	See Table 7	Company's plant operated by IOC to pelletize IOC concentrate: expansion of 4,500,000 tons.	Pellets (64.3% Fe)	10,000,000
Wabush Mines; Pickands Mather & Co. managing agent; Wabush, Labrador City, Lab., 190 m. N. of Sept-Iles (1967)	Wabush, Labrador	See Table 7	Expand concentrating plant capacity by 700,000 tons a year.	Specular-hematite concentrate (64.16% Fe)	6,000,000
Arnaud Pellets operated by Pickands Mather & Co. to process Wabush Mines' concentrates (1967)	Pointe Noire, Quebec	All participants of Wabush Mines.	Expand pellet producing capacity by 1.1 million tons a year.	Pellets (65.77% Fe)	6,000,000
Steep Rock Iron Mines Limited (1967)	Steep Rock Lake, Ontario	Premium Iron Ores Ltd.; The Cleveland-Cliffs Iron Company and others.	Hematite-goethite from open-pit and underground mines (54.1% Fe)	Pellets (about 64% Fe)	1,350,000
The Sherman Mine (1967)	Near Timagami, Ontario	Dominion Foundries and Steel, Limited (90%) and The Cleveland-Cliffs Iron Company (10%) through Tetapaga Mining Company Limited, a wholly-owned subsidiary.	Magnetite iron formation from open-pit mine (22-25% Fe)	Pellets (about 65% Fe)	1,200,000
The Griffith Mine (1968)	Bruce Lake, near Red Lake, Ontario	The Steel Company of Canada, Limited and Pickands Mather & Co. (managing agent).	Magnetite iron formation from open-pit mine (30-33% Fe)	Pellets (about 65% Fe)	1,500,000
Wesfrob Mines Limited (1967)	Tasu Harbour, Moresby Is., Queen Charlotte Is., B.C.	Falconbridge Nickel Mines, Limited.	Magnetite and chalcopyrite from open pit (37% Fe)	Magnetite concentrate for sintering and pelletizing (about 60% Fe)	1,100,000

Sources: Company reports and others.

TABLE 9

World Pellet Capacity, 1966 and Estimated Capacity in 1970 and 1975
(million long tons)

Year	United States	Canada	Balance of World	Total
1966	37.10	15.58	11.87	64.55
1970	54.00	26.00	12.00	92.00
1975	70.00	40.00	..	..

(Canadian Pellet Plants Operating in 1966)

Company	Location	Annual Capacity (million long tons)
Bethlehem Steel Corp.		
Marmoraton	Ontario (Marmora)	.50
The Hanna Mining Company		
Carol Pellet Co. (IOC)	Nfld. (Labrador City)	5.50
National Steel Corporation of Canada, Limited (Lowphos)	Ontario (Moose Mtn.)	.63
The International Nickel Co. of Canada, Limited	Ontario (Copper Cliff)	.90
Jones & Laughlin Mining Company, Ltd.		
Adams Mine	Ontario (Kirkland Lake)	1.25
Inland Steel Company		
Caland Ore Company Limited	Ontario (Steep Rock Lake)	1.00
Pickands Mather & Co.		
Hilton Mines, Ltd.	Quebec (Shawville)	.90
(Jones & Laughlin Steel, STELCO)		
Arnaud Pellets	Quebec (Pointe Noire)	4.90
Total Canada		15.58

Sources: American Iron Ore Association; company reports and trade publications.
.. Not enough reliable data available to justify an estimation.

PRICES AND TARIFFS

Traditionally, prices received by most iron ore producers in central and eastern Canada for sale to North American consumers are a reflection of the Lake Erie base price, which is the price paid per long ton unit of iron* in iron ore delivered at the 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

*Equals 22.4 pounds of iron (i.e. 1% of 2,240 pounds). An iron ore containing 60% iron ore has 60 units.

lowering the Lake Erie base price by that amount at which level it has remained.

TABLE 10

Iron Ore Lake Erie Base Prices, 1951-66
(Mesabi, non-Bessemer grade)

	($ US)	
	Per Long Ton*	Per Long Ton Unit*
1951–52 (to July)	8.30	0.1612
1952	9.05	0.1757
1953 (to July)	9.70	0.1884
1953–54	9.90	0.1922
1955	10.10	0.1961
1956	10.85	0.2107
1957–61	11.45	0.2223
1962–63 (to July)	10.65	0.2068
1963–66	10.55	0.2049

* Basis 51.50% Fe, unscreened, delivered to rail of vessel at Lake Erie ports. Premium for coarse ore 80¢ a ton; penalty for fine ore 45¢ a ton.

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.

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 (US $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.

Neither Canada nor any of its iron ore customers have tariffs on iron ore. European prices decreased during 1966 and the trend accelerated as new contracts were signed in the second half of the year. The levelling of steel output and the availability of good quality ores indicates that prices will remain low with little likelihood of rising in 1967.

IRON ORE FROM A LAKE BOTTOM: Roberts open pit Steep Rock Iron Mines Limited, in drained and dredged Steep Rock Lake, 142 miles west of Port Arthur, Ontario.

Iron and Steel

G.E. WITTUR*

The steel industry experienced a very good first half in 1966 with operation of most plants at record levels. A downturn in deliveries occurred in June and July and they remained at lower levels for the rest of the year. Crude steel production was 10.0 million tons** compared with 10.03 million tons in 1965 and 9.13 million tons in 1964. Indicated consumption fell 7.5 per cent to 10.8 million tons; it is believed that consumers substantially reduced their steel inventories during the second half of 1966 and that real consumption during the year was approximately the same as in 1965. The net trade deficit in iron and steel products declined in 1966 as exports rose and imports fell, reflecting the easing in domestic demand and increased productive capacity. Investment in new facilities continued at a high level but is expected to decline in 1967. The outlook for the steel industry in 1967 is uncertain, reflecting a similar outlook in many important steel-consuming industries. However, production is expected to be about the same as in 1966. The outlook to the early 1970's is for continued growth but at a more moderate rate than in the 1961-65 period.

WORLD PRODUCTION

Canada declined from tenth to eleventh place among world steel producers in 1966, having been displaced by Poland and Czechoslovakia and having displaced Belgium. World steel production continued to expand and reached 519 million tons. Growth was particularly strong in Japan, Italy and United States, while production fell in West Germany, United Kingdom, France and Belgium. The trend towards growing world steel overcapacity continued in 1966; this was of serious concern to steelmakers throughout the world because overcapacity has resulted in very low prices in both export and many domestic markets. Several national and international groups and organizations have initiated studies on how to solve the problem.

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*Mineral Resources Division.

**The net ton of 2,000 pounds is used throughout unless otherwise noted.

TABLE 1

General Statistics of Canada's Primary
Iron and Steel Industry, 1964-66

	1964	1965	1966P
Production			
Index (1949 = 100)			
Total industrial production	235.3	254.9	275.1
Primary Iron and Steel Industry	291.2	320.0	324.8
	($ millions)	($ millions)	($ millions)
Value of shipments*	1,108.2	1,214.8	1,230.5
Value of unfilled orders, year-end*	140.0	135.2	145.2
Value of inventory owned, year-end*	218.3	263.4	275.6
Value of exports**	212.9r	206.2	214.7
Value of imports**	286.1r	373.6	308.4
Employees			
Administrative	6,928r	8,121	7,604
Hourly Rated	34,577r	37,433	39,078
Total	41,505r	45,554	46,682
Average hours per week by hourly rated	40.7	40.7	40.3
Average earnings per hour by hourly rated	2.71	2.83	2.94
Average wages and salaries per week, all employees	114.48	118.36	123.03
Employment index, all employees (1961 = 100)*	121.9	129.6	133.8
Expenditures			
Capital	($ thousands)	($ thousands)	($ thousands)
On construction	36,600	34,338	39,277
On machinery	169,468	128,868	165,035
Total	206,068	163,206	204,312
Repair			
On construction	5,497	6,439	7,376
On machinery	108,319	119,400	138,795
Total	113,816	125,839	146,171
Total Capital and Repair	319,884	289,045	350,483

Source: Dominion Bureau of Statistics.

* The basis on which these figures is calculated has been revised; therefore the figures given are not comparable with previously-published figures.

** Includes pig iron, steel castings, steel ingots and rolled products but does not include steel in forgings or manufactured products such as machinery and equipment.

P Preliminary; r Revised.

CANADIAN PRIMARY IRON AND STEEL INDUSTRY*

Pig iron is made at seven plants in Canada, including five that also make steel, one that produces blast furnace pig iron for sale, and one that makes iron as a co-product with titania slag in the electric-furnace smelting of ilmenite.

The fifth plant integrating iron and steel, operated by Cominco Ltd., reached that position in 1966 with the addition of a small basic oxygen steel furnace to its electric-furnace ironmaking plant at Kimberley, B.C. The plant does not have steel rolling facilities; ingots are shipped to subsidiary plants at Vancouver and Calgary.

*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, available from the Mineral Resources Division or The Queen's Printer, Ottawa.

TABLE 2
World Production of Steel, 1964 to 1966
(thousands of net tons)

	1964	1965p	1966p
North America, total	136,204	141,491	144,075
Canada	9,198	10,029	10,003
United States	127,076	131,462	134,072
Latin America, total	8,952	8,992	9,328
Western Europe, total	137,481	142,673	139,376
Belgium	9,510	10,099	9,823
France	21,806	21,609	21,587
West Germany	41,160	40,588	38,929
Italy	10,795	13,978	15,034
Luxembourg	5,133	5,054	4,839
Netherlands	2,930	3,467	3,629
Total ECSC	91,334	94,795	93,841
Britain	29,378	30,247	27,233
Other	16,769	17,631	18,302
Eastern Europe, total	123,733	131,884	140,484
Czechoslovakia	9,234	9,478	10,062
Poland	9,450	10,018	10,858
USSR	93,733	100,309	106,813
Other	11,316	12,077	12,751
Africa, total	3,633	3,640	3,625
Middle East, total	292	292	295
Far East, total	63,255	67,242	75,729
China	11,000	13,228	14,000
India	6,653	6,899	7,341
Japan	43,870	45,372	52,672
Other	1,732	1,743	1,716
Oceania, total	5,772	5,886	6,481
Australia	5,622	5,736	..
Other	150	150	..
World Total	475,689	502,100	519,393

Source: OECD, Special Committee for Iron and Steel, AISI Annual Statistical Report, ECE Steel Committee and STEEL, March 27, 1967.

.. Not available; p Preliminary.

The four largest integrated plants — two at Hamilton, Ont., and one each at Sault Ste. Marie, Ont., and Sydney, N.S. — accounted for 87 per cent of 1966 crude steel production. There are two major specialty steel producers — one with plants at Welland, Ont., and Tracy, Que., and the other with a plant at Sorel, Que. — but many carbon steel producers also make alloy steel. Small but regionally-important steel ingot plants are located in Newfoundland (one), Nova Scotia (one), Quebec (one), Ontario (two), Manitoba (one), Saskatchewan (one), Alberta (two) and British Columbia (two). Numerous steel foundries, some of which occasionally produce ingots for sale, are distributed widely across Canada.

PIG IRON

Production of pig iron rose in 1966 although shipments from domestic plants, and both imports and exports, fell (Table 3). Pig iron had been in short supply at some integrated plants for several years. Capacity rose slightly in 1966 through improvements to existing furnaces. Two large blast furnaces and one electric furnace are under construction and when completed by 1970 pig iron capacity will exceed 11 million tons a year.

TABLE 3
Pig Iron Production, Shipments, Trade and Consumption, 1964-66
(net tons)

	1964	1965	1966P
Furnace capacity, Dec. 31	7,288,000	7,643,000	7,764,000
Production			
Basic iron	5,668,176	6,310,754	6,365,258
Foundry iron	436,374	479,277	467,633
Malleable iron	446,285	274,849	379,652
Total	6,550,835	7,064,880	7,212,543
Shipments			
Basic iron	76,509	98,816	59,160
Foundry iron	453,191	484,192	412,702
Malleable iron	301,043	322,186	267,739
Total	830,743	905,194	739,601
Imports	15,891	33,474	32,456
Exports	585,841	578,879	507,239
Consumption of pig iron			
Steel furnaces	5,678,060r	6,145,663r	6,320,969
Iron foundries	386,554r	372,450r	303,114
Consumption of iron and steel scrap			
Steel furnaces	4,559,216r	5,236,580r	5,013,356
Iron foundries	924,000r	919,607r	1,056,885

Source: Dominion Bureau of Statistics, Primary Iron and Steel (monthly) and Iron and Steel Mills (annual).

Note: Value of trade is shown in Table 9.

P Preliminary; r Revised.

CRUDE STEEL

Production of crude steel fell slightly in 1966 from the previous year (Table 4). Output of steel castings rose because of increased automobile parts production and heavy demand for machinery of all types. Both imports and exports of steel castings and forgings were sharply higher than in 1965.

Basic oxygen furnaces produced 33.8 per cent of total crude steel, up from 32.2 per cent in 1965. Electric furnaces produced 13.4 per cent (12.8 per cent in 1965) while open hearth furnaces accounted for 52.8 per cent (55 per cent in 1965). The relative share of both oxygen and electric furnaces has been increasing at the expense of open hearths and this trend will continue. Although it is almost certain that no new open hearth furnaces will be built in Canada, most existing units will continue in operation and open-hearth capacity will continue to expand, through technological improvement, until 1970. Total crude steel capacity was 12.18 million tons at the end of 1966 and is expected to rise to 14 million tons by 1970.

SHIPMENTS OF STEEL PRODUCTS

The tight domestic supply situation for rolled steel products that existed during much of the past few years eased in 1966 to the point that from mid-year onwards, almost all products were in plentiful supply. The value of shipments by the primary iron and steel industry rose very slightly in 1966 (Table 1) to $1,230.5 million, despite the decline in crude steel production. Total shipments of hot- and cold-rolled steel rose to 7,128,390 tons (Table 7). Among individual products, shipments of rails rose 32 per cent while shipments of bars, track material, hot-rolled sheet and strip, and galvanized sheet rose slightly. Shipments of all other products declined marginally. Trends in shipments to individual steel-consuming industries were equally variable (Table 8). Increases were recorded, in particular, to the railway operating group, agricultural equipment manufacturers, the automobile and aircraft industry, and machinery and tool producers. Significant declines occurred in shipments to shipbuilding firms, the appliance industry, and wholesalers and warehouses. Part of the decline may have been attributable to reduction of steel inventories held by consumers.

TABLE 4

Crude Steel Production, Shipments, Trade and Consumption, 1964-66

(net tons)

	1964	1965P	1966P
Furnace capacity, Dec. 31			
Steel ingot			
Basic open-hearth	5,981,500	6,270,000	6,470,000
Basic oxygen converter	3,100,000	3,550,000	3,630,000
Electric	1,324,900	1,434,650	1,616,826
Total	10,406,400	11,254,650	11,716,826
Steel castings	502,436	534,120	544,400
Total	10,908,836	11,788,770	12,261,226
Production			
Steel ingot			
Basic open-hearth	5,334,329[r]	5,514,035	5,278,104
Basic oxygen [e]	2,785,482	3,232,572	3,377,733
Electric	847,707[r]	1,118,991	1,158,228
Total	8,967,518[r]	9,865,598	9,814,065
of which continuously cast	..	347,437	442,680
Steel castings			
Basic open-hearth	1,351[r]	*	*
Electric	159,590[r]	163,301	188,803
Total	160,941[r]	163,301	188,803
Total Steel Production	9,128,459[r]	10,028,899	10,002,868
Alloy Steel in Total	564,032[r]	740,458	812,606
Shipments from plant			
Steel ingots	212,879[r]	251,493	272,581
Steel castings	148,787[r]	157,935	174,404
Rolled steel products	6,710,249	7,101,650	7,128,390
Total	7,071,915[r]	7,511,078	7,575,375
Exports in equivalent steel ingots	1,485,056	1,235,208	1,289,809
Imports in equivalent steel ingots	2,134,990	2,891,970	2,096,261
Indicated consumption **	9,778,396[r]	11,685,661	10,809,320

Source: Dominion Bureau of Statistics; estimates by Department of Energy, Mines and Resources, Ottawa.

* Included with electric; ** Crude steel production plus imports less exports.

P Preliminary; [r] Revised; .. Not available; [e] Estimated.

TABLE 5

Production, Trade and Apparent Consumption of Primary Iron and Steel in Canada, 1957-1966
(thousand net tons ingot equivalent)

	Crude Steel Production	Imports*	Exports*	Indicated Consumption**
1957	5,068	3,004	407	7,665
1958	4,359	1,841	383	5,817
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	8,197	1,295	1,369	8,123
1964	9,128	2,135	1,485	9,778
1965	10,029	2,892	1,235	11,686
1966	10,003	2,096	1,290	10,809

Source: Dominion Bureau of Statistics.
* From Trade of Canada adjusted to equivalent crude steel by Mineral Resources Division.
** Production plus imports, less exports with no account taken of stocks.

TABLE 6

Shipments of Rolled Steel Products By Type, 1964-66
(net tons)

	1964	1965	1966p
Hot-rolled products			
Semis	378,386	382,909	326,262
Rails	269,004	213,469	282,293
Wire Rods	442,561	444,659	428,109
Structurals			
Heavy	462,292	442,482	433,159
Light	105,582	99,675	86,787
Bars, concrete reinforcing	564,332	643,009	655,525
Bars, other hot-rolled	603,020	680,123	686,120
Tie plate and track material	80,868	55,953	62,872
Sheet and strip	1,058,783	1,181,385	1,210,119
Plates	865,975	951,463	935,687
Total	4,830,843r	5,095,127	5,106,933
Cold-rolled products			
Bars	68,905	74,207	78,987
Sheet, tin mill blackplate and tinplate	1,335,384	1,412,556	1,401,589
Galvanized sheet	475,117	519,760	540,881
Total	1,879,406	2,006,523r	2,021,457
Total shipments	6,710,249	7,101,650r	7,128,390
Alloy steel in shipments	274,931	342,904	366,348

Source: Dominion Bureau of Statistics, Primary Iron and Steel (monthly).
p Preliminary; r Revised.

TABLE 7

Rolled Steel Products, Shipments to Consuming Industries, 1964-66
(net tons)

	1964	1965	1966
Automotive and aircraft	492,139	586,261	642,939
Agricultural equipment manufacturers	185,751	191,962	214,925
Construction	1,143,610	1,373,751	1,406,735
Containers	413,863	440,646	462,279
Machinery and tools	230,726	272,890	300,567
Wire, products, fasteners	522,548	545,757	513,349
Resources and extraction	155,177	176,745	176,643
Appliances, utensils, stampings, pressings	666,922	600,891	544,106
Railway operating	208,607	207,185	258,939
Railway cars and locomotives	79,785	132,114	127,182
Shipbuilding	108,573	125,136	101,240
Pipe and tubes	751,458	797,868	762,652
Wholesalers and warehouses	947,438	1,025,072	924,364
Miscellaneous	19,920	15,754	19,771
Total	5,926,517	6,492,032	6,455,691
Direct Exports*	783,732	609,618	672,699
Total	6,710,249	7,101,650	7,128,390

Source: Dominion Bureau of Statistics, Primary Iron and Steel (monthly).
* Does not include exports by nonproducers nor ingots and castings exported.

TRADE

Canada's balance of trade in iron and steel products improved substantially in 1966 as exports increased and imports declined but the net trade deficit in iron and steel was still $93.7 million. There was a definite trend away from the export of primary products and towards the export of more highly-processed products, reflecting increased steelmaking and rolling capacity at domestic plants. Exports of both pig iron and semi-finished steel declined significantly. This decline was more than cancelled by increased exports of more highly-processed products, particularly hot-rolled bars, structurals, plate and sheet.

Imports of rolled steel products fell 27 per cent in 1966, led in particular by declines in hot-rolled products. For several years, some Canadian steelmakers, lacking sufficient rolling capacity of their own, have been exporting ingots or slabs for hire-rolling and importing the resulting hot-rolled sheet, etc. for further processing and/or sale in Canada. The tonnage involved in this trade, which cannot be considered strictly as true foreign trade, declined steadily during the past two years as new capacity was installed in Canada.

Net imports of steel products were halved in 1966, to 806,000 tons ingot equivalent. It will be difficult to maintain this trend in 1967. Excess capacity in most of the major producing countries has resulted in very low world export prices which, in many cases, are below the total cost of production. It is therefore difficult for Canadian companies to profitably export steel to overseas markets and similarly, imports are able to capture domestic markets on the basis of low price. However, the domestic industry has invested very large sums of money in recent years to modernize, expand and diversify and, on average, it is competitive with other world steel producers.

MANPOWER AND LABOUR

The index of employment in the primary iron and steel industry (1961 = 100) rose from

129.6 in 1965 to 133.8 in 1966; total employment rose to 46,682. As labour contracts at many plants expired in 1966, new contracts were negotiated and a number of strikes occurred. The most significant work stoppages occurred at the Hilton Works (Hamilton, Ont.) of The Steel Company of Canada, Limited when a four-day strike took place in August; at the Montreal Works of Dosco Steel Limited which was closed by strike from October 21, 1966, to January 22, 1967; and at the Sault Ste. Marie Works of The Algoma Steel Corporation, Limited where a gradual shut-down, beginning on December 18, was forced by a strike of 80 members of a bricklayer's union which was not settled until January 15, 1967. New contracts resulted in substantial increases in wages and other benefits over their three-year terms.

Substantial layoffs occurred at a number of major plants between September and the year-end as domestic steel demand declined. The total number of workers affected at Dosco's Sydney and Contrecoeur Works, STELCO's Hilton Works, DOFASCO's Hamilton Works and Algoma's Sault Ste. Marie Works approached 2,000.

TABLE 8

Trade in Steel Castings, Ingots and Rolled Products, 1964-66

(thousand net tons)

	Imports			Exports		
	1964	1965	1966[p]	1964	1965	1966[p]
Steel castings	5.7	5.9	9.0	19.3	18.3	20.8
Steel forgings	4.8	6.5	9.9	13.1	16.4	22.9
Steel ingots	2.7	1.2	16.1	103.5[r]	194.7	133.7
Hot-rolled products						
Semis	3.7	28.4	21.7	338.8	109.0	87.3
Rails	5.2	7.4	6.1	126.2	72.6	77.4
Wire rod	117.6	183.5	144.0	7.0	5.8	8.0
Structurals	393.2	528.9	369.1	21.8	18.6	37.2
Bars	254.8	382.1	244.5	27.6	28.1	49.0
Track material	2.7	2.0	3.5	35.1[r]	14.3	13.9
Plates	148.1	396.2	221.2	25.7	25.7	40.3
Sheet and strip	193.9	210.4	80.3	127.9	104.0	131.6
Total, hot-rolled	1,119.2	1,738.9	1,090.4	710.1[r]	378.1	444.7
Cold-rolled and other products						
Bars	8.9	12.3	11.3	8.2	9.3	8.9
Sheet and strip						
Cold-rolled	19.7	30.1	24.6	115.7	135.0	115.2
Galvanized	6.4[r]	8.0	7.3	66.8	59.9	57.2
Other	89.5[r]	113.8	112.3	151.1[r]	133.3	155.4
Pipe	154.3	158.9	197.6	36.2	55.2	60.0
Wire	69.7	82.1	74.7	5.2	6.7	7.0
Total, cold-rolled	348.5	405.2	427.8	383.2[r]	399.4	403.7
Total, rolled products	1,467.7	2,144.1	1,518.2	1,093.3[r]	777.5	848.4
Total, steel	1,480.9	2,157.7	1,553.2	1,229.2[r]	1,006.9	1,025.8

Source: Dominion Bureau of Statistics, Trade of Canada.

Note: Related values are in Table 9.

[p]Preliminary; [r]Revised.

TABLE 9

Value of Trade in Pig Iron, Steel Castings, Ingots and Rolled Products, 1964-66
(thousand dollars)

	Imports			Exports		
	1964	1965	1966P	1964	1965	1966P
Steel castings	3,572	4,881	6,783	5,938	5,586	7,450
Steel forgings	4,399	6,413	10,911	7,936	9,259	11,803
Steel ingots	1,046	336	1,320	12,557	21,891	13,691
Rolled products						
Hot-rolled	158,439	218,299	138,547	83,788	55,453	69,850
Cold-rolled	117,936r	142,273	149,357	73,343r	84,579	84,871
Total	276,375r	360,572	287,904	157,131r	140,032	154,721
Total steel	285,392r	372,202	306,918	183,562r	176,768	187,665
Pig Iron	727	1,395	1,451	29,391	29,482	27,056
Total iron and steel	286,119r	373,597	308,369	212,953r	206,250	214,721

Source: Dominion Bureau of Statistics, Trade of Canada.
Note: The values in this table relate to the tonnage shown in Tables 3 and 8.
P Preliminary; r Revised.

RAW MATERIALS

The supply of raw materials used in the steel industry was generally adequate in 1966. Some regional shortages of scrap, mainly involving the smaller scrap-melting plants, continued to exist but abundant supplies were available to the major producers and prices declined significantly in Ontario and Quebec during 1966. Several steelmakers continued to investigate alternative sources of iron in the form of reduced iron ore but no definite plans to proceed with commercial production of such a product were announced. Prices of most additive materials including ferroalloys were stable and supplies were adequate. Prices paid by some steel producers for certain grades of ferromanganese and ferrochrome were lower than in 1965. Nickel is expected to be in tight supply in 1967; cobalt and molybdenum prices rose in January 1967.

The trend towards increased use of domestic iron ore continued in 1966. Approximately 56 per cent of the ore consumed was mined in Canada compared with 51 per cent in 1965. Most of the output of three pelletizing plants under construction, having a designed annual capacity of about 4.5 million net tons a year, is committed to Canadian steel companies. An existing pellet producer, owned in part by two Canadian steel companies, is also expanding its capacity. When these projects are completed in the next two years, imports are expected to fall from the 1966 level of 4.8 million net tons to an annual rate of less than 2 million tons. Most imported ore comes from the United States with smaller tonnages from Brazil and other countries. Similarly, the trend towards increased use of beneficiated ore continued in 1966. Pellets constituted 52 per cent of all ore used in blast furnaces while sinter accounted for a further 32 per cent. Corresponding figures in 1965 were 49 and 34 per cent.

The shortage of coke at one integrated plant was relieved upon completion of a new coke battery; new batteries will be completed at two other plants in 1967. Coal supply is adequate with three of the four major integrated firms having ownership interests in United States coal mines. Increased wages in the United States coal industry resulted in slightly higher coal costs.

TABLE 10

Canadian Steel, Iron, Coke and Sinter Capacity and Production at Integrated * Plants, 1966

(net tons)

	Algoma: Sault Ste. Marie	Algoma: Port Colborne	Cominco, Kimberley	Dofasco, Hamilton	Dosco Sydney**	Q.I.T. Tracy	Stelco, Hamilton(2)	Total for Six Companies	National Total
Crude Steel									
Capacity Dec. 31									
Open hearth	1,150,000	–	–		1,070,000	–	4,250,000	6,470,000	6,470,000
Basic oxygen	1,450,000	–	80,000	2,100,000	–	–	–	3,630,000	3,630,000
Electric	–	–	–	50,850	30,000	–	–	80,850	2,081,226
Total	2,600,000	–	80,000	2,150,850	1,100,000	–	4,250,000	10,180,850	12,181,226
Production	2,346,628	–	20,000	1,877,337	748,726	–	3,692,601	8,685,292	10,002,868
Pig Iron									
Capacity Dec. 31									
Blast furnace	2,225,000	240,000	–	1,550,000	876,000	–	2,350,000	7,241,000	7,241,000
Electric	–	–	110,000	–	–	413,000	–	523,000	523,000
Total	2,225,000	240,000	110,000	1,550,000	876,000	413,000	2,350,000	7,764,000	7,764,000
Production	2,006,200	234,364	96,600	1,590,273	560,305	353,479	2,377,863	7,219,084 †	7,212,543
Coke from Coal									
Capacity Dec. 31	1,366,500	–	–	911,625	612,000	–	1,275,000	4,165,125	4,709,125
Production	1,409,609	–	–	681,965	403,546	–	1,306,861	3,801,981	4,426,051
Sinter									
Capacity Dec. 31	725,000	–	300,000	–	250,000	–	900,000	2,175,000	4,515,000 ††
Production	741,523	–	152,900	–	209,466	–	808,952	1,912,841	3,934,712 ††
Number of Furnaces									
Steel furnaces									
Open hearth	6	–	–	–	6	–	14	26	26
Basic oxygen	3	–	1	3	–	–	–	7	7
Electric	–	–	–	4	1	–	–	5	..
Pig Iron									
Blast furnaces	4	1	–	3	2	–	4	14	14
Electric	–	–	2	–	–	8	–	10	10
Coke Ovens	230	–	–	158	114	–	191	693	819
Sinter strands	1	–	1	–	1	–	1	4	4 ††

Sources: Company data supplied directly to the Mineral Resources Division, and Dominion Bureau of Statistics.

* The seven plants listed account for all pig iron and 87 per cent of the raw steel produced in Canada; ** Dosco and Stelco also have electric steel furnaces at Montreal (150,000 net tons a year capacity) and Edmonton (128,000 tons), respectively; † Total reported by companies to Mineral Resources Division exceeds DBS national total; †† Includes one mine sinter plant owned by Algoma.

.. Not available; – Nil.

Details on raw materials consumed at integrated steel plants and two pig iron plants are listed in Table 11.

ENERGY AND REDUCTANT MATERIALS

Table 12 lists consumption of energy and reductant materials at the four integrated steel plants in 1966. 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. Although this gas contains on average only 9 per cent of the energy in natural gas and 18 per cent of the energy in coke oven gas, it is estimated that about 400 trillion cubic feet are used annually by the companies covered in Table 11. It is used mainly for heating blast furnace stoves, steam raising and miscellaneous heating.

TABLE 11

Consumption of Raw Materials at Canadian Pig Iron and Integrated Steel Plants*, 1966

(net tons)

	In Sinter Plants	In Iron and Steel Furnaces: Blast Furnaces	Electric Pig Iron	Steel Furnaces	Total In Furnaces
Iron Ore					
Crude and Concentrate	1,102,147	1,696,954	1,065,367**	117,454	2,879,775
Pellets	113,688	5,534,385	–	167,314	5,701,699
Sinter (from mines)	22,284	1,697,187	–	–	1,697,187
Total	1,238,119	8,928,526	1,065,367	284,768	10,278,661
Sinter (produced at plant)	–	1,760,520	152,900	–	1,913,420
Total iron ore	1,238,119	10,689,046	1,218,267	284,768	12,192,081
Contained iron	681,627	6,338,848	510,793	190,561	7,040,202
Other Iron-Bearing Materials					
Calcine and pyrite	153,900	–	–	–	–
Flue dust	141,985	–	–	–	–
Scale, sponge iron, etc	398,011	119,749	–	104,982	224,731
Total	693,896	119,749	–	104,982	224,731
Contained iron	430,196	76,632	–	103,594	180,226
Other Materials					
Ferromanganese	–	–	–	72,834	72,834
Pig Iron	–	26,320	–	6,274,011	6,300,331
Coal	–	–	..	–	..
Coke: Own make	68,124	3,690,655	–	753	3,691,408
Purchased	15,600	254,113	56,000***	–	310,113
Total	83,724	3,944,768	56,000	753	4,001,521
Scrap: Own make	63,058	113,146	–	2,541,116	2,654,262
Purchased	–	80,117	–	871,118	951,235
Total	63,058	193,263	–	3,412,234	3,605,497
Stone: Limestone	169,752	594,860	–	177,098	771,958
Dolomite	139,853	462,491	38,000	101,120	601,611
Total	309,605	1,057,351	38,000	278,218	1,373,569
Burnt Stone: Lime	–	–	–	269,081	269,081
Dolomite	3,600	–	–	90,883	90,883
Total	3,600	–	–	359,964	359,964
Production	1,912,841	6,769,005	450,079	8,685,292	–

Source: Company data supplied directly to Mineral Resources Division.
* Includes the 7 plants in Table 10.
** Ilmenite ore used to make titania slag and pig iron.
*** Includes some coal and coal char.
– Nil; .. Not available.

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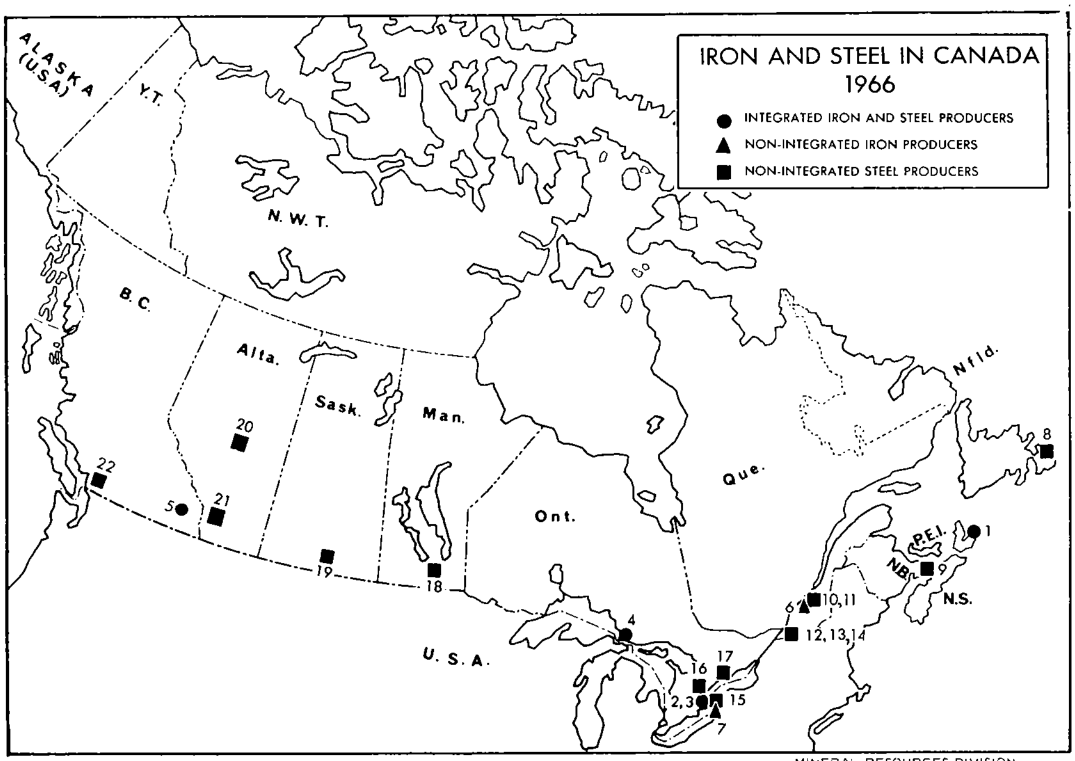

MINERAL RESOURCES DIVISION
DEPARTMENT OF ENERGY, MINES AND RESOURCES

INDEX FOR MAP

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1. Dosco Steel Limited (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)

Non-Integrated Steel Producers (a partial listing) ■

8. Newfoundland Steel Company Limited (Octagon Pond)
9. Enamel & Heating Products, Limited (Amherst)
10. Atlas Steels Company (Tracy)
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12. Canadian Steel Foundries Division (Montreal)
13. Canadian Steel Wheel Limited (Montreal)
14. Dosco Steel Limited (Montreal)
15. Atlas Steels Company (Welland)
16. Burlington Steel Company (Hamilton)
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18. Manitoba Rolling Mill Division (Selkirk)
19. Interprovincial Steel and Pipe Corporation Ltd. (Regina)
20. Premier Works of STELCO (Edmonton)
21. Western Canada Steel Limited (Calgary) (plant leased from Western Rolling Mills Ltd.)
22. Western Canada Steel Limited (Vancouver)

TABLE 12

Energy and Reductant Consumption at Major Integrated* Canadian Steel Plants, 1966

	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 (million Kwh)
In Coke ovens....	5,315,456	–	13,773	–	–	–	–	46
In sinter plants...	–	68,124	526	–	–	–	–	26
In blast furnaces .	–	3,944,768	5,791	..	..	29,294	3	60
In steel furnaces .	–	753	2,402	..	..	72,999	11,744	137
For other uses ...	85,057	27,252	28,161	..	..	98,594	861	1,737
Total Consumption	5,400,513	4,040,897	50,653	4,539	8,585	200,887	12,608	2,006

Source: Company data supplied directly to the Mineral Resources Division.
* Includes Algoma (Sault Ste. Marie and Port Colborne Works), Stelco (Hilton Works), Dofasco (Hamilton Works) and Dosco (Sydney Works).
–Nil; ..Included in total, publication would disclose confidential company data.

INVESTMENTS AND CORPORATE DEVELOPMENTS

Capital expenditures by iron and steel mills totalled $204.3 million compared with $163.2 million in 1965. Repair expenditures totalled $146.2 million compared with $125.8 million in 1965. An industry survey by the Dominion Bureau of Statistics and the Department of Trade and Commerce late in 1966 indicated that intended capital and repair expenditures in 1967 were $150.8 million and $158.8 million, respectively. The decline in capital expenditures reflects the completion of a number of major expansion programs but investment is expected to continue at relatively high rates for the next few years. The federal government's decision to remove the 5-per-cent refundable tax on corporate profits and to reduce the sales tax on production machinery may have an expanding influence on capital investment.

THE ALGOMA STEEL CORPORATION, LIMITED

Capital expenditures were $33.5 million in 1966 compared with $25.2 million in 1965 and $37.5 million in 1964. Expenditures scheduled for 1967 total $50 million. Included in 1966 expenditures were the rebuilding of one blast furnace, dismantling of another in preparation for a new unit, site clearance for a new steel furnace shop, a forge and fabricating building and additional plant transportation equipment at Sault Ste. Marie, Ont.; a new 12-foot-wide sinter strand at Wawa, Ont.; and new mine equipment at the company's iron ore and coal mines. Among projects underway for completion in 1967 are a 60-oven coke battery with by-product recovery facilities, relining of one blast furnace at each of the Sault Ste. Marie and Port Colborne plants, and a large continuous casting plant. Other projects underway in 1967 include a large new blast furnace, a 160-inch-wide plate mill, several new buildings, and improvements and additions to several rolling mills, all at Sault Ste. Marie. Algoma also plans a new steelmaking shop at Sault Ste. Marie with two 200-ton basic oxygen furnaces to replace existing open hearths and expand capacity, and additional sheet and strip facilities to be completed by 1970.

ATLAS STEELS DIVISION OF RIO ALGOM MINES LIMITED

Atlas completed the hot planetary strip mill at its Tracy, Que., plant early in 1966 but production problems delayed full operation during the year. A second cold-rolling mill with related annealing and pickling facilities was also completed but was not expected to reach full production until 1967.

BAYCOAT LIMITED

Baycoat, owned jointly by Dominion Foundries and Steel, Limited and The Steel Company of Canada, Limited, completed a plant at Hamilton, Ont., to produce painted and coated steel strip. The plant can handle coils to 20,000 pounds in widths to 54 inches.

BURLINGTON STEEL DIVISION OF SLATER STEEL INDUSTRIES LIMITED

Burlington Steel announced an expansion program at its Burlington, Ont., plant to include a third electric furnace, which will raise annual crude steel capacity to 200,000 tons, a continuous casting machine for billets, additional reheating and grinding ball equipment, a new crane and modernization and expansion of the 12-inch bar mill.

CANADIAN STEEL FOUNDRIES DIVISION, HAWKER SIDDELEY CANADA LTD.

The company plans a $3-million expansion program at Montreal for completion in 1967, to include a new 20-ton electric furnace, annealing furnace and shot-blast facilities.

COMINCO LTD.

A new steelmaking shop, consisting of an 18-ton basic oxygen furnace and conventional ingot-teeming facilities, was completed at Kimberley, B.C., in mid-1966. Ingots are railed to subsidiary Western Canada Steel Limited's plants at Vancouver and Calgary.

CRUCIBLE STEEL OF CANADA LTD.

The company neared completion of a large manipulator for the 5,000-ton forging press at its specialty-steelmaking plant at Sorel, Que. The manipulator will handle steel shapes to 40 tons and 40 feet long.

DOMINION FOUNDRIES AND STEEL, LIMITED

Investment expenditures were $82.0 million in 1966 compared with $44.8 million and $37.7 million in 1965 and 1964, respectively. Expenditures at the Hamilton steelworks were $57.7 million of the 1966 total with iron mining properties accounting for the remainder. Expenditures authorized but not yet made as of the end of 1966 were $48.4 million including $27.8 million for iron mines. Major investment items completed in 1966 were additional raw material dock facilities, a 53-oven coke battery with byproduct facilities, relining of a blast furnace, a hot-scarfing machine, conversion of the hot strip mills to 7 continuous stands, a 2-stand, 56-inch cold reduction and temper mill, and a third pickle line. Projects for 1967 include a fourth oxygen plant, additional batch annealing furnaces, a 5-stand, 56-inch continuous cold-rolling mill, a third continuous galvanizing line, and a new personnel-safety-medical building. The company increased its ownership to 16.4 per cent in both the Scully Mine in Labrador and Arnaud Pellets in Quebec. Construction continued on the 90-per-cent-owned Sherman Mine near Timagami, Ont., with completion scheduled for 1968. Early in 1967, the company purchased 20-acre and 73-acre tracts of land adjoining its own land.

DOSCO STEEL LIMITED

Capital expenditures during 1966 were $30.4 million compared with $17.6 million in 1965. Most of these expenditures were made at the Contrecoeur, Que., plant. Major projects completed in 1966 included the cold-rolling strip mill, temper mill and shot-blast strip descaling line with related facilities at Contrecoeur, and relining of a blast furnace and a new dock and raw materials handling system at Sydney, N.S. The most significant project to be completed in 1967 will be the hot strip mill at Contrecoeur, scheduled for the first quarter. Miscellaneous modernization and improvement projects will be carried out at all plants.

INTERPROVINCIAL STEEL AND PIPE CORPORATION LTD.

The company completed a $2-million expansion program in 1966 at its plant in Regina, Sask., that included increased sheet and coil capacity and a 50-per-cent increase in pipe capacity. In 1967 the company will obtain a $2-million, large diameter, mobile, spiral-weld pipe plant and will begin a $500,000-program to increase crude steel capacity to 200,000 tons through increased transformer capacity and additional auxiliary equipment. A third electric furnace was purchased but no plans to install it have been announced.

MANITOBA ROLLING MILLS DIVISION OF DOMINION BRIDGE COMPANY, LIMITED

An $8-million program, including replacement of existing steelmaking furnaces with two new electric furnaces, having an annual capacity of 160,000 tons, and installation of a continuous casting machine, was essentially completed at Selkirk, Man., in 1966.

NEWFOUNDLAND STEEL COMPANY LIMITED

The company completed a new plant at Octagon Pond, near St. John's, Nfld., consisting of a 25-ton electric steelmaking furnace with an annual capacity of 60,000 tons, a continuous billet-casting machine and a 16"/ 12" merchant rolling mill.

QUEBEC IRON AND TITANIUM CORPORATION

A $13.5-million expansion program, to raise pig iron and titania slag capacity by 20 per cent at the Sorel, Que., plant, neared completion at the end of 1966. Transformer capacity at two existing furnaces was increased and a new furnace, the ninth, will be completed early in 1967. A $2-million research centre was also completed in 1966.

THE STEEL COMPANY OF CANADA, LIMITED

Capital expenditures in 1965 were $99.5 million compared with $75.5 million in 1965 and $109.3 million in 1964. Current expansion programs are estimated to require an additional $112 million, mostly to be spent in 1967. Major projects completed at Hamilton in 1966 were the $30-million rod mill, the $8-million continuous billet-casting machine and modification and improvements at two open hearth shops, the slabbing mill and the plate mill. The final section of the bar mill was completed at Contrecoeur, Que., and additional equipment was installed at a number of processing and fabricating plants including the Premier Works at Edmonton, Alta. Projects to be completed at Hamilton in 1967 include a 73-oven coke battery, a large blast furnace and a third continuous galvanizing line. Further additions and improvements are scheduled for several other plants. The company's ownership share in the Scully Mine (Wabush Mines) in Labrador and Arnaud Pellets in eastern Quebec was increased to 25.6 per cent and annual capacity of the two operations is being increased. The capacity of Erie Mining Company in Minnesota, 10-per-cent-owned by Stelco, is being raised to 10.3 million long tons of pellets a year. The 90-per-cent-owned Griffith Mine near Red Lake, Ont. will begin iron ore pellet production at an annual rate of 1.5 million long tons in 1968. A new coal mine in Kentucky will begin production in 1967. A $4-million research centre in Burlington, Ont., will also be completed in 1967.

WESTERN CANADA STEEL LIMITED

Western Canada, a subsidiary of Cominco Ltd., in 1966 leased, with option to purchase, the plant of Western Rolling Mills Ltd. at Calgary. The plant was completed in 1964 and has an electric furnace with an annual steel ingot capacity of 25,000 tons plus a merchant rolling mill. At its Vancouver steel plant, the company completed a $2-million expansion program to provide facilities for the production of steel rods.

PRICES AND TARIFFS

List prices for domestic steel were generally stable throughout 1966. Prices for some flat-rolled and bar products were reduced in some parts of the country, mainly in eastern Canada, during the year as a result of new productive capacity becoming available plus competition from imports. Import competition was chiefly responsible, also, for fairly substantial price reductions for pipe, mainly in western Canada. Prices for some types of specialty steel were increased. In September, one large producer announced price increases for a broad range of steel products but rescinded them at the request of the Minister of Finance.

Early in 1967, most producers revised their prices on a wide range of steel products, resulting in some decreases (certain rod, bar and merchant products, electrical sheet, and plate delivered to eastern Canada) and some increases of between 2 and 3½ per cent (for hot- and cold-rolled and galvanized sheet and strip, and specialty bar products). Many of the increases were either rescinded for, or did not apply to, western Canada.

There were no changes in the Canadian tariff schedule for primary iron and steel products in 1966 (Table 13). Meetings in

Geneva, Switzerland, under the General Agreement on Tariffs and Trade (GATT), continued throughout 1966 with the object of multilaterally reducing tariffs on all products, including steel. The negotiations are scheduled for completion early in 1967.

TABLE 13

Canadian Customs Tariff on Selected Iron and Steel Items

	British Preferential	Most Favoured Nation	General	Tariff Item
Iron ore	free	free	free	32900–1
Iron and steel scrap	free	free	free	37301–1, 37302–1, 37303–1
Pig iron ($ per ton)	$1.50	$2.50	$2.50	37400–1
Ingots, n.o.p. ($ per ton)	free	$3.00	$5.00	37700–1
Semis (blooms, billets, slabs)	free	5%	10%	37800–1
Bars or rods, hot-rolled	5%	10%	20%	37900–1
Bars or rods, cold-rolled	5%	15%	25%	37905–1
Rods for wire manufacture ($ per ton)	free	$3.00	$5.00	37915–1
Shapes and sections either hot-rolled or cold-rolled				
General, n.o.p.	5%	10%	20%	38001–1
Large sections not made in Canada ($ per ton)	free	$5.00	$20.00	38002–1
	free	free	10%	38003–1
Plate, hot- or cold-rolled	5%	10%	20%	38100–1
Sheet and strip				
Hot-rolled	5%	10%	20%	38201–1
Cold-rolled	5%	15%	25%	38202–1
Coated with tin or enamel	10%	15%	25%	38203–1
Galvanized	7.5%	15%	25%	38204–1
Skelp (plate and sheet for pipe)	free	7.5%	15%	38400–1
Rails	5%	10%	20%	38700–1
Castings, n.o.p.	15%	17.5%	27.5%	39000–1
Forgings	17.5%	22.5%	30%	39200–1
Pipe, large diameter	10%	15%	30%	39900–1
Wire, n.o.p.	15%	15%	20%	40107–1

Note: Details for specific variations of which there are many can be found in the Department of National Revenue's The Customs Tariff and Amendments.

n.o.p. Not otherwise provided for.

Lead

J.G. GEORGE*

In 1966, 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 3 per cent from 1965. Output in the Northwest Territories increased nearly 40 per cent to 115,000 tons because of the mill at Pine Point Mines Limited having completed its first full year of operations. Production rose by about 4,300 tons in New Brunswick. In British Columbia output dropped 25,000 tons.

From 1902 until 1966 the refinery at Trail, B.C., operated by Cominco Ltd., remained Canada's sole producer of primary lead metal. Late in 1966 the lead-zinc smelter of East Coast Smelting and Chemical Company Limited, a subsidiary of Brunswick Mining and Smelting Corporation Limited, began tune-up operations at Belledune Point, N.B., and became Canada's second primary producer. The plant has an annual capacity of 48,000 short tons of lead metal. Refined lead output at the Trail smelter was 184,871 tons in 1966 or some 1,600 tons less than in 1965. Cominco Ltd. treated most of the lead ores and concentrates from western Canada at its Trail plant; the remainder were treated at plants in northwestern United States and Japan. Most of the lead ores and concentrates produced in eastern Canada were shipped to smelters in Europe and the United States.

Exports of ores and concentrates were almost 6 per cent higher than in 1965, with about 80 per cent of them again going to the United States and Belgium. Metal exports in 1966 were nearly 18 per cent lower than those in 1965, with Britain and the United States continuing to be our major customers.

Canada's reported consumption of primary and secondary lead was more than 5 per cent higher than in 1965. Greater use of primary lead for semifinished products and cable covering, and higher consumption of secondary lead for batteries, battery oxides, and antimonial lead were mainly responsible for the increase.

UNITED STATES STOCKPILE

In April 1965 the United States Government authorized the release of 200,000 short tons of lead from its stockpile, which included 50,000 tons for government use only. Of the 200,000 tons authorized for sale, 36,218 tons were sold in 1965 and 74,054 tons were sold in 1966, leaving an unsold balance of 89,728 tons at the end of 1966. Stockpile lead at the end of 1966 amounted to 1.22 million tons, all of which was considered to be surplus to conventional and nuclear war requirements.

*Mineral Resources Division.

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TABLE 1

Canada, Lead Production, Trade and Consumption, 1965–66

	1965		1966P	
	Short Tons	$	Short Tons	$
Production				
All forms[1]				
Northwest Territories	82,831	25,677,695	115,000	34,362,000
British Columbia	125,167	38,801,671	100,183	29,934,731
New Brunswick	43,654	13,532,677	47,999	14,342,101
Newfoundland	21,916	6,793,882	21,112	6,308,227
Yukon	8,926	2,766,953	8,186	2,446,126
Quebec	4,213	1,306,066	3,754	1,121,736
Ontario	1,943	602,518	1,943	580,437
Nova Scotia	1,841	570,871	1,626	485,836
Manitoba	1,316	407,990	546	162,996
Total	291,807	90,460,323	300,349	89,744,190
Mine output[2]	302,952		324,490	
Refined[3]	186,484		184,871	
Exports				
In ores and concentrates				
United States	46,063	8,925,910	56,095	10,038,000
Belgium and Luxembourg	39,384	7,401,972	33,003	5,313,000
Japan	1,885	527,393	13,125	2,316,000
West Germany	3,895	695,714	5,057	822,000
Britain	5,689	1,166,916	4,652	740,000
Other countries	10,048	1,766,349	1,002	192,000
Total	106,964	20,484,254	112,934	19,421,000
In pigs, blocks and shot				
Britain	60,476	19,818,635	43,046	9,985,000
United States	31,622	9,534,950	36,304	10,476,000
Netherlands	11,212	3,527,027	10,209	2,439,000
India	10,399	3,257,680	7,788	1,850,000
West Germany	5,042	1,484,409	2,913	697,000
Japan	3,761	1,104,183	2,651	689,000
Greece	—	—	1,126	249,000
Italy	1,568	438,310	580	142,000
Spain	2,222	707,431	560	148,000
Other countries	2,763	793,041	1,291	326,000
Total	129,065	40,665,666	106,468	27,001,000
Lead and lead-alloy scrap				
United States	4,511	827,917	3,412	676,000
Yugoslavia	823	814,736	754	128,000
Britain	223	57,166	160	46,000
Japan	—	—	159	70,000
Other countries	3,485	762,012	—	—
Total	9,042	2,461,831	4,485	920,000
Lead fabricated materials, not elsewhere specified				
United States	894	418,401	1,746	611,000
India	—	—	203	162,000
Dominican Republic	—	—	50	15,000
Venezuela	2	1,190	36	17,000
Jamaica	68	29,179	30	11,000
Other countries	380	128,798	53	17,000
Total	1,344	577,568	2,118	833,000

TABLE 1 (Cont.)

Imports				
Lead pigs, blocks and shot	71	35,906	626	188,000
Lead oxide: litharge, red lead, mineral orange	1,185	478,082	1,504	541,000
Lead fabricated materials, not elsewhere specified	258	235,714	227	237,000
Total	1,514	749,702	2,357	966,000

	1965			1966P		
	Primary	Secondary	Total	Primary	Secondary	Total
	(short tons)			(short tons)		
Consumption						
Lead used for or in the production of:						
Antimonial lead	1,132	16,932	18,064	1,094	17,612	18,706
Battery and battery oxides	18,967	1,338	20,305	18,757	2,539	21,296
Cable covering	4,500	2,114	6,614	5,476	1,914	7,390
Chemical uses: white lead, red lead, litharge, tetraethyl lead, etc	17,537	2,065	19,602	17,391	2,725	20,116
Copper alloys: brass, bronze, etc.	275	151	426	483	53	536
Lead alloys						
Solders	2,878	2,591	5,469	2,895	2,849	5,744
Other, including babbitts, type metal, etc.	354	1,699	2,053	465	2,114	2,579
Semifinished products: pipe, sheet, traps, bends, blocks for caulking, ammunition, foil, collapsible tubes, etc.	11,256	3,753	15,009	13,082	1,674	14,756
Other	1,097	1,529	2,626	1,554	2,270	3,824
Total	57,996	32,172[4]	90,168	61,197	33,750[4]	94,947

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.

P Preliminary; – Nil.

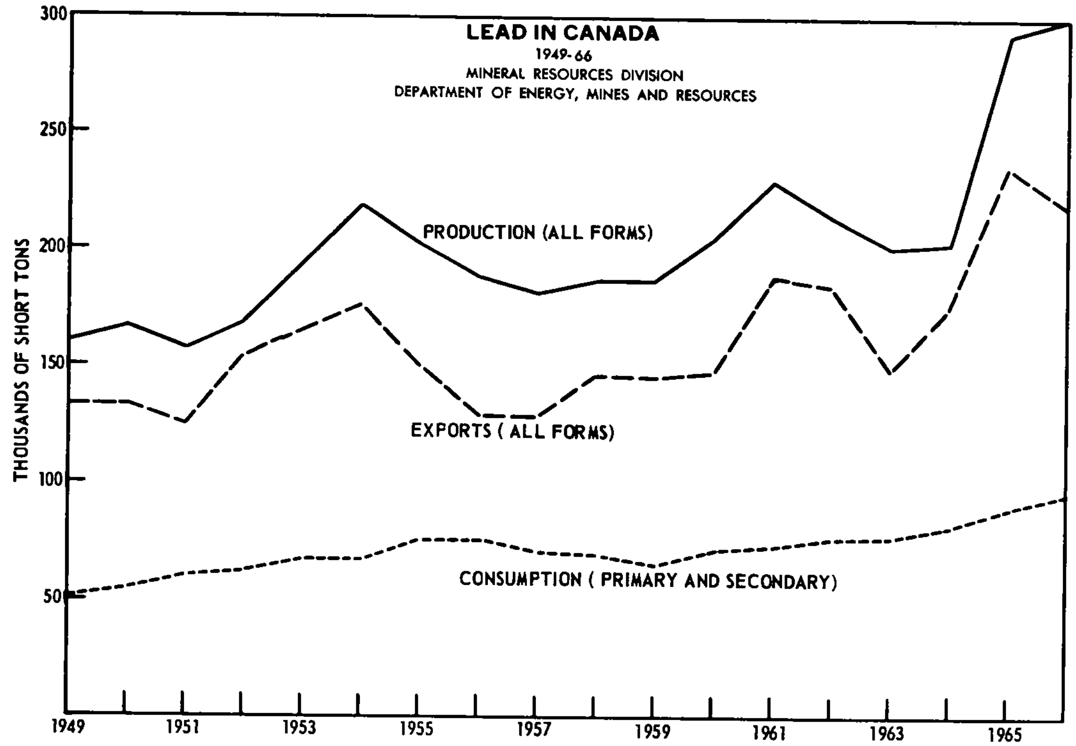


TABLE 2

Canada, Lead Production, Trade and Consumption, 1957-66
(short tons)

	Production		Exports				
	All Forms[1]	Refined[2]	In Ores and Concentrates	Refined	Total	Imports Refined[3]	Consumption[4]
1957	181,484	142,935	44,167	84,541	128,708	1,507	71,583
1958	186,680	132,987	54,081	92,351	146,432	1,668	69,769
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
1966P	300,349	184,871	112,934	106,468	219,402	626	94,947

Source: Dominion Bureau of Statistics.
[1] Lead content of base bullion produced from primary materials (concentrates, slags, residues, etc.) plus recoverable lead in domestic ores and concentrates exported. [2] Primary refined lead from all sources. [3] Lead in pigs and blocks. [4] Consumption of lead, primary and secondary in origin.
P Preliminary.

WORLD PRODUCTION AND CONSUMPTION

Non-communist world mine production of lead was 2.34 million short tons in 1966, or slightly more than 5 per cent higher than in 1965. Higher production by Peru, Canada and the United States together accounted for more than half of the increase. Canada retained its position as the non-communist world's third largest mine producer following Australia and the United States. Non-communist world production of primary and secondary refined lead, at 2.94 million short tons was almost 32,000 tons more than in 1965. West Germany, Mexico and France reported the largest increases.

TABLE 3

Non-communist World Mine Production of Lead, 1965-66
(short tons)

	1965	1966*
Australia	397,800	395,200
United States	313,700	331,000
Canada	302,900	320,900
Mexico	186,700	..
Peru	162,100	188,600^e
Yugoslavia	117,200	117,300^e
Republic of South Africa	98,100	..
Morocco	86,200	..
Sweden	73,300	76,300
Japan	60,500	69,700
Spain	62,200	68,800
West Germany	57,200	66,800
Italy	39,100	40,500
Other countries	264,800	..
Total	2,221,800	2,339,200^e

Source: International Lead and Zinc Study Group.
*Total includes estimates for those countries for which figures are not available.
.. Not available; ^{e}Estimate.

Consumption of lead, primary and secondary, in the non-communist world continued to rise and in 1966 reached a new record of 3.07 million short tons, an increase of 3 per cent from 1965. The United States remained the world's largest consumer, using over 1.3 million tons or almost 59,000 tons more than in 1965. The major increases occurred in the use of lead for gasoline antiknock additives and for ammunition and collapsible tubes. Larger amounts were also used in pigments, cable covering and storage batteries.

In reviewing the estimates for lead made at its November 1966 meeting in Munich, West Germany, the International Lead and Zinc Study Group noted that non-communist world supply and demand were approximately in balance in 1966. For 1967 its forecast was for supplies to grow slightly more than demand, which would result in a surplus of some 50,000 short tons. This surplus would be increased by disposals from United States Government stocks.

CANADIAN PRODUCTION AND DEVELOPMENTS

PRODUCTION

In 1966 Pine Point Mines Limited, 69 per cent owned by Cominco Ltd., completed its first full year of regular operations at Pine Point, N.W.T., and became Canada's largest single mine producer of lead. Its output of some 121,000 tons accounted for more than 37 per cent of Canada's mine production of lead. Output was again lower at the Sullivan, Bluebell and H.B. mines owned and operated by Cominco Ltd. in southeastern B.C. Operations were suspended at the H.B. mine on November 1.

Other major producers in declining order of output were: Brunswick Mining and Smelting Corporation Limited, which brought into production its No. 6 mine near Bathurst, N.B.; the Buchans unit of American Smelting and Refining Company in Newfoundland; and United Keno Hill Mines Limited at Elsa, Y.T.

Other producers included Canadian Exploration, Limited and Reeves MacDonald Mines Limited in southeastern B.C., and Heath Steele Mines Limited, about 32 miles northwest of Newcastle, N.B. In addition to Brunswick's No. 6 mine, production was initiated at 3 other new mines in 1966 – Western Mines Limited on Vancouver Island, B.C. ; Giant Soo Mines Limited near Wasa, B.C. ; and Texas Gulf Sulphur Company near Timmins, Ontario. Operations were suspended at 2 small mines in the Slocan district of B.C., namely Johnsby Mines Limited and London Pride Silver Mines Ltd.

DEVELOPMENTS

YUKON TERRITORY

Late in 1966, Anvil Mining Corporation Limited completed a diamond drilling program on the Faro No. 1 orebody at its lead-zinc-silver deposit in the Vangorda Creek area in central Yukon Territory about 140 miles northeast of Whitehorse. Drilling results indicated reserves of about 40 million tons grading more than 10 per cent combined lead and zinc. Further diamond drilling was done by Kerr Addison Mines Limited on its Swim Lakes "A" Group of claims in the Vangorda Creek area. Results of the drilling indicated reserves of about 5 million tons grading 9.5 per cent combined lead and zinc.

NORTHWEST TERRITORIES

Although prospecting continued at a high pace and was widespread in the N.W.T., the most prominent area was Pine Point. In June 1966, Pine Point Mines Limited purchased 408 mineral claims of Pyramid Mining Co. Ltd. in the Pine Point area, adjacent to or near the south boundary of Pine Point's original property. Pyramid's ore reserves have been estimated at 11.2 million tons grading about 2.5 per cent lead and 8.0 per cent zinc.

A group comprised of Newconex Canadian Exploration Ltd., Conwest Exploration Company Limited, and Central Patricia Gold Mines, Limited, outlined a deposit of about 1,250,000 tons grading 13 per cent combined lead and zinc on property adjoining the claims of Pine Point Mines Limited. Coronet Mines Ltd. continued diamond drilling and exploration work at its property in the Pine Point area. Previous work indicated a deposit of 1.1 million tons averaging 13.2 per cent combined lead and zinc.

BRITISH COLUMBIA

Tune-up operations commenced in December at the 750-ton-a-day concentrator at the copper-zinc-lead-silver-gold property of Western Mines Limited near Myra Falls in central Vancouver Island. Reasonably assured ore reserves at the company's Lynx and Paramount mines have been estimated at over 2 million tons grading 1.10 per cent lead. In the latter part of 1966 Giant Soo Mines Limited brought into production the Estella zinc-lead-silver mine and mill near Wasa in the East Kootenay area. The new concentrator has a rated capacity of 120 tons of ore daily and millheads were expected to average about 8 per cent lead. Giant Soo is the operating company, jointly owned by Giant Mascot Mines, Limited and Copper Soo Mining Company Limited.

Columbia River Mines Ltd. continued exploration and underground development work at its silver-zinc-lead property on Vermont Creek, about 20 miles southwest of Golden. Proven and probable ore reserves have been calculated at about 600,000 tons grading almost 7 per cent combined lead and zinc.

SASKATCHEWAN

Surface and underground development work continued at the zinc-lead-copper-silver property (Par group of claims) of Share Mines & Oils Ltd. in the Hanson Lake area of Saskatchewan about 45 miles west of Flin Flon, Man. A 350-ton-a-day concentrator was under construction and expected to commence operations by the end of May 1967. Ore reserves have been estimated at 253,000 tons grading 8.09 per cent lead.

ONTARIO

Tune-up operations began in November at the first of three similar 3,000-ton-a-day units making up the 9,000-ton capacity concentrator of Texas Gulf Sulphur Company near Timmins. The entire plant was expected to be operating at capacity in the spring of 1967. Although zinc and copper concentrates will be the main products derived from milling operations, the company will also produce a quantity of byproduct lead concentrates.

NEW BRUNSWICK

In September 1966 Brunswick Mining and Smelting Corporation Limited brought into production its No. 6 open-pit mine near Bathurst. Reserves at year-end were 13.4 million tons grading 2.37 per cent lead and 5.94 per cent zinc, together with copper and silver values. Ore from the No. 6 orebody was milled at a newly-constructed 2,250-ton-a-day concentrator at the company's No. 12 minesite. At the base-metal property of Heath Steele Mines Limited, 40 miles northwest of Newcastle, sinking of a new shaft was started on B orebody as part of an expansion program to double ore production by 1968.

TABLE 4

Principal Lead Producers in Canada, 1965–66

Company and Location	Mill Capacity (tons ore/day)	Grade of Ore Milled in 1966 (principal metals) Lead (%)	Zinc (%)	Copper (%)	Silver (oz/ton)	Ore Produced 1966 (1965) (short tons)	Lead in Concentrates and Direct-Shipping Ores 1966 (1965) (short tons)	Remarks
British Columbia								
Aetna Investment Corporation Limited, Mineral King mine, Toby Creek	500	1.54	3.89	..	0.40	114,737 (145,196)	1,612 (1,578)	Continuing development on 11 and 12 levels from new No. 2 shaft.
Canadian Exploration, Limited, Jersey mine, Salmo	1,900	0.89	3.39	–	..	417,440 (377,124)	3,249 (3,522)	
Cominco Ltd., Sullivan mine, Kimberley	10,000.	..	..	–	..	2,135,660 (2,301,071)	88,861 (101,091)	Major revision to underground ventilation system completed.
Bluebell mine, Riondel	700	..	..	–	..	246,390 (256,332)	12,733 (12,930)	Exploration and development to the north end of the mine will be continued.
H.B. mine, Salmo	1,200	..	..	–	..	388,130 (415,290)	3,256 (4,770)	Operations suspended October 31, 1966
Giant Soo Mines Limited, Estella mine, Wasa	150	5.09	11.0	–	2.10	11,141 (–)	514 (–)	Production commenced in August; diamond drilling to test orebody at depth.
Johnsby Mines Limited, Silverton	150	3.00	5.52	–	7.55	5,928 (10,925)	171 (421)	Operations suspended in September 1966.
London Pride Silver Mines Ltd., Cork Province mine, Kaslo	100	..	..	–	..	.. (26,019)	.. (540)	Operations suspended in April 1966.

Table 4 (Cont.)

Company and Location	Mill Capacity (tons ore/day)	Grade of Ore Milled in 1966 (principal metals)				Ore Produced 1966 (1965) (short tons)	Lead in Concentrates and Direct-Shipping Ores 1966 (1965) (short tons)	Remarks
		Lead (%)	Zinc (%)	Copper (%)	Silver (oz/ton)			
Mastodon-Highland Bell Mines Limited, Beaverdell	100	2.19	2.01	–	30.88	24,138 (23,213)	528 (316)	Mill capacity increased.
Reeves MacDonald Mines Limited, Remac	1,200	1.20	3.85	–	..	395,921 (409,504)	3,989 (4,119)	Diamond drilling indicated possible new orebody in an area southwest of Pend Oreille River.
Western Mines Limited, Myra Falls, Vancouver Island	750	..	..	..	..	.. (–)	.. (–)	Began production in December 1966.
Yukon Territory-Northwest Territories								
United Keno Hill Mines Limited, Hector-Calumet, Elsa, and Keno mines, Mayo District, Y.T.	500	7.60	5.61	–	36.56	120,374 (146,850)	8,324 (9,377)	Underground development and production curtailed.
Pine Point Mines Limited, Pine Point, N.W.T.	5,000	4.9	10.5	–	..	1,457,990[1] (75,356)[1]	121,023 (..)	Acquired Pyramid orebodies and plan to bring them into production by 1969.
Manitoba-Saskatchewan								
Hudson Bay Mining and Smelting Co., Limited, Flin Flon mine, Flin Flon	6,000 treated at central mill, Flin Flon	0.2	2.90	2.00	0.65	1,044,206 (873,934)	866 (1,271) (Flin Flon and Chisel Lake mines combined)	Developed new additions to known orebodies at Chisel Lake mine.
Chisel Lake mine, Snow Lake		0.4	9.98	0.83	0.95	250,524 (293,221)		

Ontario								
Noranda Mines Limited (Geco Division), Manitouwadge	3,700	..	4.15	1.95	2.03	1,459,586 (1,326,400)	836 (1,060)	Preparations made to install underground crusher immediately above 3,850-ft. level.
Texas Gulf Sulphur Company, Kidd Creek mine, Timmins	9,000	..	..	..	..	.. (–)	.. (–)	In November, tune-up operations began at first of three similar 3,000-ton-a-day concentrator units. The other two units were expected to commence operations in the first quarter of 1967.
Willecho Mines Limited, Lun-Echo mine, Manitouwadge	ore custom-milled	0.22	3.89	0.63	1.79	325,738 (283,259)	639 (382)	
Willroy Mines Limited, Manitouwadge	1,700	0.22	2.80	0.60	2.03	219,400 (293,989)	443 (619)	Put in addition to crushing plant to handle Willecho and Big Nama Creek ores.
Quebec								
The Coniagas Mines, Limited, Bachelor Lake	500	0.58	7.12	–	3.14	140,093 (123,059)	600 (606)	Company expected to suspend milling operations about the end of May 1967.
Cupra Mines Ltd., Cupra mine, Stratford Place	ore custom-milled	0.48	4.25	3.40	1.395	158,130 (82,427)	157 (5)	In 1966 did considerable underground drilling, development, and stope preparation.
Manitou-Barvue Mines Limited, Val d'Or	1,300	0.32	3.72	..	2.75	173,130[2] (168,895)[2]	455 (586)	
New Calumet Mines Limited[3], Calumet Island	800	2.07	7.03	–	4.03	95,761 (97,586)	1,924 (1,544)	
Solbec Copper Mines, Ltd., Stratford Place	1,500	0.73	6.23	1.41	1.926	154,795 (403,869)	1,021 (1,832)	Operations suspended September 9 by labour strike which was still not settled at year-end.

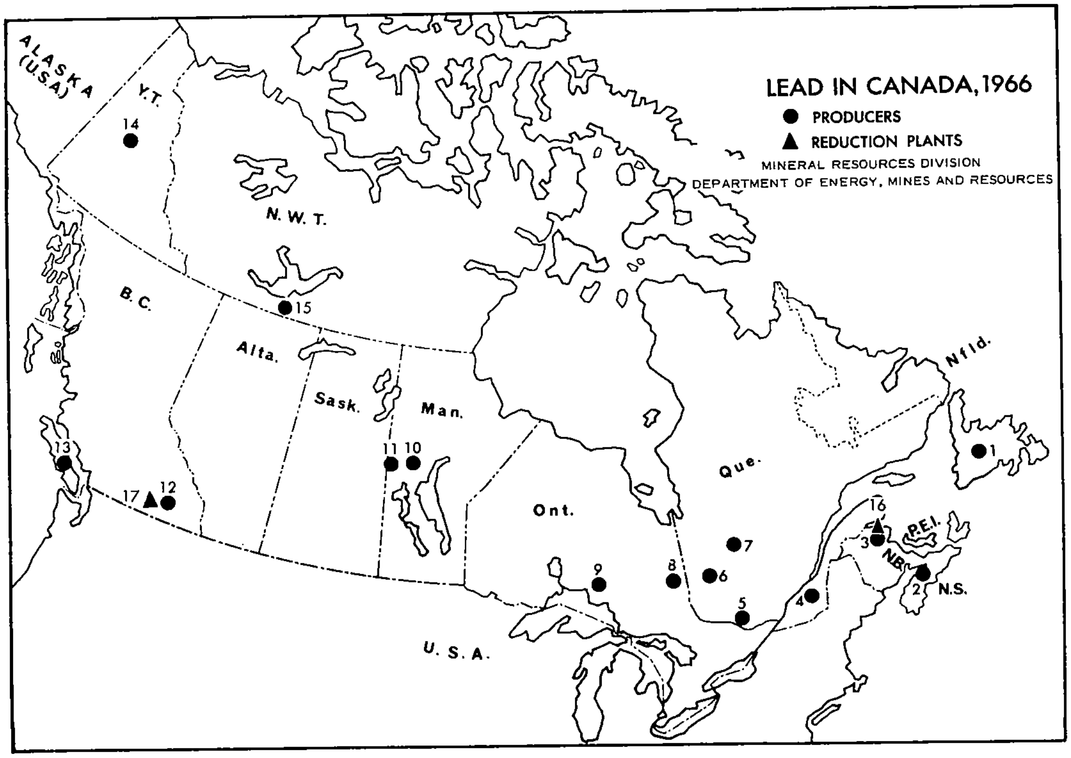
TABLE 4 (Cont.)

Company and Location	Mill Capacity (tons ore/day)	Grade of Ore Milled in 1966 (principal metals)				Ore Produced 1966 (1965) (short tons)	Lead in Concentrates and Direct-Shipping Ores 1966 (1965) (short tons)	Remarks
		Lead (%)	Zinc (%)	Copper (%)	Silver (oz/ton)			
New Brunswick								
Brunswick Mining and Smelting Corporation Limited, No. 12 mine, Bathurst	4,500	3.64	9.26	0.22	2.21	1,650,120 (1,657,519)	. . (. .)	
No. 6 mine, Bathurst	2,250	2.75	6.19	0.35	1.72	300,676 (–)	. . (–)	Operations commenced in September 1966
Heath Steele Mines Limited,[4] Newcastle	1,500	2.08	5.90	1.04	2.11	287,515 (. .)	3,829 (4,679)	Commenced sinking of new production shaft, which is expected to be completed in 1967 to depth of 1,750 feet.
Nova Scotia								
Magnet Cove Barium Corporation, Walton	125	3.0	1.6	0.61	12.0	50,213 (48,594)	1,432 (1,737)	Exploration program underway.
Newfoundland								
American Smelting and Refining Company, Buchans Unit, Buchans	1,250	7.28	12.80	1.09	4.19	355,000 (366,000)	24,752 (26,177)	

Source: Company reports.

[1] Figures represent tons of ore milled. Milling operations commenced mid-November 1965. In 1966 company also produced 282,309 tons of direct-shipping ore of grade averaging 26.26 per cent zinc and 18.75 per cent lead. [2] Production does not include copper ore milled in separate circuit. In 1966, 295,875 short tons of copper ore grading 0.93 per cent copper were treated. [3] Production for fiscal years ending September 30. [4] About one half of Heath Steele's mill capacity is used to treat ore mined by Cominco Ltd. at its Wedge Mine.

–Nil; . .Not available.



PRINCIPAL PRODUCERS

(numbers refer to numbers on the map)

1. American Smelting and Refining Company (Buchans Unit)
2. Magnet Cove Barium Corporation
3. Brunswick Mining and Smelting Corporation Limited (Nos. 12 and 6 mines)
   Heath Steele Mines Limited
4. Cupra Mines Ltd.
   Solbec Copper Mines, Ltd.
5. New Calumet Mines Limited
6. Manitou-Barvue Mines Limited
7. The Coniagas Mines, Limited
8. Texas Gulf Sulphur Company
9. Noranda Mines Limited (Geco Division)
   Willecho Mines Limited
   Willroy Mines Limited
10. Hudson Bay Mining and Smelting Co., Limited (Chisel Lake mine)
11. Hudson Bay Mining and Smelting Co., Limited (Flin Flon mine)
12. Aetna Investment Corporation Limited (Mineral King mine)
    Canadian Exploration, Limited
    Cominco Ltd. (Bluebell mine, H.B. mine, Sullivan mine)
    Giant Soo Mines Limited
    Johnsby Mines Limited
    London Pride Silver Mines Ltd.
    Mastodon-Highland Bell Mines Limited
    Reeves MacDonald Mines Limited
13. Western Mines Limited
14. United Keno Hill Mines Limited
15. Pine Point Mines Limited

REDUCTION PLANTS

16. East Coast Smelting and Chemical Company Limited
17. Cominco Ltd.

Nigadoo River Mines Limited, a subsidiary of the Sullivan group of companies, continued surface and underground development work at its silver-lead-zinc-copper property in Gloucester County in the Bathurst area. Indicated ore reserves have been calculated to a vertical depth of 1,000 feet at almost 1.4 million tons grading 2.97 per cent lead. A 1,000-ton-a-day concentrator was under construction and expected to be in operation late in 1967.

Further diamond drilling and metallurgical testing were carried out at the base-metal property of Restigouche Mining Corporation, Ltd., about 70 miles west of Bathurst, jointly owned by Teck Corporation Limited and The New Jersey Zinc Company. Earlier work indicated 2.6 million tons of ore grading 5.49 per cent lead and 6.76 per cent zinc. The Anaconda Company (Canada) Ltd. continued exploration and metallurgical test work on its large Caribou base-metal deposit about 36 miles west of Bathurst.

USES

Lead has many useful chemical and mechanical properties and because of this versatility it has a variety of industrial applications. It is ductile, malleable and easily worked. Lead alloys readily with 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 still in lead-acid storage batteries, the bulk of which are used for starting and lighting 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. Batteries consume about equal quantities of lead in the metallic grids and posts, and in the oxide paste. Lead's next important uses are for gasoline antiknock additives, solders and type 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 attenuation qualities, lead is being increasingly used in the architectural and building fields for acoustical privacy and noise reduction in both commercial and residential construction. In the allied field of vibration isolation, lead-asbestos antivibration pads are frequently installed in the foundations of skyscrapers and other buildings exposed to severe vibration from nearby trains, subways, or heavy haulage vehicles.

Other miscellaneous uses include 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 and growing uses are for leaded procelain-enamelled 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. Research is endeavouring to develop new markets for organometallic lead compounds in lubricating oils, antifouling paints, as wood impregnants for repelling marine borers, biocides, fungicides, insecticides, curing agents for rubber and polyurethane foam catalysts.

TABLE 5

United States Consumption of Lead by End-Use, 1965-66
(short tons)

	1965	1966[p]
Batteries	455,347	457,066
Gasoline antiknock additives	225,203	246,879
Pigments	108,883	118,230
Solder, type metal, terne metal and bearing metals ...	134,944	126,561
Ammunition and collapsible tubes.	68,215	88,926
Caulking	66,584	58,672
Cable sheathing	59,645	66,020
Sheet and pipe	47,406	45,217
Miscellaneous	75,255	68,829
Estimated undistributed consumption..	–	23,800
Total	1,241,482	1,300,200

Source: U.S. Bureau of Mines Mineral Industry Surveys, United States Lead Industry, December 1966.
[p] Preliminary. –Nil.

Refined lead is marketed in several grades that vary mainly according to the content of impurities, which include silver, copper,

THE CROWNING TOUCH TO NEW BRUNSWICK'S BASE-METAL INDUSTRY: The lead-zinc-silver refinery of East Coast Smelting and Chemical Company Limited at Belledune on Chaleur Bay, nearing completion in 1966.

arsenic, antimony, tin, zinc, iron and bismuth. The three principal grades are: corroding, common and chemical. 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.

RESEARCH

In a long-term fundamental research program at the Mines Branch, Department of Energy, Mines and Resources, on the properties of liquid metals, experimental data were obtained on the viscosity, surface tension and density of binary lead-base alloys with antimony, and ternary alloys with tin and antimony.

An extensive critical survey of existing literature on surface tension phenomena and measurement has been prepared for publication. In a related activity, computer reprocessing of comprehensive mathematical data pertinent to experimentation in this field, has considerably simplified the evaluation of measurement, and the existing Bashforth and Adam's tables used in surface tension measurements have been expanded to limit interpolative errors.

PRICES AND TARIFFS

The Canadian price, f.o.b. Toronto and Montreal, was 15.5 cents a pound from the beginning of 1966 until May 5 when it declined to 15.0 cents. On October 11 the price moved downward to 14.0 cents and remained at this level for the rest of the year. The U.S. price, f.o.b. New York, was 16.0 cents a pound from the beginning of 1966 until May 5 when it dropped to 15.0 cents. On October 10 the price declined to 14.0 cents and remained at this level for the rest of the year. On January 3, 1966, the London Metal Exchange (LME) settlement and cash sellers' price was £111.75 per long ton (15.0 cents a pound Can.), which was the high for the year. The LME price declined during the year and reached a low of £78.5 (10.6 cents Can.) on December 28.

Canadian and U.S. tariffs in 1966 were as follows:

	British Preferential	Most Favoured Nation	General
Canada			
Lead in ores and concentrates	free	free	free
Lead, old, scrap, pig and block, per lb	½¢	½¢	1¢
Lead in bars and sheets	10%	10%	25%
Babbitt metal and type metal in blocks, bars, plates, sheets	10%	20%	20%
Lead capsules for bottles	free	22½%	30%
Lead, manufactures, n.o.p.	20%	25%	30%
Collapsible tubes of lead or lead coated with tin	10%	25%	30%

United States

Lead in ores and concentrates	0.75¢ per lb on lead content
Lead, bullion, waste and scrap	1.0625¢ per lb on 99.6% of lead content
Other forms of unwrought lead	1.0625¢ per lb on lead content

Varying tariffs ranging from 1.3125¢ per lb. to 1.5¢ per lb and from 11.25% ad val. to 24% ad val. apply on wrought lead products.

Lime

D.H. STONEHOUSE*

Preliminary statistics indicate lime production during 1966 was 1.5 million tons, valued at $19.6 million. This is little changed from 1965. Although the general trend of lime production over the past few decades has been steeply upwards, yearly records do not present an uninterrupted increase.

From information supplied by lime producers, the chemical-metallurgical industries absorbed 84 per cent of the lime shipments during 1965. The amounts used by steel plants and by pulp-and-paper operations increased significantly. In the construction field, finishing lime and mason's lime were used in greater quantities but less lime was used in the production of sand-lime brick. Agricultural and soil stabilization uses each accounted for greater consumption of lime during 1965.

PRODUCTION

A sufficient quantity of limestone, suitable for lime manufacture, is available near most urban and industrial centres in all provinces except Prince Edward Island and Saskatchewan. In the production of a low-cost commodity such as lime this is an important factor because the industry cannot absorb high-cost, long transportation. About two thirds of Canada's total lime production comes from Ontario; and Ontario and Quebec together account for 92 per cent of the total production.

Commercial lime was not produced in 1966 in Newfoundland, Prince Edward Island, Nova Scotia, Saskatchewan or British Columbia although some lime was recovered from pulp-and-paper operations in British Columbia. Most of the lime shipped or used captively in Canada is high-calcium quicklime. Dolomitic and magnesian quicklime are produced as well and the hydrated forms of all types are also made. In 1966 quicklime constituted 84 per cent of total lime production.

The trend within the lime industry is to automation and greater capacities. Over the past few years production facilities designed to increase efficiency have been put to use but a major problem remaining is that of choosing a kiln of proper design. Whether a rotary or a vertical kiln is incorporated in a plant is determined by conditions peculiar to individual operations. One major lime producer intends to install a calcimatic kiln which will boost plant capacity by 300 tons a day. Hydration equipment has not changed greatly and conventional crushing and pulverizing equipment is used. Quarrying techniques involving the use of heavy equipment have kept pace with other comparable open-pit mining operations.

During 1966, 20 companies operated a total of 27 plants: one in New Brunswick, 5 in Quebec, 13 in Ontario, 4 in Manitoba, and

*Mineral Processing Division, Mines Branch.

TABLE 1

Lime — Production and Trade

	1965		1966P	
	Short Tons	$	Short Tons	$
Production*				
By type				
Quicklime	1,340,386	15,998,141	1,300,000e	
Hydrated lime	280,018	4,136,167	246,428e	
Total	1,620,404	20,134,308	1,546,428	19,634,088
By province				
Ontario	1,132,193	13,842,169	1,065,449	13,524,359
Quebec	371,251	4,190,113	352,342	3,768,306
Alberta	61,207	1,154,931	71,824	1,337,628
Manitoba	52,199	846,253	53,090	898,145
New Brunswick	3,554	100,842	3,723	105,650
Total	1,620,404	20,134,308	1,546,428	19,634,088
Imports				
Quick and hydrated				
United States	25,143	529,411	29,155	561,000
Britain	124	2,443	76	1,000
France	67	5,143	18	6,000
Total	25,334	536,997	29,249	568,000
Exports				
Quick and hydrated				
United States	238,318	2,660,268	176,921	2,087,000
British Guiana	780	6,999	2,703	26,000
Bahamas	103	2,280	460	11,000
Bermuda	115	2,250	427	9,000
Leeward and Windward Islands	10	184	340	7,000
Other countries	8	506	13	1,000
Total	239,334	2,672,487	180,864	2,141,000

Source: Dominion Bureau of Statistics.

* Shipments and quantities used by producers. In 1965, 1,082,036 tons of the total were shipped and 538,368 tons were used at the producing plants.

p Preliminary; e Estimated.

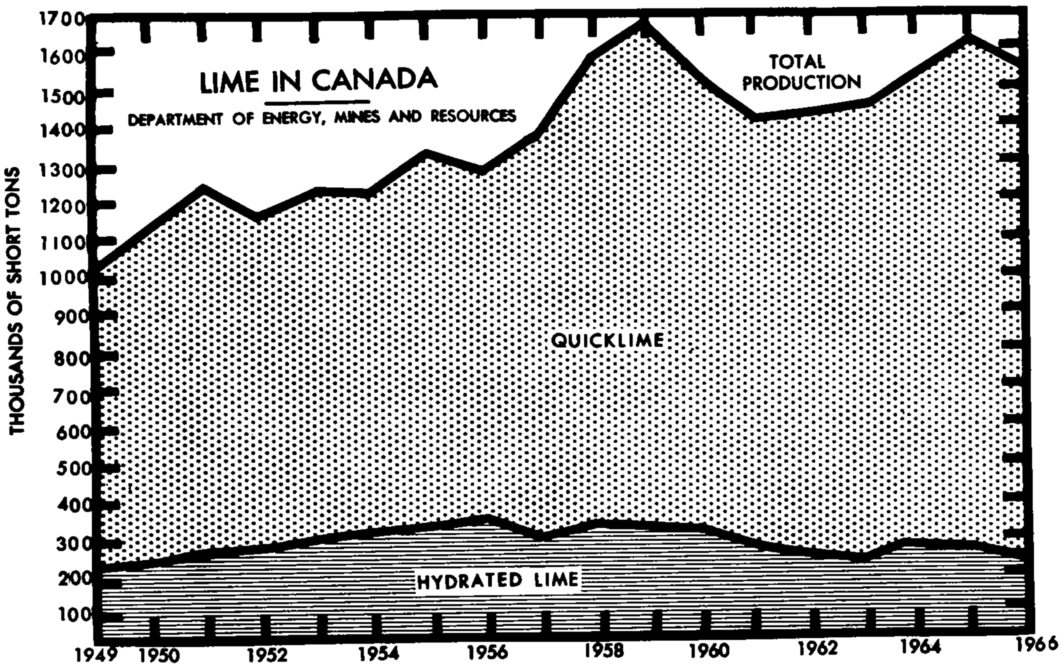
4 in Alberta. A total of 100 kilns was maintained, 84 shaft and 16 rotary, affording a daily rated capacity of 10,000 tons. Only 76 kilns were operated during the year, 60 shaft and 16 rotary, capable of producing 9,000 tons per day. Assuming 340 operating days and using the preliminary production tonnage of 1,546,428, the industry operated at 45 per cent of its rated capacity.

Significant quantities of lime were produced for captive use and unknown quantities were recovered from sludge-burning operations in pulp-and-paper plants. Not all captive lime production is recorded.

Total exports of lime in 1966 decreased to 180,864 tons from the record 239,334 tons of the previous year though substantially above the 1964 exports; the decrease was attributable to a decrease in exports to the United States. Imports increased to 29,249 tons, most of which came from the United States.

CONSUMPTION AND USE

The greatest single use for lime is as a flux in the production of steel, and with the wide acceptance of the basic-oxygen-furnace



process (BOF) of steel manufacture, Canadian lime production will find greater markets in this industry. The BOF technique requires 125 pounds of high-calcium lime per ton of steel produced, compared to 28 pounds per ton in the open hearth process. There is a continued increase in the amount of lime used by the pulp-and-paper industry but many tons of lime are reclaimed from sludge and by recovering cooking chemicals.

Other chemical uses showing increased consumption of lime include water and sewage treatment. The rapidly growing concern for care and treatment of water supplies and the strong appeal for enforced anti-pollution measures can result in greater requirements for lime. A.S.T.M. Designation: C 53-63 concerns the standard specifications for quicklime and hydrated lime for water treatment.

In the construction industry, slight increases are recorded in the use of mason's lime and finishing lime. The former is meeting stiff competition from prepared masonry cement and the latter is competing with dry-wall and plastics in the building trades. A.S.T.M. specifications covering quicklime and hydrated lime for structural purposes are as follows:

Specification	Relating to
C 207-49 (1961)	Hydrated lime for masonry uses
C 141-61	Hydraulic hydrated lime for structural use
C 6-49 (1961)	Normal finishing hydrated lime
C 415-63	Sand lime products
C 49-57	Silica brick manufacture
C 5-59	Quicklime for structural purposes
C 206-49	Special-finishing hydrated lime

In general, calcium and magnesium oxides must be at least 95 per cent of the whole by weight, carbon dioxide no greater than 5 per cent at point of manufacture, 7 per cent if sampled elsewhere, and unhydrated oxides as received, Type S no more than 8 per cent, Type N no requirement. Sieve analyses allow a maximum of 0.5 per cent retained on a No. 30 sieve and a maximum of 15 per cent retained on a No. 200 sieve.

Agricultural lime, used to neutralize soil acidity, has found growing but small use in Canada. A considerable amount of ground limestone, usually called "lime", is used as a soil conditioner, but large areas of farmland are not treated. Road and soil stabilization have not been implemented in Canada to the degree that they have in the southern United States where over 500,000 tons of lime was used for that purpose in 1965.

Markets should require additional lime in future years and existing operations are equipped to produce increased amounts from well-distributed, high-quality raw materials.

TABLE 2

Consumption of Lime
(producers' shipments by use)

	1964		1965	
	Short Tons	$	Short Tons	$
Chemical and Metallurgical				
Iron and steel plants	282,010	3,311,229	355,913	4,303,619
Pulp mills	190,870	2,344,978	204,956	2,490,442
Uranium plants	47,075	552,575	18,698	215,161
Nonferrous smelters	103,123	790,834	85,956	599,071
Sugar refineries	46,686	694,197	41,258	700,015
Cyanide and flotation mills	18,843	279,792	19,235	272,748
Glass works	4,342	41,218	4,318	43,701
Fertilizer plants	14,090	150,213	9,144	93,645
Tanneries	4,030	62,238	3,774	60,912
Water and sewage treatment	15,041	255,537	15,434	282,726
Other	622,067	7,478,407	619,010	7,126,748
Construction				
Finishing lime	83,556	2,008,185	85,092	1,922,713
Mason's lime	30,875	522,539	32,282	581,997
Sand-lime brick	31,219	355,892	28,530	327,231
Agricultural	16,939	203,090	19,081	226,984
Road stabilization	5,061	84,702	8,274	143,385
Other	24,900	273,078	69,449	743,210
Total	1,540,727	19,408,704	1,620,404	20,134,308

Source: Dominion Bureau of Statistics.

TABLE 3

Lime Producers, 1966

Name of Firm and Plant Location	Type of quicklime
New Brunswick	
Snowflake Lime, Limited, Saint John	High-calcium and dolomitic*
Quebec	
Aluminum Company of Canada, Limited, Wakefield	Magnesian*
Dominion Lime Ltd. Lime Ridge	High-calcium*
Domtar Chemicals Limited, Joliette	" *
Quebec Sugar Refinery, St. Hilaire	"
Shawinigan Chemicals Limited, Shawinigan	"

TABLE 3 (Cont.)

Name of Firm and Plant Location	Type of quicklime
Ontario	
The Algoma Steel Corporation, Limited, Sault Ste. Marie	High-calcium
Bonnechere Lime Limited, Grattan tp.	"
Allied Chemical Canada Ltd., Anderdon tp.	"
Canada and Dominion Sugar Company Limited, Chatham	"
Canadian Gypsum Company, Limited, Guelph tp.	Dolomitic*
Carleton Lime Products Co., Carleton Place	High-calcium
Cyanamid of Canada Limited, Niagara Falls	"
Cyanamid of Canada Limited, Beachville	"
Dominion Magnesium Limited, Haley	Dolomitic
Domtar Chemicals Limited, Hespeler	" *
Domtar Chemicals Limited, Beachville	High-calcium*
Rockwood Lime Company Limited, Rockwood	Dolomitic
The Steel Company of Canada, Limited, Ingersoll	High-calcium
Manitoba	
B.A.C.M. Limited, Inwood	Dolomitic*
The Manitoba Sugar Company, Limited, Fort Garry	High-calcium
The Manitoba Sugar Company, Limited, Spearhill	"
The Winnipeg Supply and Fuel Company, Limited, Stonewall	Dolomitic
Alberta	
Canadian Sugar Factories Limited, Raymond	High-calcium
Canadian Sugar Factories Limited, Picture Butte	"
Canadian Sugar Factories Limited, Taber	"
Steel Brothers Canada Ltd., Kananaskis	" *
Summit Lime Works Limited, Crowsnest	" *
British Columbia	
Crown Zellerback Canada Limited, Ocean Falls	"
Crown Zellerback Canada Limited, Campbell River	"
Domtar Chemicals Limited, Granville Island	"

* The hydrated varieties are also produced.

PRICES

Quicklime is marketed in lump, pebble, crushed and pulverized form. It may be sold as bulk or in bags. Hydrated lime is normally shipped in bags. Prices vary with the type of product, type of shipment, amount sold, and supply and demand. In 1965 shipments of quicklime and hydrated lime averaged, respectively, $11.94 and $14.77 a ton at the plant.

Limestone

D.H. STONEHOUSE*

Production of limestone in Canada has increased steadily in recent years and is directly related to increased activities in the construction industry. Since 1960 the amount of limestone produced for cement manufacture has increased 50 per cent to an estimated 12.3 million tons in 1966. Increases as great as 14 per cent have been recorded in a single year.

Limestone produced in 1966 for non-cement, non-lime uses is estimated at 64 million tons, of which only about 10 per cent was shipped or used for non-construction purposes. This grouping has been recorded in Table 1 as "miscellaneous" and detailed under the "by use" section. Annual increases in production for non-cement, non-lime uses have been as great as 22 per cent, due mainly to expanding highway construction projects, and since 1960 a 75 per cent increase in production has been recorded. The amount of limestone mined for production of lime has not increased greatly over the past 10 years and for 1966 is estimated to be 2.7 million tons.

Plants were operated in all provinces except Saskatchewan and Prince Edward Island in 1966 and 95 per cent of the limestone produced for non-cement, non-lime uses came from two provinces, Ontario and Quebec. Total value of this commodity is estimated at $73.9 million for 1966, an increase of more than 5 per cent over the final value for 1965.

For the most part, the import-export trade with respect to limestone is with the United States and results because of deposit location as well as because of chemical or physical properties associated with the raw material. Exceptions are whiting-grade material such as that imported from European countries and some chemical-grade limestone entering northwestern United States from British Columbia and Alberta, and Ontario from adjacent States. Compared to total production, tonnages traded are minor. Crushed limestone and refuse exported to the United States in 1966 amounted to 1.15 million tons valued at $1.94 million, whereas imports of the same materials were 1.4 million tons valued at $3.6 million, each representing a slight increase over the quantity and value reported for 1965.

Within the cement industry major changes are taking place with respect to materials handling and quality control. The general trend, especially in new plants, is to a computer-controlled operation. Normal improvements in open-pit mining techniques have been adopted where applicable within the limestone industry.

DISTRIBUTION OF DEPOSITS

Limestones possessing the physical or chemical qualities required for use in the

*Mineral Processing Division, Mines Branch.

TABLE 1

Limestone — Production, Trade, Consumption

	1965		1966P	
	Short Tons	$	Short Tons	$
Production[1]				
By province				
Quebec	35,473,875	36,461,581	39,052,084*	40,535,224*
Ontario	23,241,567	27,227,844	21,610,707	25,717,656
British Columbia	1,759,567	2,879,861	1,410,436	2,822,179
Manitoba	936,625	1,351,653	1,198,532	2,212,340
New Brunswick	366,390	821,743	233,138	684,568
Alberta	166,657	488,880	177,990	917,105
Newfoundland	11,985	89,887	—	—
Nova Scotia	222,167	652,556	316,275	969,689
Total	62,178,833	69,974,005	63,999,162	73,858,761
	1964		1965	
By type				
General[2]	56,909,844	62,919,534	62,003,833	69,708,082
Marl	110,046	221,194	175,000	265,923
Total	57,019,890	63,140,728	62,178,833	69,974,005
By use				
Metallurgical	2,876,659	3,498,967	2,359,530	2,766,531
Pulp and paper	543,328	1,335,197	339,773	1,047,287
Glass	75,896	265,439	82,639	279,821
Sugar refining	63,472	113,692	92,420	175,037
Other chemical uses	367,413	375,119	487,092	612,097
Pulverized for agricultural use	1,195,117	3,253,209	1,156,869	3,183,647
Pulverized for other uses	1,199,190	1,749,004	1,271,121	1,983,860
Road metal	28,364,591	28,800,655	39,441,850	39,630,232
Concrete aggregate	15,638,544	15,591,168	11,482,662	12,866,748
Rubble and riprap	687,808	740,592	683,948	774,496
Railroad ballast	1,897,360	1,715,206	2,145,647	2,332,488
Structural[3]	67,635	1,357,844	67,634	1,648,278
Other uses	4,042,877	4,344,636	2,567,648	2,673,483
Total	57,019,890	63,140,728	62,178,833	69,974,005
Exports	1965		1966	
Crushed limestone and refuse				
United States	1,098,048	1,576,299	1,150,165	1,939,000
Leeward and Windward Islands	25	650	—	—
Total	1,098,073	1,576,949	1,150,165	1,939,000
Stone, crude; not elsewhere specified				
United States	165,314	401,859	193,661	393,000
St. Pierre and Miquelon	—	—	5,163	45,000
Bahamas	—	—	1,202	4,000
Ceylon	—	—	245	4,000
Belgium and Luxembourg	—	—	80	4,000
Other countries	356	10,872	26	8,000
Total	165,670	412,731	200,377	458,000

TABLE 1 (Cont.)

Imports				
Stone, crushed, including stone refuse				
United States	1,488,273	3,384,959	1,437,105	3,571,000
Italy	4,796	97,973	5,157	65,000
Belgium and Luxembourg	61	1,564	86	2,000
Other countries	309	8,908	–	–
Total	1,493,439	3,493,404	1,442,348	3,638,000
Limestone flux and calcareous stone, used for manufacturing of lime and cement[4]				
United States	1,138,769	2,630,244	1,172,900	3,071,465
Consumption				
In production of cement	11,517,771		12,300,000^{e}	
In production of lime	2,927,691		2,700,000^{e}	
Miscellaneous	62,178,833		63,999,162	
Total	76,624,295		78,999,162	

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. Includes sedimentary limestone and minor coloured recrystallized limestone. 3. Includes building, monumental and ornamental stone as well as flagstone and curbstone. 4. US Department of Commerce, United States Exports of Domestic and Foreign Merchandise (Report FT 410). Values are in US dollars.

^{p} Preliminary; – Nil; * Includes marble; ^{e} Estimated.

TABLE 2

Limestone Consumption 1957–1966

Year	Cement Mfg.	Lime Mfg.	Miscellaneous*	Total
1957	8,741,863	2,562,740	32,686,552	43,991,155
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	2,866,000^{e}	57,019,890	70,161,243
1965	11,517,771	2,927,691	62,178,833	76,624,295
1966	12,300,000^{e}	2,700,000^{e}	63,999,162^{p}	78,999,162

* Includes limestone used for metallurgical, chemical, agricultural and construction purposes.

^{e} Estimated; ^{p} Preliminary.

construction or chemical industries occur near the more heavily populated areas where they are required. In many centres in southern Ontario and Quebec the effects of urbanization are being felt in limestone operations as they are in the sand, gravel and crushed stone industries. Most of Canada's production is mined, processed and used in these areas although producing deposits occur in all other provinces except Saskatchewan and Prince Edward Island. Suitable and easily accessible deposits are not known in northwestern Ontario nor in eastern Alberta.

Marl is an unconsolidated form of limestone usually mixed with organic material and usually containing some silica. Where quality is good, quantity ample and a demand exists, this material, which occurs in all provinces, is recovered for agricultural applications.

USES

The uses for limestone are many and varied. The physical properties of a limestone, together with its location, quantity and availability, can make it the preferred stone for many applications in the construction industries. The chemical properties of a limestone determine its use in the cement, lime, chemical and metallurgical fields. Limestones consist mainly of calcium carbonate (calcite) or the double carbonate of calcium and magnesium (dolomite). Classification based on content of these constituents is generally accepted.

In Canada over 90 per cent of limestone quarried in 1965 was used in the many phases of the construction industry as road metal, concrete aggregate, railroad ballast, rubble and riprap, structural stone, terrazzo, stucco,, fillers in construction products and as the basic raw material in the manufacture of cement and lime products. 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 produce lime. Texture, hardness and colour are physical properties that are important in other construction applications.

In chemical applications the limestone or lime may or may not appear in the end product. Some major uses in the chemical field are: neutralization of acid waste liquors; manufacture of soda ash from sodium chloride brine; extraction of aluminum oxide from bauxite; production of ammonia, 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.

Limestones are used in the metallurgical industries as a fluxing material, which combines with impurities in the ore to form a fluid slag which can be separated from the metal. A calcium limestone is used in open-hearth operations whereas both calcium limestones and dolomitic limestones are used as a flux in the production of pig iron from iron ore in blast furnaces.

Limestone is used extensively as a filler and, where quality permits, as a whiting or whiting substitute. In such applications both physical and chemical properties must be considered. Specifications vary greatly depending on the particular use to which the material is put. 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 as well as a filler.

Agricultural limestone has been used for many years to correct soil acidity and to add calcium and magnesium to the soil. The amount used is not as great as it should be to maintain and improve soil conditions, however, through continued promotional efforts of agricultural departments, the use of agricultural limestone is increasing. Limestone and lime are used as soil stabilizers, particularly on highway construction projects.

Dolomitic limestone is the source of magnesium metal produced by Dominion Magnesium Limited, at Haley, Ontario. Dead-burned dolomitic limestone, for use as a refractory, is produced by Steetley of Canada Limited at Dundas, Ontario, and brucitic limestone is the source material for the production of magnesia and lime by Aluminum Company of Canada, Limited, at Wakefield, Quebec.

PRICES

Depending on the type, quality, degree of preparation, local supply and demand, and the quantity involved, limestone prices vary greatly. Screenings and refuse could be sold for 50 cents per ton, ground whiting substitute could bring $13 to $14 per ton. Transportation costs provide a major portion of the final price and make it undesirable to move the less expensive grades any great distance.

TARIFFS

	British Preferential (%)	Most Favoured Nation (%)	General (%)
Canada			
Limestone, not further processed than crushed or screened	Free	Free	25
Flagstone and building stone, not hammered, sawn or chiselled	10	10	20

United States

Limestone, crude, not suitable for use as monumental, paving, or building stone — 20¢ per short ton

Limestone, crude, broken or crushed, when imported to be used in the manufacture of fertilizer — free

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Lithium Minerals

J.E. REEVES*

The operations of Quebec Lithium Corporation —mine, concentrator and chemicals plant— have been inactive since they were closed by a strike near the end of October 1965. Late in 1966, the company stated that it would not resume production until prices and markets improved. During 1966, lithium carbonate and lithium hydroxide monohydrate, containing a little less than a quarter million pounds of lithia (Li_2O) and worth a little more than a quarter million dollars, were shipped from storage.

The consumption of lithium products is increasing steadily, although somewhat less dramatically than has been forecast or anticipated from time to time. Improvements in technology and new and expanding markets continue to provide promise of long-term growth.

CANADIAN OCCURRENCES

Lithium minerals, particularly spodumene, occur in several widely distributed areas.

QUEBEC

The property of Quebec Lithium Corporation in Lacorne Township, north of Val d'Or, contains numerous parallel pegmatite dikes containing a large quantity of spodumene. Indicated reserves exceed 20 million tons of ore containing an average of 1.15 per cent Li_2O. These deposits are some of a large number of spodumene-bearing pegmatites associated with the Lacorne granitic batholith.

In several places to the north and west of Chibougamau, pegmatites with abundant spodumene have been found.

MANITOBA

Lithium-bearing pegmatites occur in the Winnipeg River — Cat Lake area. A nearly flat deposit controlled by Chemalloy Minerals Limited on the north shore of Bernic Lake contains large quantities of low-iron spodumene and lepidolite, a small amount of amblygonite, an unusual concentration of the cesium mineral, pollucite, and small amounts of beryl and tantalite. There are 5 million recoverable tons of lithium-bearing material containing an average of more than 2 per cent Li_2O.

OTHER OCCURRENCES

Many occurrences of spodumene-bearing pegmatites have been discovered in several areas of northwestern Ontario, most notably in the area south and southeast of Lake Nipigon. Pollucite has been identified in a spodumene pegmatite northeast of Dryden.

In the Northwest Territories to the north and east of Yellowknife, pegmatites containing spodumene, lesser amounts of amblygonite, minor amounts of other lithium minerals and beryl and columbite-tantalite have been described.

* Mineral Processing Division, Mines Branch.

FOREIGN PRODUCTION

The United States is the principal producer and consumer of lithium minerals, chemicals and metal. It has been relying largely on vast reserves of spodumene in pegmatites in North Carolina and on dilithium sodium phosphate, one of several products recovered from the processing of brine at Searles Lake in southern California. In June 1966 at Silver Peak, Nevada, Foote Mineral Company began producing lithium carbonate as the principal product of the processing of brine that contains a relatively high lithium content — 0.04 per cent lithium compared with 0.006 per cent in the Great Salt Lake brine and a similar amount in the Searles Lake brine. The use of solar evaporation in the early concentration steps permitted the company to offer lithium carbonate from Nevada initially at reduced prices. By the end of the year Foote had announced its intention to double the rate of production to 10 million pounds of lithium carbonate a year.

Rhodesia has been the principal source of petalite and lepidolite for various world markets. They have a low iron content, and in the United States are consumed directly in glass and various other ceramic products. Rhodesia also produces spodumene, eucryptite and occasionally amblygonite. A ban by many countries on imports of lithium mineral concentrates from Rhodesia should result in a decline in production. Foote Mineral Company is preparing to market a low-iron spodumene concentrate that could be used by the ceramics industry in place of Rhodesian concentrates.

TECHNOLOGY

Lithium is a relatively common element in the earth's crust. An abundance of lithium minerals occurs in granitic pegmatites in many parts of the world. Those of economic importance are listed in Table 1.

TABLE 1

Principal Lithium Minerals

Mineral	Simplified formula	Theoretical Li_2O Percentage	Actual Range Li_2O Percentage
Spodumene	$LiAlSi_2O_6$	8.0	4 – 7.5
Petalite	$LiAlSi_4O_{10}$	4.9	3 – 4.5
Lepidolite	$KLi_2AlSi_4O_{10}(F, OH)_2$	7.7	3 – 5
Amblygonite	$LiAlFPO_4$	10.1	7.5 – 9
Eucryptite	$LiAlSiO_4$	11.9	5.5 – 6.5

Lithium is also present in commercial quantity, along with various other elements, in some brine deposits.

Lithium is consumed mainly in the form of various chemical compounds, which are derived by many different processing methods from the raw materials. Smaller quantities of low-iron lithium mineral concentrates are important for direct use. A small amount of lithium metal is produced.

USES

The ceramics industry is one of the main consumers of lithium chemicals, especially lithium carbonate, and the sole consumer of lepidolite, petalite and spodumene concentrates. These chemicals and concentrates are important primarily because of their content of lithia, a very strong flux, lithium carbonate being used when a high proportion of lithia is required. Petalite is a source of lithia with a low potash, soda and iron content. Lithia permits the development of low-temperature bodies that reduce the cost of refractories and fuel. It lowers the maturing temperature and increases the fluidity and gloss of glasses, glazes and enamels. It makes possible glasses that are harder and that have higher electrical, chemical and thermal resistance.

Another main use is in the manufacture of lubricating greases. 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°F to +320°F, and to be highly water resistant. Developed originally for use in aircraft, lithium greases have become of widespread importance.

Lithium chloride and lithium bromide are hygroscopic and are used for moisture absorption in air conditioning and refrigeration.

Lithium hydroxide monohydrate is added to the electrolyte in nickel-iron alkaline storage batteries to increase their life and output. The prospect of battery-powered automobiles offers a potentially promising long-range market.

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.

To a small extent, lithium carbonate is added to the electrolyte in the Hall cell of aluminum smelters. The strong fluxing action of lithia reduces power requirements. The aluminum industry offers a potentially large market.

Lithium metal is used as a scavenger of oxygen, nitrogen and sulphur in copper and some brasses and bronzes, and as a reducing agent in the synthesis of such pharmaceutical products as vitamins and antihistamines. Butyl lithium is used as a catalyst in the production of synthetic rubber. Alloys of lithium and magnesium or aluminum have promise as light-weight and high-strength structural metals.

PRICES

In mid-December 1966, producers in the United States announced increases in the price of several lithium compounds. The price of lithium carbonate was increased by 4 cents a pound to 42½ cents and of lithium hydroxide monohydrate by 3½ cents a pound to 53½ cents, in truckloads or carlots. Prices of many of the compounds are quoted regularly in the *Oil, Paint and Drug Reporter.*

TARIFFS

Tariffs in effect at the time of writing include:

	British Preferential (%)	Most Favoured Nation (%)	General (%)
Canada			
Lithium compounds			
Of a class or kind not produced in Canada	free	15	25
Of a class or kind produced in Canada	15	20	25

United States

Lithium compounds and salts –	10.5%
Lithium stearate –	1.5¢ a pound plus 10% ad val.
Lithium metal –	25%

Magnesite and Brucite

D.H. STONEHOUSE*

The magnesia industry in Canada is based on two operations in the province of Quebec – one mining a brucitic limestone and the other a dolomitic magnesite. Active interest in a deposit of magnesite near Timmins, Ontario, continues.

Although increased use of magnesia by the pulp and paper processing industry is indicated, the major portion of domestic production and of imports is consumed in the manufacture of refractory materials.

Canadian production of dead-burned and calcined magnesia during 1966 was valued at \$3.9 million, a slight decrease from that of 1965. World production of crude magnesite** continues to increase and for 1965 was estimated to be 10.7 million tons of which 3.2 million tons was estimated to be from the USSR, by far the largest single producer. Quantities of magnesia obtained from brine and from sea-water operations are not known but constitute a major part of total United States production.

Exports of crude refractory materials to the United States increased greatly during 1966 to 1.3 million tons valued at \$2.7 million. These included items for refractory use other than magnesia. Refractory magnesia, bricks and shapes imported by the United States from Canada accounted for a smaller tonnage than the crude refractories but were valued at \$3.2 million, very close to the value recorded for 1965. Canadian imports of magnesia and magnesia products during 1966 came from the United States, Yugoslavia, Austria, Greece, Japan and Britain with minor amounts from West Germany and the Netherlands. Total value of imports was \$5.4 million.

PRODUCERS

The two Quebec operations are Canadian Refractories Limited and Aluminum Company of Canada, Limited. The former ships a dead-burned magnesia, the latter markets calcined magnesia and magnesium hydroxide.

At Kilmar, in southwestern Quebec, Canadian Refractories Limited mines from underground a magnesite-dolomite rock, which is beneficiated at the plant site by heavy media separation, dead-burning, crushing and sizing. Small quantities of the product are shipped to the United States but most of it goes to the company's plant at nearby Marelan, where it is used in the manufacture of basic refractories. The company put its third tunnel kiln into operation during 1966 – a unit 400 feet in length, oil-fired, automatically controlled, and operated at 3200°F. The new kiln is used primarily for "high-firing" of direct-bonded basic brick, mainly of high-purity magnesia and chrome content.

At Wakefield, Quebec, Aluminum Company of Canada, Limited mines, by open pit methods, a brucitic limestone, extracting the brucite as magnesia and producing lime from the limestone. The quarried rock is selectively loaded onto

*Mineral Processing Division, Mines Branch.
**Source: U.S. Bureau of Mines *Minerals Yearbook 1965*.

TABLE 1

Magnesite and Brucite-Production and Trade, 1965-66

	1965		1966P	
	Short tons	$	Short tons	$
Production[1], Quebec				
Magnesia from magnesite and brucite	..	4,010,927	..	3,928,158
Exports				
Crude refractory materials[2]				
United States	905,271	1,872,418	1,302,245	2,682,000
Australia	123	4,564	116	8,000
Other countries	22	1,048	—	—
Total	905,416	1,878,030	1,302,361	2,690,000
Imported by United States[3]				
Refractory magnesia including fused magnesia and dead-burned magnesia and dolomite	1,969	112,511	2,470	144,953
Magnesia, brick and other shapes	20,759	3,381,995	19,872	3,208,679
Imports				
Magnesia, dead-burned and sintered				
United States	23,797	1,832,375	21,625	1,743,000
Yugoslavia	5,055	305,587	7,235	475,000
Austria	3,745	258,587	4,133	292,000
Japan	—	—	1,102	91,000
Greece	2,976	226,421	722	57,000
Other countries	447	40,720	—	—
Total	36,020	2,663,690	34,817	2,658,000
Magnesia, not elsewhere specified				
United States	1,660	233,993	1,728	269,000
Britain	564	42,602	1,013	90,000
Netherlands	77	5,500	—	—
Total	2,301	282,095	2,741	359,000
Magnesium oxide				
United States	771	364,418	1,114	396,000
Britain	95	52,523	85	46,000
West Germany	44	7,939	—	—
Total	910	424,880	1,199	442,000
Dolomite calcined				
United States	29,417	559,671	17,227	323,000
Sweden	339	22,254	—	—
Total	29,756	581,925	17,227	323,000
Magnesite firebrick and other shapes				
United States	297	809,646	429	1,363,000
Britain	195	178,912	285	268,000
West Germany	7	18,162	11	15,000
Other countries	79	78,087	—	—
Total	578	1,084,807	725	1,646,000

Source: Dominion Bureau of Statistics except where otherwise indicated.
[1] Includes the value of brucitic magnesia shipped, and of dead-burned magnesia and a small quantity of serpentine used or shipped. Since 1963, some magnesium hydroxide has been shipped. [2] Mainly includes materials other than magnesia. [3] Not recorded separately in the official Canadian trade statistics. The figures shown are reported in United States imports of Merchandise for Consumption, 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; — Nil; .. Not available.

trucks and taken to a crushing plant where it is reduced to minus 1 7/8 inches and screened to four size ranges to ensure uniform calcination. The granular form of the brucite is retained during the calcination, thus affording a basis for separation. The magnesia is sold for use in the refractory industry, the agricultural industry and the chemical processing industry.

High-magnesia refractories are produced at four plants in Canada: Canadian Refractories Limited, Marelan, Quebec; General Refractories Company of Canada Limited, Smithville, Ontario; Refractories Engineering and Supplies Limited, Bronte, Ontario; and Norton Company, Chippawa, Ontario. Each plant, except that at Marelan, is dependent upon imported magnesia.

Other magnesite deposits have been found in British Columbia, the Northwest Territories, Saskatchewan, Ontario, Quebec, Nova Scotia and Newfoundland. However, except for test shipments, no magnesite has been produced from these deposits. Brucitic limestone has been found near Rutherglen, Ontario, but it has been used only as a source of construction aggregate. Deposits of brucite have been found in other areas of Quebec and Ontario, as well as in British Columbia and Nova Scotia.

Dead-burned dolomitic limestone, commonly referred to as dead-burned dolomite, contains much less magnesia than most basic refractories. It is produced near Dundas, Ontario, by Steetley of Canada Limited but production and export statistics for this commodity are not available.

TABLE 2

Magnesite and Brucite-Production*, 1957-66

1957	$3,046,298
1958	2,529,161
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
1966P	3,928,158

Source: Dominion Bureau of Statistics.
* Brucitic magnesia shipped and dead-burned magnesia and a small quantity of serpentine used or shipped. Since 1963, some magnesium hydroxide has been shipped.
P Preliminary.

TABLE 3

Available Data on Consumption of Magnesia in Canada, 1965
(short tons)

Refractory brick, cements, mixes ..	73,336
Paper and paper products	31,988
Glass wool and fibre	5,466
Foundry	5,218
Other*	1,137
Total	117,145

* Includes: Fertilizers, rubber production, ferrosilicon, sugar processing etc.

TECHNOLOGY

The minerals magnesite and brucite theoretically contain 47.6 and 69.0 per cent magnesia, respectively, and they may be converted to magnesia by calcination. Dolomite, sea-water, sea-water bitterns and some brines may also be processed to recover magnesia. Since 1954 there has been an appreciable increase in the recovery of this commodity from brines and sea-water in the United States. 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.

Technical developments in the steel industry have led to increased use of magnesia-containing refractories, and because of higher temperatures attained with the use of oxygen, the demand for purer refractory grades is increasing. A high-density refractory material is required to ensure longer life of furnace linings and to prevent penetration of the melt or slag. Pelletized material containing 98 per cent MgO is being offered in the United States.

As a means of reducing the erosion of magnesia-based furnace linings in basic oxygen steel refining. One American company is marketing a fluxing lime containing 10-30 per cent of calcined dolomite. The product goes into solution more rapidly than high-calcium limes and supplies the slag with magnesium oxide which it normally leaches from the refractories.

CONSUMPTION AND USES

Statistics relating to the consumption of magnesia in Canada during 1965 appear in Table 3 and, although incomplete, depict the ratio in which major consumption centres use the commodity. Refractory uses account for 68 per cent of reported consumption and the pulp and paper industries used slightly over 30 per cent.

Dead-burned magnesia is employed as an ingredient in such basic refractory products as bricks and shapes, hearth clinker, gunning and ramming mixes, cements and mortars. It has the ability to withstand the effects of basic slags for reasonable periods during metallurgical processing and is particularly popular as a refractory in steel and cement production.

Calcined magnesia is used as a raw material in the production of other magnesium compounds and occasionally in the production of the dead-burned product for use in refractories. It is a source of magnesium metal and an ingredient in magnesium-oxychloride and magnesium-oxysulphate cements which are employed in floor construction and in composition board. Magnesia is also used to control acidity in chemical processing, as a constituent of manufactured fertilizers and in the production of heating elements, rayon, rubber, petrochemicals, magnesian chemicals, welding rod coatings, certain types of insulation and catalysts.

A significant recent development associated with the use of magnesia products has been the conversion of some major pulp and paper manufacturing operations to the Magnefite process based on magnesium bisulphite pulping. The change from a calcium- to a magnesium-based process results in a newsprint of increased strength, permitting greater use of jackpine wood pulp.

PRICES

Prices vary with product quality and product demand. The December 26, 1966, issue of *Oil, Paint and Drug Reporter* quotes the following United States prices per short ton.

Magnesia, dead-burned, standard grade, bulk, car lots, Chewela, Washington	$46.00
Magnesia, calcined, technical, heavy, bags, car lots, f.o.b. Lunning, Nevada	
90%	53.00
93%	56.00
95%	61.00
Magnesia, calcined, chemical grade, powdered, bags, car lots, works	88.75

Magnesium

W.H. JACKSON*

THE CANADIAN INDUSTRY

Smelter shipments of primary magnesium were 6,786 tons in 1966 compared to 10,108 tons in 1965 and this decrease was accompanied by changes in the import pattern. Primary imports from the United States, valued at 38.3 cents a pound, increased 16 per cent to 1,903 tons. For the first time, a major shipment of 1,102 tons was imported into Canada from the USSR having a value, presumably f.o.b. port of shipment, of 26.09 cents a pound. Although the total value of exports declined in 1966, there were increases to the United States, France, Australia and Israel which partially offset a decline in sales to Britain. The total value of metal and alloy exports, including an estimated 732 tons of scrap, were $3.8 million. Imports were worth $2.9 million.

Consumption of primary magnesium has been rising gradually for several years and amounted to 5,187 tons in 1966, an increase of 16 per cent from the previous year.

Dominion Magnesium Limited continues to be the only producer of magnesium in Canada. Other products of the company's mine and smelter at Haley, near Renfrew, Ontario include metallic calcium, thorium, barium, strontium and zirconium. Annual smelter capacity of 11,500 tons of magnesium was not fully utilized in 1966 owing to a prolonged strike lasting almost 4 months. Operations subsequently returned to normal but production of magnesium 'crowns' was only 7,671 tons compared with 11,215 tons in 1965.

Magnesium smelter operations at Haley are based on a local ore supply. The orebody is Precambrian dolomite that lies between a quartzite hanging-wall and a paragneiss foot-wall. Reserves are about 4 million tons to 100-foot depth. Mining is by open pit with benches 20 feet high. The dolomite has exceptional physical characteristics and purity, which permit efficient use of smelter capacity. Following crushing, sizing and calcining in the 400-ton-a-day mill, the calcined dolomite is mixed with ferrosilicon and fluorspar, briquetted, bagged and charged into horizontal retorts for smelting by the Pidgeon process. At high temperature under vacuum, the magnesia (MgO) content is reduced by ferrosilicon and the magnesium is distilled and collected as crystalline rings called 'crowns' in the water-cooled head sections of the retorts. The plant now has a total of 544 retorts in 16 furnaces. For commercial grade magnesium, the crowns are remelted and cast into ingot forms. Subsequent refining operations produce the higher purity grades.

The following grades and purities of magnesium are available: Commercial, 99.90 per cent; High Purity, 99.95 per cent; Special 99.97 per cent; and Refined, 99.99 per cent. These are produced in 20-pound, 5-pound and 1-kilogram ingots, as billets from 4 to 20 inches in diameter and as minus 4 mesh plus 50 mesh granules. Other magnesium products are master alloys, rods, bars, wire, structural shapes, and magnesium alloys to all specifications.

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*Mineral Resources Division.

96411—18½

TABLE 1
Canada, Magnesium Production, Trade and Consumption, 1965-66

	1965		1966 P	
	Short Tons	$	Short Tons	$
Production[1] (metal)	10,108	6,067,057	6,786	3,868,280
Imports				
Magnesium metal				
United States	1,637	1,271,426	1,903	1,458,000
USSR	—	—	1,102	575,000
Other countries	4	6,259	6	9,000
Total	1,641	1,277,685	3,011	2,042,000
Magnesium alloys				
United States	154	547,276	285	878,000
Britain	12	18,937	45	32,000
Total	166	566,213	330	910,000
Exports				
Magnesium metal				
United States	..	594,210	..	1,134,000
Britain	..	1,833,924	..	951,000
West Germany	..	1,476,704	..	893,000
France	..	289,765	..	286,000
Australia	..	78,543	..	82,000
Israel	..	26,066	..	30,000
Other countries	..	157,043	..	76,000
Total	..	4,456,255	..	3,452,000
Consumption (metal)				
Castings	512		554	
Extrusions[2] (structural shapes, tubing)	587		572	
Aluminum alloys	2,959		3,630	
All other products[3]	415		431	
Total	4,473		5,187	

Source: Dominion Bureau of Statistics. 1. Shipments of metal in all forms (ingots, crowns, powder, and in alloys). 2. Includes a small amount of other wrought products. 3. Including other alloys and magnesium used for cathodic protection and as a reducing agent.

P Preliminary; — Nil; .. Not available.

TABLE 2
Canada, Magnesium Production, Trade and Consumption, 1957-66

	Production (short tons)	Imports: Alloys (short tons)	Imports: Metal (short tons)	Exports $	Consumption (short tons)
1957	8,385	..	..	4,535,570	840
1958	6,796	..	..	2,871,991	711
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
1966P	6,786	330	3,011	3,452,000	5,187

Source: Dominion Bureau of Statistics.

P Preliminary; .. Not available.

TABLE 3

World Production of Primary Magnesium, 1964-66
(thousand short tons)

	1964	1965	1966p
United States	79.5	81.4	79.0
USSR	35.0e	36.0e	36.0e
Norway	24.3	25.4	32.0
Canada	9.4	10.1	6.9
Italy	6.6	6.6	6.6
Britain	5.5	5.5	2.0
Japan	3.2	3.7	5.0
France	1.1	3.1	..
Other countries	1.8	2.0	..
Total	166.4	173.8	176.0

Source: US Bureau of Mines Mineral Trade Notes, June 1966 and US Bureau of Mines Commodity Data Summaries, January 1967.
e Estimated; p Preliminary.

WORLD DEVELOPMENTS

Estimates place world primary production at 176,000 tons, 139,000 tons of which was non-communist production. Available information on production by country is listed in Table 3. Secondary magnesium adds considerably to effective supply in Europe, Japan and the United States but the amount produced is not known.

During 1966, the United States Government stockpile of magnesium was reduced by 17,050 tons leaving 7,033 tons in excess of the 145,000 ton stockpile objective that was in effect. In January 1967, the objective was reduced to 90,000 tons. Primary production was 79,774 tons, a slight decrease from 1965 production of 81,361 tons. Shipments increased to 96,416 tons

TABLE 4

Principal World Producers of Magnesium, 1966

	Raw Material	Process	Estimated Capacity 1966	Planned
			(short tons)	
Canada				
Dominion Magnesium Limited	Dolomite	Pidgeon ferrosilicon	11,500	
France				
Société des Produits Azotes	Dolomite	Magnetherm ferrosilicon	3,900	
West Germany				
Knapsack Griesheim A.G.	..	..	(500	
Vereinigte Aluminum Werke A.G.	..	..	(	
Italy				
Societe Italiana per il Magnesio e Leghe di Magnesio, S.P.A.	Dolomite	Ferrosilicon	7,000	
Japan				
Furukawa Magnesium Company	Dolomite	Ferrosilicon	5,000	
Ube Kosan KK	..	..	2,000	5,000
Norway				
Norsk Hydro-Elektrisk	Dolomite, sea-water	Electrolytic	29,700	42,000
United States				
Alamet Division of Calumet & Hecla, Inc.	Dolomite	Pidgeon ferrosilicon	7,000	8,750
The Dow Chemical Company	Sea-water	Electrolytic	100,000	120,000
Nelco Division of Charles Pfizer Company	Dolomite	Pidgeon ferrosilicon	5,000	(closed)
Titanium Metals Corporation	Recycled $MgCl_2$	Electrolytic	12,000	
United Kingdom				
Magnesium Elektron Limited	Dolomite	Pidgeon ferrosilicon	5,000	(closed)
China (mainland)	..	..	1,100	
Soviet Union	Dolomite, carnallite	Electrolytic	50,000	
Poland	..	..	300	

.. Not available.

from 85,796 tons. Producer and consumer stocks declined by 42 per cent to 10,000 tons. Exports in crude form including scrap were 14,868 tons and imports of metal were 3,265 tons. Owing to military action in Viet Nam, United States consumption was unusually high and increased 25 per cent to 87,000 tons.

Basic data are lacking for consumption in most other countries. The individual producers, aware of their markets and growth potential, appear satisfied that planned in- increases in capacity will be absorbed by industry. Table 4 lists nominal capacities by country at the end of 1966 and indicates the level of capacity planned in 1967-68.

The two commercial methods of producing magnesium are the reduction by ferrosilicon of magnesium oxide and the electrolysis of magnesium chloride. The ferrosilicon plants have flexibility in operation but have a high labour content, and require low cost ferrosilicon, heat and a high purity source of dolomite. Costs dictate that most of these plants serve local markets. About 10 tons of dolomite, which contains 13 per cent magnesium, must be mined for each ton of metal produced. Pidgeon-type plants can produce high-purity magnesium, which is desirable as a reducing agent but has no particular advantage when alloyed over metal from electrolytic sources. Electrolytic plants, while built on a larger scale, are more inflexible in adjusting to market demand. Incremental capacity is added cautiously, and capital and market considerations are a deterrent to new ventures.

In Japan, primary magnesium has been produced only by Furukawa Magnesium Company, which has a primary capacity of 5,000 tons and remelt production of about 3,500 tons. A second company, Ube Kosan KK, commenced operation in 1966 with an annual capacity of 2,000 tons; an increase to 5,000 tons a year is planned. The Mitsubishi organization is studying the feasibility of building a smelter.

In Britain, the plant of Magnesium Elektron Limited, completed in 1963 at Hopton in Derbyshire, was closed in April 1966 for economic reasons. The company will now market metal from Norway.

In the United States, Alamet Division of Calumet and Hecla, Inc., producing at a rate of 7,000 tons a year at the end of 1966, planned to increase its annual production rate to 8,750 tons early in 1967. Nelco Division of Charles Pfizer ceased magnesium production in June. Output had mainly been sold to the United States Atomic Energy Commission.

Most world production comes from electrolytic plants in Norway and the United States. The Norwegian plant uses anhydrous magnesium chloride as cell feed. It is close to the main European market and operates with low cost power; capacity will be raised to 38,000 metric tons a year by the end of 1967.

In the United States, the plants of The Dow Chemical Company in Texas use a partially hydrated magnesium chloride as cell feed. These plants have the advantage of product integration with a major chemical complex in addition to the benefits of advanced plant technology, favourable cost structure including power and source of lime for the precipitation of magnesium hydroxide from sea-water (magnesium content 0.13 per cent), good shipping facilities and a basically strong domestic market. Dow will be operating at an annual rate of 95,000 tons early in 1967 and plans to raise output to 120,000 tons a year by 1968. Its potential capacity can likely be raised another 30,000 tons. A new experimental cell using lithium chloride in the electrolyte has been patented and if commercial application is feasible may result in lower energy consumption per pound of magnesium produced.

Interest continues in the recovery of various salts, including magnesium chloride, from Great Salt Lake in Utah although these saline minerals have not qualified for depletion allowance. Magnesium smelters based on low cost power in the northwestern United States have been considered as a possibility for utilization of the salts. While the situation is not clear and it is doubtful if many plans will reach fruition, those contemplating recovery of magnesium salts or smelting on the west coast include: The Dow Chemical Company in association with Lithium Corporation of America, Inc. and Salzdetfurth of Hanover, Germany; the association of National Lead Company, Hogle-Kearns Company and Hooker Chemical Corporation; Kaiser Aluminum & Chemical Corporation; and Harvey Aluminum (Incorporated).

USES

The main market for magnesium, and a 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 rise. Sacrificial anodes for corrosion protection and incendiary devices are other uses that depend on the chemical properties of magnesium.

As a structural material, an extensive technology has been developed to utilize the properties of magnesium alloys. Industry has been gradually accepting magnesium for its intrinsic properties of strength, lightness and rigidity. For many applications, zinc and aluminum are firmly established and market penetration has been difficult except where finished products show a distinct advantage in cost or performance. Extrusions and sheet products of magnesium are available for a wide variety of applications but die-castings are likely to show the best growth rate.

PRICES

The quoted Canadian price of commercial grade magnesium, f.o.b. Haley, was 31.0 cents a pound in 1966. This price has been constant for a number of years. The market price in the United Kingdom is currently 31 cents a pound and in West Germany 27 cents. In the United States, the quoted price of magnesium pig has been unchanged since 1956 at 35.25 cents. Die-casting alloy has been available since 1963 at 30 cents and, under an incentive program for alloyers of aluminum, The Dow Chemical Company initiated a declining price scale in 1965. In that year the basic price of magnesium pig was 35.25 cents but the basic price for smelter alloy purposes was 33.25 cents, which was further reduced to 32.25 cents in 1966. An intent to further modify the published price structure has been announced. For 1967 and for each succeeding year through to 1970 the price would be ½ cent a pound less than the year before and would result in a price of 30.25 cents for pig and 31 cents for ingot in 1970. These prices should stimulate demand in the United States where a 40 per cent tariff on imported ingot is in effect, but should not affect major markets elsewhere where lower prices prevail.

TARIFFS

	British Preferential (%)	Most Favoured Nation (%)	General (%)
Canada			
Pure magnesium	free	15	25
Alloys of magnesium, ingots, pigs, sheets, plates, strips, bars, rods, tubes	5	10	25
Magnesium scrap	free	free	free
Sheet or plate, of magnesium or alloys of magnesium, plain, corrugated, pebbled, or with a raised surface pattern, for use in Canadian manufacture	free	free	25
Magnesium wire	10	20	35
United States			
Magnesium, unwrought: other than alloys; and magnesium waste and scrap (duty on waste and scrap suspended to June 30, 1967)		40% ad val.	
Magnesium alloys, unwrought		16¢ per lb on magnesium content +8% ad val.	
Magnesium alloys, wrought		13.5¢ per lb on magnesium content +7% ad val.	

Manganese

G.P. WIGLE*

Manganese ore is not produced in Canada but small amounts have been mined from scattered occurrences in Nova Scotia, New Brunswick and British Columbia. Large low-grade occurrences have been examined in New Brunswick and Newfoundland but they are of no present economic significance. The one near Woodstock, New Brunswick, is said to contain 50 million tons grading 11 per cent manganese and 14 per cent iron.

Canada's imports of manganese in ores and concentrates in 1966 totalled 184,103 tons, valued at $10.9 million, compared with 89,480 tons valued at $5.4 million in 1965. Imports of ferromanganese and silicomanganese including spiegeleisen totalled 51,049 tons valued at $6.7 million compared with 35,349 tons valued at $4.7 million in 1965. The increased imports are related to increased consumption of manganese and its ferroalloys which, in turn, reflects growing use of alloy steels and castings, and to increases in supplier and consumer stocks. Canada's consumption of manganese ore in 1966 increased 33,247 tons to 152,536 tons.

WORLD PRODUCTION AND TRADE

Estimated world mine production of manganese ores was 20.1 million tons in 1966 compared with 19.4 million tons in 1965. Russia is the largest producer with an estimated 1965 production of 8.5 million tons, and probably more in 1966. The Republic of South Africa, India, Gabon and Brazil produced from 1.4 to 1.8 million tons in 1966.

Canada's imports of manganese ores came mainly from Ghana, which supplied 51 per cent, Brazil, United States (transshipments), Gabon and India. The principal supplier of ferromanganese and silicomanganese was the Republic of South Africa. Canadian producers were unable to maintain their 1965 share of the Canadian market in competition with foreign suppliers of manganese alloys.

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* Mineral Resources Division.

TABLE 1

Canada, Manganese Trade and Consumption, 1965-66

	1965		1966P	
	Short Tons	$	Short Tons	$
Imports				
Manganese in ores and concentrates*				
Ghana	26,981	1,410,349	94,140	5,023,000
Brazil	17,695	1,094,539	36,749	2,233,000
Gabon Republic	–	–	11,704	770,000
India	3,537	236,522	10,227	480,000
Republic of South Africa	6,469	299,267	8,128	337,000
Guyana	7,217	335,583	7,894	396,000
Republic of the Congo (Kinshasa)	12,867	768,043	6,672	382,000
United States	5,653	774,979	6,136	1,018,000
Mexico	12	3,545	2,406	210,000
Other countries	9,049	507,215	47	17,000
Total	89,480	5,430,042	184,103	10,866,000
Ferromanganese including spiegeleisen**				
Republic of South Africa	26,803	3,427,890	47,819	6,190,000
United States	1,450	282,939	1,035	190,000
Japan	78	23,174	99	29,000
France	68	33,002	83	42,000
USSR	–	–	53	15,000
Other countries	6,163	804,200	29	9,000
Total	34,562	4,571,205	49,118	6,475,000
Silicomanganese including silico spiegeleisen**				
Republic of South Africa	–	–	1,792	245,000
United States	635	99,585	139	37,000
Other countries	152	21,553	–	–
Total	787	121,138	1,931	282,000
Exports**				
Ferromanganese				
United States	3,817	748,154	5,722	1,297,000
Consumption**				
Manganese ore				
Metallurgical grade	117,218r		151,070	
Battery and chemical grade	2,071r		1,466	
Total	119,289		152,536	

Source: Dominion Bureau of Statistics.
* Mn content; ** Gross weight
P Preliminary; r Revised; – Nil.

The United States is the leading importer and consumer of manganese ore. The US Bureau of Mines, Mineral Industry Surveys, reported imports for consumption of 2.6 million tons of manganese ore, 35 per cent or more Mn, in 1966; consumption was 2.3 million tons. The United States iron and steel industry used 93 per cent of total consumption, the chemical and miscellaneous industries used 5.5 per cent, and the dry-cell battery industry used 1.5 per cent. Manganese ores were received from more than 20 countries with Brazil, the leading source, supplying 685,000 tons. Gabon was the second largest supplier followed by India, Ghana, Republic of South Africa and the Republic of the Congo. United States imports of ferromanganese at 257,000 tons were about the same as in 1965 and reflected the continuing competition of imported ferroalloys with United States domestic production. France, West Germany, Republic of South Africa and Japan were among the principal suppliers of high and low-carbon ferromanganese.

Russia is singular among major industrial nations in being self-sufficient in manganese ore and in having reserves which far exceed the known reserves of other countries. World reserves of manganese ores are principally large, near-surface, bedded deposits estimated to exceed 2 billion tons of varying grades.(1) The largest known deposits outside the USSR are in the Republic of South Africa, India, Gabon, Brazil, Ghana, Guyana and China. Many other countries contribute small amounts to world production. Australia started shipment of manganese ores from Groote Eylandt, in the Gulf of Carpentaria, in 1966.

Many locations on the deep ocean floors have a cover of manganese oxide nodules. Estimates of the total amount of manganese on ocean beds have been exceedingly large and investigations into methods of recovery are being carried out; however, recovery of manganese from this source is not yet economic.

TABLE 2

Canadian Manganese Imports, Exports and Consumption
1957-66
(gross weight, short tons)

	Imports			Exports	Consumption	
		Addition Agents				
	Manganese Ore	Under 1% Silicon	Over 1% Silicon	Ferro-manganese	Ore	Ferro-manganese
1957	131,318	743	2,257	46,733	195,088	37,906
1958	42,060	2,483	2,185	225	46,143	31,242
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	138,959r	66,202
1965	89,480*	34,562	787	3,817	119,289r	61,352
1966p	184,103*	49,118	1,931	5,722	152,536	..

Source: Dominion Bureau of Statistics.
p Preliminary; .. Not available; r Revised.
* Mn content, all other gross weight.

USES AND SPECIFICATIONS

There are many manganese minerals but only a few are of economic importance. Most manganese is obtained from two minerals – pyrolusite (MnO_2) and psilomelane ($MnO_2 \cdot H_2O$; K, Na, Ba variable). These may be accompanied by other oxides of manganese such as wad or bog manganese, hausmannite and manganite. The carbonate rhodocrosite ($MnCO_3$) and the silicate rhodonite ($MnSiO_3$) are not usually of commercial importance except where they have been weathered and decomposed then recon-centrated as oxides.

(1) United States, Bureau of Mines, preprint from Bulletin 630, Manganese.

Most manganese is consumed in steel manufacture where it is used to remove sulphur, as a deoxidizer, and as an alloying agent to improve the properties of strength, hardness and hardenability of certain steels. It is one of the basic elements in carbon and alloy steels. The Hadfield or manganese steels, containing 10 to 14 per cent manganese, are noted for work-hardening whereby hardness is increased by cold working under impact. Fine-grained manganese steels have unusual toughness and strength. Such steels are often used in making gears, spline shafts, axles, rifle barrels, cylinders for compressed gas, crusher parts and many other products.

Major use distribution of manganese ore in the United States in 1966 was 95 per cent metallurgical, 4 per cent chemical and miscellaneous, and 1 per cent in the dry-cell battery industry. In Canada, 99 per cent of consumption was metallurgical grade, nearly all being used in the steel industry.

The principal form in which manganese is used by the steel industry is as ferromanganese, which is the most important of the ferroalloys used in steelmaking. Standard or high-carbon ferromanganese contains 74 to 82 per cent manganese, 7.5 per cent carbon and not over 1.25 per cent silicon, 0.35 per cent phosphorus or 0.05 per cent sulphur. Low-carbon ferromanganese is used when it is important to limit carbon entering the steel and is available in several grades containing increasing amounts of carbon (e.g., 0.07 per cent, 0.10, 0.15, 0.30 and 0.75 per cent) and containing 80 to 85 per cent manganese. Medium-carbon ferromanganese contains a maximum of 1.5 per cent carbon and 74 to 85 per cent manganese. Silicomanganese contains 1.5 per cent carbon, 18 to 20 per cent silicon and 65 to 68 per cent manganese. Spiegeleisen was formerly used more extensively than at present and is available in grades containing 16 to 28 per cent manganese, carbon not over 6.5 per cent and from 1.0 to 4.5 per cent silicon. A grade known as silicospiegel contains 25 to 30 per cent manganese, 2 to 3 per cent carbon, and 7 to 8 per cent silicon. Electrolytic manganese is also used as a source of low-carbon manganese.

The consumption of manganese used in additive agents in the United States steel industry in 1965 was 13.8 pounds per ton of ingot steel produced. The proportions of the various additives used were 11.7 pounds as ferromanganese, 1.7 pounds as silicomanganese, 0.1 pounds as spiegeleisen, and 0.3 pounds manganese metal.(1)

METALLURGICAL-GRADE MANGANESE ORE

Manganese ores having a manganese-iron ratio of 7 to 1 or more are preferred for making ferromanganese because it maintains high productive capacity in the ferroalloy plant. High silica is undesirable because it increases the quantity of slag with attendant high

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.*

(1) United States Bureau of Mines, Minerals Yearbook, 1965.

TABLE 3

World Production of Manganese Ore, 1964-66
(short tons)

	1964	1965	1966[e]
USSR	7,822,000	8,598,000	..
Republic of South Africa	1,455,262	1,727,811	1,800,000
India	1,437,412	1,657,874	1,700,000
Gabon	1,045,324	1,417,571	1,500,000
Brazil	1,490,077	1,296,987	1,400,000
China	1,102,000	1,102,000	..
Ghana	509,341	665,821	..
Republic of the Congo (Kinshasa)	341,385	416,205	..
Morocco	375,974	414,337	..
Japan	313,825	338,409	..
Other countries	1,543,400	1,778,985	..
Total	17,436,000	19,414,000	20,070,000[e]

Sources: U.S. Bureau of Mines Mineral Trade Notes, September 1966 and U.S. Bureau of Mines Commodity Data Summaries, January 1967.
[e] Estimate; .. Not available.

manganese loss. Since any ore is seldom of ideal composition most ferromanganese producers purchase ores from more than one source and blend them to attain the specifications they require. Manganese ores imported by the United States in 1965 and used in producing ferromanganese, silicomanganese and manganese metal varied in grade from 38.9 to 48.1 per cent manganese and averaged 45.8 per cent. General specifications for metallurgical-grade ore and the bases for price quotations call for 46 to 48 per cent Mn 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. Table 4 shows some representative analyses of manganese ores and concentrates.

BATTERY-GRADE MANGANESE ORE

Battery-grade manganese ores are used in much smaller quantities than metallurgical-grade. Battery-grade 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 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.

TABLE 4

Representative Analyses of Manganese Ores and Concentrates
(per cent)

Country of Origin	Mn	Fe	SiO_2	Al_2O_3	P	Moisture	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
Cuba[4]	50	2.5	9.8	2.2	0.07	1.2	19.8
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
Southwest 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)[5]	53	1.2	..	2.0	0.17	7.5	44.2
USSR (Nikopol)[6]	49	1.5	..	1.4	0.20	12.0	32.7

Source: Compiled from a survey of technical and trade publications.
Notes: 1) 12.5 to 13.5% CaO+MgO; 2) 0.18% As; 3) 0.25% As, 8.42% CaO and 1.38% BaO; 4) 8.33% As; 5) 0.15 to 1.6% CaO+MgO; 6) 1.1 to 2.3% CaO+MgO.
.. Not available

CANADIAN SUPPLIERS AND CONSUMERS

Union Carbide Canada Limited, Metals and Carbon Division, uses metallurgical-grade ore to manufacture standard high-carbon ferromanganese, medium and low-carbon ferromanganese and silicomanganese. Chromium Mining & Smelting Corporation, Limited produces manganese alloys at its plant in Beauharnois, Quebec.

Among principal Canadian consumers of ferromanganese are – *in Nova Scotia:* Dominion Steel and Coal Corporation, Limited, 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.

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.

Consumers of battery-grade ore are National Carbon Limited and Mallory Battery Company of Canada Limited, both of Toronto; Burgess Battery Company Limited, Niagara Falls; and Ray-O-Vac (Canada) Limited, Winnipeg.

PRICES

Prices of manganese in the United States according to *E & MJ Metal and Mineral Markets*. December 26, 1966, were:

Manganese ore, per long-ton unit, c.i.f. United States ports, import duty extra		
Minimum 48% Mn (low impurities)		77–78¢
46% Mn		73–74¢
Prices vary depending on impurities.		

Manganese metal. Electrolytic metal 99.9% f.o.b. shipping point, per lb Mn	
Regular	28.85¢
Hydrogen removed	29.60
4% N	33.60
6% N	34.60

Ferromanganese, carload lots, lump, bulk, f.o.b. shipping point, freight equalized to nearest main producer, per long ton		
Standard	74–76% Mn	$167.50 (nominal)
	78–82% Mn	173.00 "
	low phos.	183.00 "
Imported standard, 74–76% Mn, delivered Pittsburgh Chicago		$158.00 – 163.00
Medium carbon, per lb Mn		16.5¢
"MS" manganese, lb Mn		17.1¢
Low carbon, per lb Mn		
low phosphorus		30¢
0.10 C		27¢
0.30% C		25.5¢
0.75% C		24.5¢
"DQ" manganese		23.5¢

Silicomanganese, per lb, lump bulk carload lots, f.o.b. shipping point, freight equalized to nearest main producer per lb	
12½ – 16% Si, 3% C	8.15¢
16 – 18% Si, 2% C	8.35¢
18½ – 21% Si, 1½% C	8.65¢

Spiegeleisen, f.o.b. shipping point, per gross ton

	Standard	Controlled Weight
16–19% Mn	$87.00	$88.00
19–21% Mn	89.00	90.00
21–23% Mn	91.50	92.50

TARIFFS

	British Preferential	Most Favoured Nation	General
Canada			
Manganese ore	free	free	free
Electrolytic manganese metal for alloying purposes	free	5%	20%
Ferromanganese and spiegeleisen, not more than 1% Si, on Mn content	free	1¢	1¼¢
Silicomanganese, more than 1% Si, on Mn content	free	1½¢	1¾¢

United States

	(cents)
Manganese ore*	0.25 per lb of Mn content
Manganese metal, unwrought	1.875 per lb plus 15% ad val.
Ferromanganese	
Not over 1% C	0.6 per lb on Mn content plus 4.5% ad val.
Over 1% but under 4% C	0.9375 per lb on Mn content
Over 4% C	0.625 per lb on Mn content
Spiegeleisen	75¢ per long ton

* Duty suspended temporarily to 30 June, 1967.

Mica

J.E. REEVES*

Statistics indicate that production of mica in Canada in 1966 was at nearly the same level as in 1965. Early in the year the final shipments of ground phlogopite were made by Blackburn Brothers, Limited, from Cantley, Quebec. Scrap and untrimmed phlogopite sheet were recovered from large waste dumps near Sydenham, Ontario, north of Kingston. The scrap and a small quantity of the ground phlogopite were exported to the United States; the untrimmed sheet was shipped to Japan.

Imports, consisting principally of sheet and ground muscovite, were higher than in 1965. Canada relies mainly on India for sheet muscovite (chiefly splittings) and on the United States for various grades of ground muscovite. Probably more than half of the imports recorded as coming from the United States consist of sheet muscovite that originated in India.

WORLD REVIEW

World production of mica continued to rise in 1965. Production in the United States, which was more than half the total, consists mainly of scrap and flake muscovite for grinding. India is the principal source of muscovite sheet; the Malagasy Republic is the only other source of phlogopite besides Canada. The demand for mica by the more industrialized countries and the high unit value of many grades of mica promote extensive world trade.

TECHNOLOGY

Mica is important because of its unusual physical characteristics. It has consistent and relatively high dielectric properties, high temperature resistance and low thermal conductivity, and its perfect basal cleavage permits it to be readily split into very thin sheets that are flexible, elastic, strong and generally transparent. The preparation of sheet mica is done mostly by hand and requires experience. When ground to a fine powder, mica retains its flaky particle shape, which is advantageous in its many uses as a filler and dusting agent.

*Mineral Processing Division, Mines Branch.

TABLE 1

Mica Production, Trade and Consumption, 1965–66

	1965		1966P	
	Pounds	$	Pounds	$
Production, shipments				
Trimmed	1,261	2,564	–	–
Untrimmed	10,800	2,415	4,000	1,600
Ground	299,500	12,895	339,800	14,082
Scrap	236,050	7,540	200,000	5,240
Total	547,611	25,414	543,800	20,922
Imports				
Rough				
United States	226,000	4,792	–	–
Brazil	2,000	4,166	–	–
Total	228,000	8,958	–	–
Sheet and ground				
United States	5,770,200	422,477	6,246,700	545,000
Britain	83,100	8,062	67,200	4,000
India	153,900	50,310	49,500	22,000
Belgium-Luxembourg	–	–	2,500	2,000
Brazil	400	856	2,400	6,000
Total	6,007,600	481,705	6,368,300	579,000
Fabricated				
United States		579,730		648,000
Britain		21,622		27,000
Other countries		4,023		7,000
Total		605,375		682,000

	1964	1965
Consumption, available data		
Paints and wall-joint sealers	1,632,000	1,236,000
Rubber	694,000	804,000
Electrical insulation	510,000	680,000
Gypsum products	402,000	352,000
Paper and wallboard	290,000	320,000
Asphalt products	282,000	24,000
Other products	130,000	160,000
Total	3,940,000	3,576,000

Source: Dominion Bureau of Statistics.
P Preliminary; – Nil

High-quality muscovite possesses the best dielectric properties of all types of mica and is used extensively for insulation at high frequencies and voltages and in capacitors. Its high strength and transparency make it useful for glazing. It may be colourless, reddish, green or brown and is found in granitic pegmatites. The wet-grinding of clean muscovite scrap, waste and flake yields a powder consisting of polished, well-delaminated particles and having a high reflectivity.

Phlogopite, or amber mica, varies considerably in dielectric strength, hardness, structural strength and other properties but is of some value because of its high thermal resistance. In southwestern Quebec and southeastern

TABLE 2

Mica, Production, Trade and Consumption, 1957–66
(pounds)

	Production*	Imports**	Exports**	Consumption
1957	1,282,416	501,900	362,200	4,028,926
1958	1,504,933	1,047,700	300,100	3,547,396
1959	813,834	1,340,400	423,800	3,622,000
1960	1,702,605	1,838,800	488,800	3,448,000
1961	1,816,160	1,475,800	222,400	3,782,000
1962	1,204,034	2,306,300	200,200	2,954,000
1963	1,183,041	1,737,600	..	3,432,000
1964	1,198,162	5,884,000	..	3,940,000
1965	547,611	6,235,600	..	3,576,000
1966p	543,800	6,368,300	..	..

Source: Dominion Bureau of Statistics.
*Producers' shipments. **Rough and sheet mica. Includes ground mica in 1964 to 1966.
p Preliminary; .. Not available.

TABLE 3

World Production of Mica
(thousand pounds)

	1964	1965
United States	229,701	241,226
India	65,898	82,741
Norway	8,800	6,600
Republic of South Africa	6,868	5,002
Brazil	3,241	3,300
Malagasy Republic	1,504	1,387
Australia	1,270	1,355
Other countries	92,718	93,389
Total	410,000	435,000

Source: US Bureau of Mines Preprint, Mica, 1965.

Ontario it is commonly found in irregular veins with green apatite and pinkish calcite. Its properties vary in relation to its composition and it may range from almost colourless to a deep brown.

USES

Mica is used in three forms: natural sheet, splittings and ground mica.

Natural sheet mica is used for insulation in electrical and electronic equipment and appliances for home and industry. In small amounts it is used in thermal insulation and for glazing boiler gauges and furnace windows. It is sold according to variety, size and quality, depending on the intended application. A trend toward the use of substitute materials has become established but the highest-quality muscovite continues in high demand.

Mica splittings are bonded together in the manufacture of built-up sheet, tape and cloth. Suitable processes of forming the products and curing the binder result in a wide variety of these flexible insulation products. Built-up sheet has replaced natural sheet, within the limits of its physical and electrical characteristics. It can be cut or moulded into washers, tubes and many other forms. Most of the splittings used are muscovite.

Mica paper and mica board have been developed as substitutes for built-up sheet, using ground mica and a binder and essentially some modification of paper-making techniques. Mica paper has the advantage of more consistent thickness.

Most of the mica consumed is ground mica. Dry-ground mica, muscovite or phlogopite, is used for dusting asphalt products, and rubber tires and tubes; as a filler in wall-joint sealing compounds and some paints and as an aid against loss of circulation of drilling mud in oil-well drilling. Wet-ground muscovite is used as an extender pigment in paints, a filler in plastic products and hard rubber, a mould lubricant and dusting agent in the manufacture of rubber tires and, to a minor extent, for adding decorative effects to wallpaper.

SPECIFICATIONS

SHEET MUSCOVITE

The American Society for Testing and Materials has three specifications for natural muscovite. Designation D351-62 provides the basis for specifying quality and size of block muscovite (minimum thickness of 0.007 inch) and the thinner muscovite film. Quality is graded according to the degree of visible stain, inclusions and imperfections. Designation D2131-65 specifies size of, and allowable physical defects for, splittings for use in the manufacture of built-up sheet. Designation D748-59 defines the requirements for electrical, physical and visual quality of block and film for use in fixed mica-dielectric capacitors.

SHEET PHLOGOPITE

In Canada, phlogopite sheet is graded in terms of its linear dimensions. In recent years, only the small sizes, 1 x 1, 1 x 2 and 1 x 3 inches, have been in common use.

No formal quality grading for phlogopite has been established, but the softer, lighter-coloured varieties are generally regarded as having the better electrical qualities.

GROUND MICA

The specification for mica pigment, ASTM Designation D607-42, requires a wet-ground muscovite with a maximum bulk density of 10 pounds per cubic foot, very low moisture and impurity contents, and a particle size that is 93 per cent minus 325 mesh. For other uses, the specifications are a matter of agreement between producer and consumer.

Dry-ground mica is sold in a wide range of particle sizes, from as coarse as minus 20 mesh for use as a dusting agent, to as fine as minus 200 mesh for other purposes. Wet-ground mica is generally at least minus 200 mesh. Mica ground in a fluid-energy mill is becoming more important because of the increasing demand for a particle size below 325 mesh.

PRICES

Prices for mica in the United States, according to *E & MJ Metal and Mineral Markets* of December 26, 1966, included:

Punch mica, per lb –	\$ 0.07–\$ 0.12
Wet-ground mica, per short ton –	160.00– 180.00
Dry-ground mica, per short ton –	34.00– 75.00
Scrap mica, per short ton –	30.00– 40.00

TARIFFS

Canada	British Preferential	Most Favoured Nation	General
Mica schist	free	free	free
Micronized mica	free	5%	25%
Mica, phlogopite and muscovite, unmanufactured, in blocks, sheets, splitting, films, waste and scrap	10%	10%	25%
Low-loss sheets and punchings for electrical and electronic manufactures	free	free	30%

United States

Varying tariffs exist on mica in the unmanufactured form from free to 12.5% ad val. In the semi-manufactured and manufactured forms tariffs range from 12.5% to 40% ad val.

Mineral Pigments and Fillers

D.H. STONEHOUSE

Natural mineral pigments have been replaced to a major degree by synthetic pigments, which are obtained from the chemical and metallurgical processing of metals and minerals. Iron oxide is the only true natural mineral pigment produced in Canada. Among the artificial pigments produced in Canada are synthetic iron oxide and titanium dioxide. The quantity of mineral pigments consumed is relatively small but these materials have many applications wherein they impart colour and opacity to products.

Other synthetic pigments include chromium oxide, lithopone, litharge, red lead, white lead, zinc oxide, blanc fixe, satin white, copper oxide, cobalt oxide and tin oxide.

Although not strictly regarded as pigment, whiting is being used in increasing quantities as a pigment extender in paint.

Many industrial minerals are used as fillers to impart some desirable physical property to a product or to replace a more expensive commodity used in the process. Crushed rock, gravel and lightweight or heavy aggregates, used in masonry and concrete, can be considered fillers, but it is more common to restrict the term to finely ground material. Other terms in common use for fillers, depending on specific applications, are loading materials, diluents or carriers.

Mineral commodities produced and consumed in Canada as fillers include: asbestos, barite, bentonite, clays, diatomite, limestone, mica, nepheline syenite, shale, silica and talc. These materials serve to increase strength and stability, improve surface characteristics, extend pigments and lower costs of the end product. Frequently the extender or filler constitutes a major portion of the finished product. There are no separate statistics available to indicate the production of any commodity for specific filler use nor to indicate shipments for such use. The application of each of the above commodities as fillers is discussed in separate reviews of these minerals.

IRON OXIDE

PRODUCTION

Natural pigment-grade iron oxide is produced at Red Mill, Quebec, from bog deposits nearby. The processing plant was sold by The Sherwin-Williams Company of Canada, Limited, to the employees in November, 1966 and during the following month it was purchased by Red Mill Industries Limited. The operation consists of air-drying, calcining, pulverizing and sizing. Total shipments of natural iron oxide, crude and calcined, during 1966 was about 300 tons. The small output of natural pigments, as compared with that of a few years ago, is continued evidence of the effect of the competition of synthetic pigments, which offer a wide range of colour and excellent quality.

*Mineral Processing Division, Mines Branch.

TABLE 1

Iron Oxide – Production, Trade and Consumption

	1965		1966p	
	Short tons	$	Short Tons	$
Production (shipments)				
Natural (crude and calcined)	309	13,879	300	14,000
Exports				
Natural and synthetic iron oxide				
United States	2,527	452,375	4,382	869,000
France	80	14,266	66	13,000
Britain	55	13,341	29	6,000
West Germany	7	1,170	23	5,000
Other countries	126	24,040	77	18,000
Total	2,795	505,192	4,577	911,000
Imports				
Natural and synthetic iron oxide				
United States	1,296	300,625	1,480	332,000
West Germany	646	85,080	1,134	163,000
Spain	443	23,530	662	35,000
Britain	143	39,169	84	32,000
Total	2,528	448,404	3,360	562,000
	1963		1964	
Consumption by the paint industry				
Calcined and synthetic iron oxide ..	2,009	520,000	2,178	584,000
Ochres, siennas, umbers	168	74,000	191	76,000

Source: Dominion Bureau of Statistics.
p Preliminary.
Production Statistics for Synthetic Iron Oxide are not available.

TABLE 2

Iron Oxide – Production, Trade and Consumption, 1957-66
(short tons)

	Production (shipments natural)	Imports			Exports	Consumption*		
						Coke and Gas Industries	Paint Industry	
		Natural and Synthetic	Ochres, Siennas, Umbers	Oxides, Fillers, Colours, etc.	Natural and Synthetic		Natural and Synthetic	Ochres, Siennas, Umbers
1957	7,518	..	946	4,826	3,440	5,999	1,895	263
1958	1,632	..	680	4,923	2,401	237	1,826	158
1959	1,235	..	833	6,103	2,624	100	1,889	138
1960	909	..	615	4,908	2,523	..	1,858	150
1961	808	..	649	4,903	2,208	..	1,755	130
1962	771	..	..	..	1,865	..	1,955	150
1963	978	..	..	..	2,218	..	2,009	168
1964	1,033	3,071	..	..	2,408	..	2,178	191
1965	309	2,528	..	..	2,795	..	..	..
1966p	300	3,360	..	..	4,577	..	..	..

Source: Dominion Bureau of Statistics.
* Partial; p Preliminary; .. Not available.

At Prescott, Ontario, Ferrox Iron Ltd. produces high-quality iron oxide concentrates for use in the production of ferrites and iron powder. Pigment-grade material has been produced but a commercial operation has not yet begun.

Northern Pigment Company, Limited, at New Toronto, Ontario, is a leading producer of synthetic iron oxide; much of its output is exported. Statistics relative to the synthetic iron oxide pigments industry are not available for publication.

Total exports of natural and synthetic iron oxides in 1966 were increased to 4,577 tons from 2,795 tons the previous year; nearly all was exported to the United States. Imports showed an increase, particularly in the amount brought in from West Germany.

USES AND SPECIFICATIONS

Pigments containing iron oxide are used in paints, wood and paper stains, linoleum, mortar colours, roofing granules, rubber, plastics, floor tile and imitation leather. Iron oxide is used also as a polishing compound and as a rust inhibiter. Specifications are based on tests to determine the mass colour or appearance when "rubbed out" in oil, the tinting strength or appearance when diluted with zinc oxide oil paste, particle size, oil absorption, opacity and chemical composition. Because synthetic iron oxides can be produced more uniformly in a wide variety of shades, they are in greater demand than are natural iron oxides.

PRICES

Prices vary considerably, particularly with grade or quality. The average price of refined natural iron oxide produced in Canada during 1966 was about $47 a ton at the plant.

United States prices for various types of iron oxides as quoted in *Oil, Paint and Drug Reporter* at the end of 1966 ranged from 7 to 17½ cents a pound.

TITANIUM DIOXIDE

Ilmenite is mined in the Allard Lake and St. Urbain areas of Quebec principally for the production of titanium dioxide slag, which in turn is used in the manufacture of titanium-dioxide pigments. Quebec Iron and Titanium Corporation controls the world's largest known reserves of ilmenite and, from its operation near Havre St. Pierre, ships ore to company smelters at Sorel, Quebec, where it is concentrated, roasted and reduced in electric furnaces to form titania slag and iron. During 1966 the company announced plans to expand plant capacity by 20 per cent, with the addition of one new furnace and by making improvements to existing ones. A research centre at Sorel was completed near the end of 1966 at a cost of over $1.5 million. Much of the slag is exported to the United States for use in making titanium dioxide pigments and some is sent to two Canadian pigment-producing companies. Refined titanium dioxide is produced by Canadian Titanium Pigments Limited at Varennes, Quebec, and by Tioxide of Canada Limited at Ville-de-Tracy, Québec. Combined capacity of these two plants is over 60,000 tons per year.

Canadian Titanium Pigments Limited is expanding its facilities to produce an additional 10,000 tons per year. The added output will be produced by the chloride process, the first titanium dioxide pigment produced by this method outside the United States and the United Kingdom. Tioxide of Canada Limited is supplying technical assistance to a new titanium dioxide plant being constructed by the parent group, British Titan Products Company Limited in Calais, France.

Continental Titanium Corp. also mines ilmenite in the St. Urbain area of Quebec. The material is sold mainly as a heavy aggregate.

Preliminary statistics indicate that 1966 shipments of titania slag were slightly less than for the previous year and were valued at $21.6 million. Total imports of titanium dioxide were about the same as in 1965, with a slight increase in the amounts from the United States and from West Germany. Imports of extended titanium dioxide pigment increased by nearly 250 tons to 9,774 tons. Exports of titanium dioxide decreased from 3,202 tons at a value of $1.3 million to 1,334 tons valued at $0.5 million. A general increase in consumption of both refined and extended titanium dioxide pigment is recorded.

USES AND SPECIFICATIONS

The use of titanium dioxide as a pigment is based on a number of characteristics, among which are its high refractive index or high opacity, its whiteness, and its chemical inactivity. The material must be ground to a very fine, uniform powder. When all properties are combined, the titanium dioxide pigment is far superior to other white pigments for use in paints, and is the strongest white pigment known.

Titanium dioxide pigment is available in three grades — rutile and anatase grades are nearly pure titanium dioxide, differing in hiding power due to different crystal structures, extended titanium pigment contains 30—50 per cent titanium dioxide. The non-pigmentary or "technical grade" titanium dioxide is made especially for titania porcelain enamels. It flows freely in the dry state and eliminates balling and sticking often associated with titanium dioxide pigments.

TABLE 3

Titanium Dioxide — Trade and Consumption

	1965		1966P	
	Short Tons	$	Short Tons	$
Production (Producer's shipments of titania slag, TiO_2 content)	410,255	22,425,094	395,523	21,615,610
Imports				
Titanium dioxide, pure				
United States	783	429,021	821	459,000
Britain	712	283,348	661	265,000
West Germany	70	29,695	109	43,000
Other countries	—	—	36	17,000
Total	1,565	742,064	1,627	784,000
Titanium dioxide, extended	9,534	1,816,869	9,774	1,856,000
Exports				
Titanium dioxide				
United States*	3,202	1,344,580	1,334	519,997
	1963		1964	
Consumption				
Refined titanium dioxide				
Industrial chemicals	159		41	
Other chemicals	500		536	
Linoleum and coated fabrics industry**	2,181		2,151	
Paint and varnish	20,589		22,812	
Paper	3,645		3,687	
Rubber	972		1,476	
Synthetic textiles	40		58	
Toilet preparations	21		24	
Other non-metallic products	785		965	
Total	28,892		31,750	
Extended titanium dioxide pigments				
Paints	8,588		9,788	
Estimated TiO_2 content	2,542		2,800	

Source: Dominion Bureau of Statistics.

* As reported by United States Imports for Consumption, FT 125. Value $ U.S.

**Includes also asphalt roofing manufacturers.

P Preliminary; — Nil.

As an extended pigment it is used in paints, papers, linoleum, rubber goods, textiles, ceramics and plastics. Specifications are based on tests similar to those used for all pigments.

PRICES

Canadian prices of titanium dioxide quoted in Canadian Chemical Processing of October 1966 were as follows:

anatase, dry milled, bags, car lots, delivered, East, per 100 lb $22.00
anatase, regular, bags, car lots, delivered, East, per 100 lb $23.75
rutile pigment, bags, car lots, delivered, East, per 100 lb $25.50
calcium pigment, 30% TiO_2, bags, car lots, delivered, East, per 100 lb .... $15.50–$15.80
non-pigment grades, bags, car lots, delivered, East, per 100 lb .... $24.30–$24.90

WHITING

PRODUCTION

Whiting is either finely ground calcium carbonate prepared from chalk, marble or limestone, or the precipitate from a solution or suspension containing lime. Whiting obtained from chalk differs physically from that obtained from the other sources in that the particles are more rounded and thus have greater surface area and

TABLE 4

Whiting – Production, Imports and Consumption

	1965		1966P	
	Short Tons	$	Short Tons	$
Production				
Stone processed for whiting	40,593	346,000	..	..
Imports[1]				
Whiting				
United States	6,781	232,403	6,408	230,000
Britain	1,623	37,154	1,076	27,000
France	685	8,748	555	7,000
West Germany	–	–	5	1,000
Total	9,089	278,305	8,044	265,000

	1965
Consumption, available data	
Ground chalk, whiting and whiting substitute	
Paints and varnish	18,519
Linoleum, oilcloth and floor tile ...	24,879
Rubber goods	23,673
Asbestos products	6,888
Paper	4,722
Gypsum products	3,845
Roofing	5,858
Sugar processing	10,198
Foundry	2,617
Fertilizers and poultry feed	1,811
Miscellaneous chemicals	1,485
Other uses	9,056
Total	113,551[2]

Source: Dominion Bureau of Statistics.

[1] True and precipitated whiting only. [2] Of the total 57,113 short tons considered pure whiting, and the balance 56,438 s.t., whiting substitute, which includes certain amounts excluded in previous years.

PPreliminary; – Nil; .. Not available.

greater absorptive capability. The tonnage of limestone processed for whiting in Canada is small and in 1966 came from plants in Quebec and British Columbia. Use of more limestone for filler applications in which only whiting is now accepted will come with the acceptance of darker, off-white material and with the use of advanced production techniques.

The amount of stone processed in Canada for whiting during 1966 is not known. Imports were reduced from 9,089 tons in 1965 to 8,044 tons.

USES AND SPECIFICATIONS

The terms "whiting" and "whiting substitute" refer to the product derived from chalk and limestone respectively although the trend is towards accepting the term "whiting" as all-encompassing.

TABLE 5

Whiting — Production, Imports and Consumption, 1957-66

(short tons)

	Production[1]	Imports[2]	Consumption
1957	21,527	9,844	31,374
1958	11,900	11,121	37,268
1959	11,633	10,322	64,933
1960	10,319	8,835	52,226
1961	14,301	8,408	62,442
1962	13,356	8,142	53,756
1963	16,195	9,789	65,082
1964	23,022	8,641	62,484
1965		9,089	113,551[3]
1966P	..	8,044	..

Source: Dominion Bureau of Statistics.

[1] Rock processed for whiting substitute. [2] Whiting only. [3] Whiting and whiting substitute; includes some ground, off-white limestone.

P Preliminary; .. Not available.

The finest grades of whiting are used in cosmetics and for dentifrices. Other uses, which absorb the largest part of production, are in paints, rubber, paper, linoleum, ceramics and putty. The physical properties required in each application relate to whiteness, particle size and shape, workability, and freedom from grit. High chemical purity is also important. Because of its extender qualities whiting is used in cold-water paints and in the lower quality oil-base paints, however, its low opacity and high oil absorbency discourage more extensive use in paints. Precipitated whiting can be treated with a resin or stearate, coating the particles and enhancing its extender qualities in paints and inks.

A.S.T.M. Specification D 1199 — 52T pertains to chemical and physical requirements for calcium carbonate for use in pigments or as a filler.

PRICES

The following United States prices for the three main types of whiting were quoted in the *Oil, Paint and Drug Reporter* of December 26, 1966. They refer to one ton of bagged material, in a carlot, at the producing plant. They are unchanged from the previous December.

Calcium carbonate	
Natural, dry-ground, 325 mesh	$13.50
Natural, water-ground 10 to 30 microns	22.00— 23.00
Chalk, 325 mesh	26.00— 38.00
Precipitated	
Dense	30.00— 38.50
Ultrafine	117.50—167.50

Molybdenum

G.P. WIGLE*

Production of molybdenum in Canada in 1966 increased for the seventh consecutive year and reached a new high of 20.4 million pounds valued at $31.6 million compared with 9.5 million pounds valued at $16.7 million in 1965. Canada's position in 1966 was second only to the United States among world producers of molybdenum. Domestic consumption of molybdenum in 1965 at 1.7 million pounds was also a new high, reflecting the increasing demand for alloy steels.

Non-communist world production of molybdenum in 1966 was about 124 million pounds, an increase of 25 million pounds from 1965. The principal contributors to the increase were the United States and Canada.

The shortage of molybdenum that developed in 1963 continued through 1965 but was relieved in 1966 by the sustained increases in production, and the release by the US General Services Administration of 9 million pounds of molybdenum from the United States stockpile. The Office of Emergency Planning had reduced the United States stockpile objective from 68 to 55 million pounds in March and further reductions were being contemplated late in the year. Releases of the remaining excess are likely to be made on a long-term disposal plan.

The recent growth in demand for molybdenum in the United States resulted from technological advances and increased economic activity; similar conditions prevailed in Europe and Japan. The largest use of molybdenum is in the low-alloy steels and growth in the use of these steels has occurred, concurrently, with an increased demand for molybdenum-base alloys, purified MoS_2 in lubricants, and for metallic molybdenum products.

Substantial improvement in the molybdenum supply situation took place in 1966. The consolidation and further expansion of established production sources and substantial new sources should permit supply to meet demand in the near future. Adequate assured supply will probably promote the development of new uses and wider acceptance of molybdenum for established applications.

PRODUCTION AND DEVELOPMENTS

CANADA

Canadian production in 1966 came from eight mines, four in British Columbia and four in Quebec. The producers in British Columbia, accounting for 80 per cent of Canadian output,

*Mineral Resources Division.

96411—19½

were Endako Mines Ltd. at Endako; Brynnor Mines Limited (Boss Mountain Division), a subsidiary of Noranda Mines Limited; Red Mountain Mines Limited near Rossland; and Bethlehem Copper Corporation Ltd. in the Highland Valley. The producers in Quebec were Molybdenite Corporation of Canada Limited at Lacorne; Preissac Molybdenite Mines Limited and Anglo-American Molybdenite Mining Corporation, both in Preissac township north of Cadillac; and Gaspé Copper Mines, Limited, a subsidiary of Noranda, at Murdochville. Red Mountain Mines came into production in mid-1966. British Columbia Molybdenum Limited, a subsidiary of Kennecott Copper Corporation, is scheduled for operation in the fourth quarter of 1967, thereby bringing the number of domestic producers to nine with seven of them producing molybdenum as a primary product and two, Bethlehem and Gaspé, recovering molybdenum as a byproduct of copper operations.

Endako Mines Ltd. in the fourth quarter of 1966 was milling over 16,000 tons of ore a day grading about 0.24 per cent MoS_2. This company is expanding its concentrator capacity to 22,000 tons a day; new construction is to commence in May 1967, and the increased facilities are expected to be in operation in the spring of 1968. Total ore reserves at December 31, 1966, using a cut-off grade of 0.08 per cent MoS_2, were estimated at 153,628,000 tons with an average grade of 0.155 per cent MoS_2. Production of molybdenum from Endako is

TABLE 1

Canada, Molybdenum Production, Imports and Consumption, 1965–66

	1965		1966P	
	Pounds	$	Pounds	$
Production (shipments)[1]				
Quebec	2,268,066	4,325,448	3,498,768	5,423,090
British Columbia	7,289,125	12,405,344	16,920,638	26,226,989
Total	9,557,191	16,730,792	20,419,406[r]	31,650,079
Imports				
Molybdic Oxide[2]				
United States	649,700	647,942	665,500	684,000
USSR	105,800	444,740	–	–
Britain	4,000	8,473	–	–
Total	759,500	1,101,155	665,500	684,000
Ferromolybdenum				
United States[3]	398,460	525,967	522,800	667,039
	Pounds 1965		Pounds 1966	
Consumption (Mo content)				
Ferrous and Non-ferrous Alloys	1,602,720		1,239,621	
Electrical and electronics	8,548		6,265	
Other uses[4]	91,321		21,039	
Total	1,702,589		1,266,925	

Source: Dominion Bureau of Statistics.

[1]Producers' shipments of molybdic oxide and molybdenum concentrates (Mo content).
[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). Imports of ferromolybdenum are not available separately in official Canadian trade statistics. [4]Chiefly pigment uses.

PPreliminary; – Nil; [r] Revised.

marketed as MoS_2 and MoO_3, the percentages of each being 73.5 and 26.5, respectively in 1966. The company expects to maintain a minimum production of 12 million pounds of molybdenum a year.

Brynnor Mines Limited, Boss Mountain Division, in the interior of British Columbia, completed its first full year of operation. An average milling rate of 1,190 tons a day, with recovery at 95.8 per cent, resulted in production of 3,576,000 pounds of molybdenum in concentrates, the form in which production is marketed.

Red Mountain Mines Limited came into production in mid-1966 at an initial rate of 400 tons of ore a day averaging approximately 0.44 per cent MoS_2. The mill was treating above its rated capacity at the end of the year and expansion was being considered. Estimated ore reserves were 1,082,000 tons with an average grade of 0.39 per cent MoS_2.

British Columbia Molybdenum Limited undertook open-pit development work and continued construction of the concentrator and other facilities at its Alice Arm project. Production is to start in October 1967 and rated capacity of 6,000 tons of ore a day could be reached by the end of the year. This operation will produce from four to five million pounds of molybdenite concentrate a year.

Brenda Mines Ltd., previously Northlands Explorations Limited, has a copper-molybdenum property of about 750 acres, 14 miles northwest of Peachland and 1 mile east of Brenda Lake. Work began in 1965 to investigate the grade of the molybdenum-copper mineralization known from earlier work to be widespread but rather low grade. Chalcopyrite and molybdenite mineralization occurs in three sets of steep fractures near volcanic and sedimentary rocks in an extensive mass of granodiorite. Development and exploration continued in 1966 and consideration was being given to bringing the property to production at 20,000, or more, tons a day. Open-pit material in excess of 100 million tons was reported to average approximately 0.2 per cent copper and 0.1 per cent molybdenite. Noranda Mines provided financial assistance through an option agreement with Brenda which could extend through to production.

Lornex Mining Corporation Ltd. carried out extensive exploration drilling on its large copper-molybdenum properties in the Highland Valley. Drill-hole information indicated over 300 million tons averaging 0.4 per cent copper and 0.03 per cent molybdenite. An underground program, bulk sampling and pilot plant test work was planned for 1967. Lornex is financed and directed by Rio Algom Mines Limited in association with The Yukon Consolidated Gold Corporation, Limited.

Highmont Mining Corp. Ltd. explored its property adjoining east of Lornex. It was reported that a large tonnage of material grading 0.3 per cent copper and .06 per cent MoS_2 had been indicated by exploration in 1966.

Climax Molybdenum (B.C.) Ltd., a wholly-owned subsidiary of American Metal Climax, Inc., completed some 5,000 feet of an 11,000-foot adit undertaken in March 1966. The adit is being driven to facilitate the exploration of a large zone of molybdenite mineralization, outlined by surface drilling, on the east side of Hudson Bay Mountain near Smithers.

In Quebec, Molybdenite Corporation of Canada Limited, Canada's oldest operating molybdenum producer, milled 236,096 tons of ore and recovered 554,183.42 pounds of molybdenum and 135,745.9 pounds of bismuth metal in the 12 months ending September 30, 1966. The molybdenite was converted to molybdic oxide in the company's roasting plant at the minesite. Ore reserves at the year end were 303,482 tons averaging 0.26 per cent molybdenite. Preissac Molybdenite Mines Limited had its first full year of operation at its mine in the Lake Preissac area where it operates a roaster for converting molybdenite to the oxide and facilities for producing ferromolybdenum. Anglo-American Molybdenite Mining Corporation, in the Lake Preissac area, also completed its first full year of operation at its 1,200-ton-a-day plant recovering both molybdenite and bismuth. Gaspé Copper Mines, Limited recovered 531,598 pounds of byproduct molybdenum in molybdenite concentrates at its copper operations at Murdochville.

Masterloy Products Limited converted concentrates at a plant at Duparquet, Quebec, and produced ferromolybdenum at its plant near Ottawa, Ontario.

TABLE 2

Canada, Molybdenum Production, Trade and Consumption, 1957–66
(pounds)

	Production[1]	Exports[2]	Imports: Calcium Molybdate[3]	Imports: Molybdic Oxide[4]	Imports: Ferro-molybdenum[5]	Consumption[6]
1957	783,739	6,009,800[7]	285,576	477,304	237,233	698,420
1958	888,264	1,892,200	135,333	304,822	196,000	519,124
1959	748,566	3,748,300	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	131,358	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
1966p	20,419,406r	..	..	665,500	522,800	..

Source: Dominion Bureau of Statistics.

[1]Producers' shipments of molybdic oxide and molybdenum concentrates (Mo content).
[2]Molybdic oxide and molybdenum concentrates (gross weight). [3]Gross weight, including vanadium oxide and tungsten oxide. [4]Gross weight. [5]U.S. exports to Canada reported in United States Exports of Domestic and Foreign Produce, gross weight. [6]Molybdenum (Mo content) reported by consumers. [7]Includes 4,892,600 pounds of molybdic oxide exported to U.S. derived from molybdenum concentrates imported from U.S. for roasting in Canada.

pPreliminary; ..Not available; rRevised.

UNITED STATES

The United States is the largest producer and consumer of molybdenum and molybdenum products. The United States Bureau of Mines estimated domestic production for 1966 at 89 million pounds of molybdenum contained in concentrates. Consumption was estimated at 76 million pounds.

The Climax mine of Climax Molybdenum Company, a division of American Metal Climax, Inc. (AMAX), is the world's largest producer of molybdenum with production in 1966 being 56.3 million pounds. In September 1966, Climax shipped the first concentrates recovered in a new hydrometallurgical facility, researched and developed by Climax, for the recovery of molybdenum oxide that, along with MoS_2, is part of its mine output. The new plant, an addition to the Climax mill, is expected to produce, at capacity, 3 million pounds of molybdenum a year. AMAX is developing the Urad mine near Empire, Colorado, for production of 7 million pounds of molybdenum a year, beginning in 1967. The AMAX Henderson ore zone, near the Urad, is also being developed. Surface drilling has indicated over 200 million tons of ore grading 0.45 per cent MoS_2. Shaft sinking and underground development is proposed for delineation of the mineral zones.

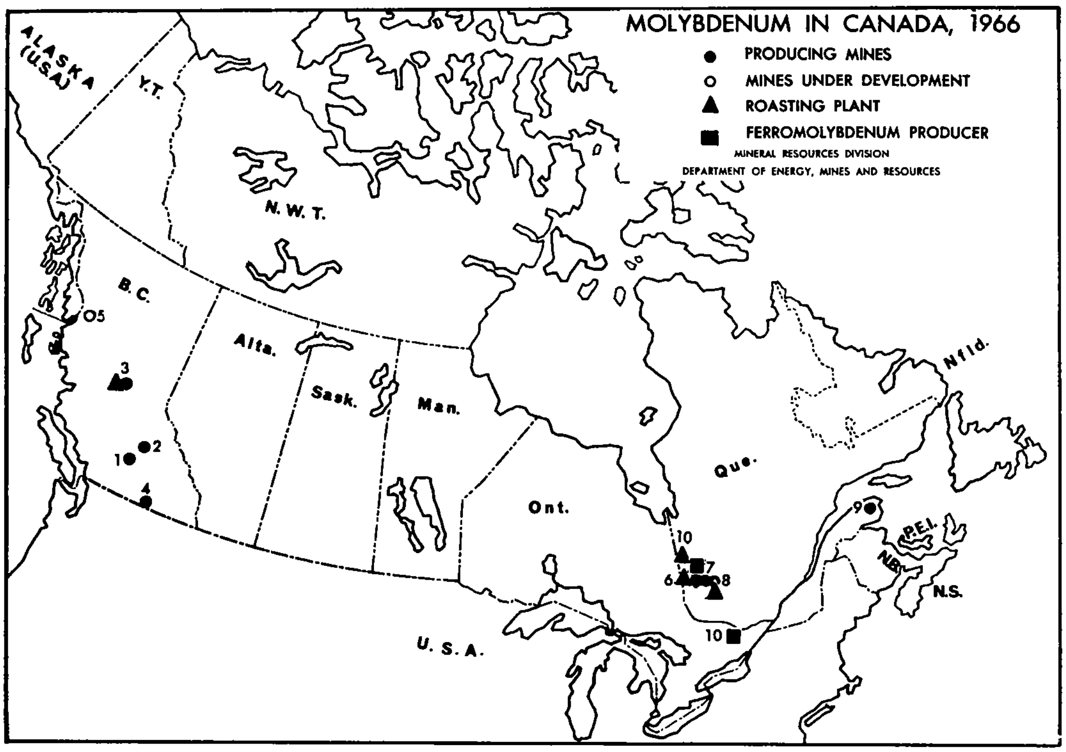
Molybdenum Corporation of America (Molycorp) is also an integrated producer of molybdenite concentrate and molybdenum consumer products. Molycorp's new plant at Questa, New Mexico, came into production in January 1966; its annual capacity is about 10 million pounds of molybdenum in concentrates.

Among the major producers of byproduct molybdenum from copper operations are Kennecott Copper Corporation, Bagdad Copper Corporation, Phelps Dodge Corporation, San Manuel Division of Magma Copper Company, American Smelting and Refining Company, and Duval Corporation. Kennecott reported production of 17.9 million pounds of contained molybdenum in 1966, including production in United States and Chile.

Chile had been second to the United States in non-communist world production of molybdenum until 1965 when it was replaced by

Canada. Molybdenum is recovered in Chile as a byproduct of its large copper operations. Molybdenite concentrate has been recovered since 1939 by Braden Copper Company from the copper ores of its El Teniente mine; The Anaconda Company installed a molybdenite-recovery unit in 1958 at its Chuquicamata copper property. Anaconda reported that molybdenum recovered at the Chuquicamata and El Salvador mines in Chile amounted to 8 million pounds in 1966.

China, North Korea and U.S.S.R. produce molybdenum but data on their output are not available. The United States Bureau of Mines estimated that production in communist countries was 16 million pounds in 1964 with Russia being the dominant producer.



PRODUCING MINES
(numbers refer to numbers on map)

1. Bethlehem Copper Corporation Ltd.
2. Brynnor Mines Limited (Boss Mountain)
3. Endako Mines Ltd.
4. Red Mountain Mines Limited
6. Preissac Molybdenite Mines Limited
7. Anglo-American Molybdenite Mining Corporation
8. Molybdenite Corporation of Canada Limited
9. Gaspé Copper Mines, Limited

MINES UNDER DEVELOPMENT

5. British Columbia Molybdenum Limited (1967)

PROCESSING PLANTS

3. Endako Mines Ltd.
6. Preissac Molybdenite Mines Limited
8. Molybdenite Corporation of Canada Limited
10. Masterloy Products Limited

TABLE 3

Estimated World Production of Molybdenum in Ores and Concentrates, 1964–66
(thousands of pounds)

	1964	1965	1966
United States	65,605	77,372	89,000
Canada	1,225[r]	9,557[r]	20,419[r]
Chile	8,594	8,400[r]	11,000
Peru	862	1,653[r]	2,000
Japan	619[r]	630	600
Norway	509[r]	498	500
Other countries	613	609	600
Total non-communist countries	78,000	98,700	124,000
Communist countries	16,000	16,000	16,000
Total	94,000	114,700	140,000

Source: Dominion Bureau of Statistics; U.S. Bureau of Mines Minerals Yearbook; U.S. Bureau of Mines Commodity Data Summaries, January, 1967; Company reports and trade publications.

[r]Revised.

CONSUMPTION AND USES

About 68 per cent of United States molybdenum consumption is in the form of molybdic oxide followed by ferromolybdenum and molybdenum powder. Molybdenum is used in lesser amounts in ammonium, calcium and sodium molybdate, in purified molybdenum disulphide as an additive in lubricants, and in molybdenite concentrates added to steel when sulphur is also to be added. It is an important additive in high-speed and other tool steels, and in specialty and stainless steels. Molybdenum metal and molybdenum-base alloys are used in high-temperature applications, thermocouples, electronics, missile parts, structural parts of reactors and as an alloying component in reactor fuel.[1]

Small additions of molybdenum promote uniform hardness, hardenability, and toughness in steel, steel castings and cast iron. Addition of molybdenum can be made in the oxide form or in the form of ferromolybdenum. It is a straightforward operation and losses are small. Molybdenum raises the strength of low and high-alloy steels at elevated temperatures. It improves the corrosion resistance of chromium-nickel stainless steels giving a superior product for the handling of corrosive chemicals such as sulphuric acid. Because of low coefficient of expansion and retention of rigidity, a number of molybdenum-uranium alloys have been chosen for use as fuel elements in reactors. Some of these alloys contain as much as 10 per cent molybdenum.[1]

The petroleum and chemical industries make use of molybdenum as a catalyst, and in many components of process equipment and containers. The glass industry uses molybdenum products in process equipment that is exposed to high temperatures and corrosion. Molybdenum is used in the production of pigment colours for printing inks, lacquers and paints noted for their permanence and brilliance. The intermediate compounds of molybdenum used in the chemical and associated industries are the molybdates and molybdic oxide. Molybdenum compounds are used in small amounts to replace molybdenum deficiencies in certain soils.

Dominion Bureau of Statistics, Industry Division, Ottawa – Consumption of Molybdenum and Tungsten 1965 – lists Canadian consumers of molybdenum and its intermediate products. Among the important users are:

In Nova Scotia: Dosco Steel Limited, 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.

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.

In Manitoba: Amsco Joliette Division of Abex Industries of Canada Ltd., Selkirk.

In Alberta: Irving Industries (Foothills Steel Foundry Division) Ltd., Edmonton.

In British Columbia: A–I Steel and Iron Foundry (Vancouver) Ltd., Vancouver; Cae Machinery Ltd., Vancouver.

[1]Molybdenum for Nuclear Energy Applications, Climax Molybdenum Company.

TABLE 4

United States Consumption of Molybdenum, by Use, 1964–66
(thousands pounds of contained molybdenum)

	1964	1965	1966[2]
Steel			
High-speed	2,155	2,814	1,989
Other alloys including stainless	27,489	29,725	16,993
Hot-work and other tool	1,095	1,313	758
Grey and malleable castings	3,525	3,335	1,827
Rolls (steel mill)	2,181	2,400	1,437
Welding rods	249	292	187
High-temperature alloys	1,522	1,846	1,876
Molybdenum metal wire, rod and sheet	1,371	1,904	1,249
Chemicals			
Catalysts	963	1,975	869
Pigments and other colour compounds	865	1,001	618
Miscellaneous[1]	1,704	2,016	1,196
Total	43,119	48,621	28,999[2]

Source: U.S. Bureau of Mines Minerals Yearbook, 1964; Mineral Industry Surveys, U.S. Bureau of Mines, 1966.
[1]Includes magnets, other special alloys, lubricants, packings, forging billets. [2] 7 months only.

PRICES

E & MJ Metal and Mineral Markets of December 26, 1966, quoted molybdenum prices in the United States as follows:

	($ per lb)
Molybdenum powder, carbon-reduced, f.o.b. shipping point	3.35
Molybdenum concentrates, contained Mo, 95% MoS_2 f.o.b. shipping point Climax, cost of containers extra	1.55(1)
Molybdic trioxide, contained Mo, f.o.b. shipping point:	
bags	1.74(1)
cans	1.75
Ferromolybdenum, contained Mo, packed, f.o.b. shipping point, 0.12–0.25% C, powdered, per lb Mo, lots 5,000 lb:	
lump	2.04
powder	2.10

TARIFFS

	British Preferential	Most Favoured Nation	General
Canada			
Calcium molybdate and molybdic oxide	free	free	5%
Molybdenum strip	free	free	30%
Molybdenum wire, rod and tubing, and molybdenum imported by manufacturers of radio tubes and parts	free	free	30%
Ferromolybdenum	free	5%	5%
Molybdenum ores and concentrates	free	free	free

[1]American Metal Climax, Inc., increased these prices to $1.62 and $1.82 early in January 1967.

United States

	(¢ per lb Contained Mo)
Molybdenum ores and concentrates	24
Calcium molybdate, ferromolybdenum and compounds of molybdenum	20 plus 6%
Molybdenum metal:	
unwrought	20 plus 6%
wrought	25.5%
waste and scrap	21%

(duty on scrap suspended to June 30, 1967).

Natural Gas

J.W. FRASER*

For the Canadian natural gas industry, 1966 was a year of moderate expansion in all phases, with a strong demand continuing for sulphur and liquid hydrocarbons produced as byproducts of gas processing. Value of natural gas production increased to $199 million and ranked sixth in terms of value of mineral output in Canada as it had in 1965. Natural gas provides over 17 per cent of Canada's primary energy requirements. Proved remaining marketable reserves of gas represent over 29 years supply based on the 1966 rate of gross new production, after allowing for removal of acid gases and liquid hydrocarbons.

COMPOSITION AND USES OF NATURAL GAS

Marketed natural gas consists chiefly of methane (CH_4) but small amounts of other combustible hydrocarbons such as ethane (C_2H_6) and propane (C_3H_8) may also be present. Methane is nonpoisonous and odourless but a characteristic odour is usually introduced into marketed natural gas as a safety measure. The heat value of natural gas averages about 1,000 British thermal units per cubic foot of gas.

Raw natural gas, as it exists in nature, may vary widely in composition. Besides the usually predominant methane, varying proportions of ethane, propane, butane and pentanes plus may be present. Water vapour is a normal constituent. Hydrogen sulphide, although not present in some Canadian natural gas, is commonly so abundant as to be an important source of sulphur. Other nonhydrocarbon gases which may be present, usually in small amounts, are carbon dioxide, nitrogen and helium.

The most important use of natural gas is as a fuel for space and water heating. Gas is now extensively used in cooking and is becoming common as a fuel for air conditioners, incinerators, dishwashers and laundry equipment. In industrial areas, such as southwestern Ontario, natural gas has been a boon to such industries as automobile plants, steel plants, metal working firms, glass factories and food-processing industries. For example, in metallurgical processing, the clean, easily controlled flame of natural gas enables the desired temperatures to be attained in rolling, shaping, drawing and tempering steel. The constituents of natural gas have become major sources of raw material for the petrochemical industry.

*Mineral Resources Division.

96411—20½

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.

PRODUCTION

In 1966, net new production of natural gas exclusive of withdrawals from storage and gas flared and wasted, totalled 1,543,281 million cubic feet or 4,228 million cubic feet a day. Although this represented a 7-per-cent increase from 1965 it was down considerably from the growth rate of past years. For example, the average increase, taken over the past five years, was almost 19 per cent per annum.

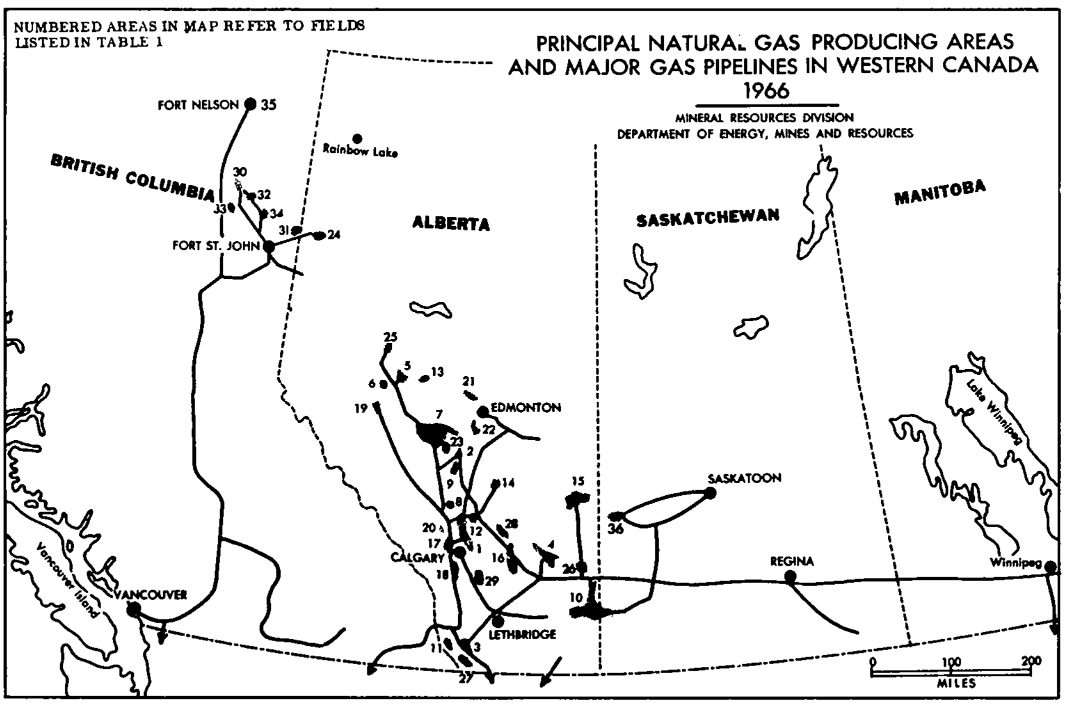


TABLE 1

Canadian Natural Gas Fields Producing 10 Million Mcf or More, 1965-66
(numbers in brackets refer to map locations)

		1965	1966
		(Mcf)	(Mcf)
Alberta			
Crossfield	(1)	80,047,286	93,566,356
Westerose South	(2)	69,818,581	69,511,819
Windfall	(5)	61,216,601	62,520,718
Waterton	(11)	52,934,072	57,274,233
Cessford	(4)	65,944,437	56,149,266
Pine Creek	(6)	46,602,419	54,115,976
Medicine Hat	(10)	50,847,295	52,159,947
Homeglen-Rimbey	(9)	47,410,943	47,566,646
Edson	(19)	4,708,582	45,992,578
Pembina	(7)	40,204,455	42,206,628
Harmattan East	(8)	46,118,163	42,087,563
Carstairs	(12)	41,106,832	39,420,827
Harmattan-Elkton	(8)	39,409,002	38,878,055
Provost	(15)	28,911,344	29,016,953
Carson Creek	(13)	33,831,918	27,034,280
Gilby	(9)	29,322,497	26,286,249
Nevis	(14)	26,351,508	26,118,160
Hussar	(16)	23,219,878	23,680,934
Pincher Creek	(3)	27,843,779	22,862,500
Jumping Pound	(17)	20,947,762	22,499,566
Wildcat Hills	(20)	20,571,964	19,696,705
Sylvan Lake	(2)	13,144,293	18,858,212
Turner Valley	(18)	19,378,600	18,159,342
Minnehik-Buck Lake	(23)	16,915,190	16,809,865
Wimbourne	(12)	10,812,953	15,818,533
Olds	(12)	12,879,773	14,481,933
Bindloss	(26)	14,805,719	14,331,601
Worsley	(24)	10,770,787	13,709,708
Lookout Butte	(27)	13,075,726	12,897,100
Leduc-Woodbend	(22)	16,114,083	12,575,043
Westlock	(21)	10,714,429	12,258,371
Wayne-Rosedale	(28)	13,736,032	11,873,898
Countess	(16)	10,232,907	11,662,736
Kaybob	(25)	13,152,796	11,190,249
Fort Saskatchewan	(21)	12,490,882	10,870,798
Okotoks	(29)	11,140,378	10,745,945
British Columbia			
Clarke Lake	(35)	16,965,910	42,622,967
Laprise Creek	(30)	18,477,613	19,493,628
Jedney	(30)	20,767,485	18,362,633
Nig Creek	(32)	12,451,447	15,920,031
Rigel	(34)	11,793,574	12,861,494
Beg	(33)	12,749,785	11,869,563
Boundary Lake	(31)	12,640,617	11,212,112
Saskatchewan			
Coleville-Smiley	(36)	13,309,758	14,321,074

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, 1965-66

(Mcf)

	1965		1966	
	Input	Reproduction	Input	Reproduction
Alberta				
Beaver Crossing	—	—	791	—
Bow Island	1,342,917	2,113,787	1,677,777	2,336,525
Carson Creek	33,045,731	—	27,672,902	—
Carstairs	1,240,512	377,821	2,095,734	380,000e
Cold Lake	1,002	—	—	—
Crossfield	355,605	—	10,424,495	—
Duhamel	99,400	—	104,848	—
Golden Spike	7,239,812	—	7,291,140	—
Harmattan East	43,076,015	—	36,753,974	—
Harmattan-Elkton	36,014,326	—	32,056,301	—
Jumping Pound	1,995,701	1,210,171	2,274,104	1,250,000e
Judy Creek	—	—	139,000	—
Leduc-Woodbend	5,404,846	768	3,841,347	—
Lookout Butte	12,434,087	—	12,124,509	—
Pembina	13,203,599	—	12,643,094	—
Pincher Creek	—	812,206		
Rainbow	—	—	154,598	—
Sundre	318,812	—	—	—
Turner Valley	3,293,901	439,082	4,488,450	510,000e
Viking-Kinsella	—	—	1,714,102	—
Westerose	753,960	—	741,470	—
Windfall	48,199,577	—	56,406,697	—
Total (14.65 psia)	208,019,803	4,953,835	212,605,333	4,476,525e
Volume adjusted to 14.73 psia	206,896,496	4,927,084	211,457,264	4,452,351e
Ontario	37,977,530	29,625,974	49,511,188	30,653,113
Saskatchewan (14.73 psia)	2,791,034	2,927,793	2,199,551	2,921,081
Total, Canada (14.73 psia)	247,665,060	37,480,851	263,168,003	38,026,545e

Source: Provincial government reports. — Nil. e Estimated.

The production listed in Table 1 is gross output and, while most of the total is marketed, only a minor portion of the output from several cycling fields is available for marketing. These include the Harmattan-Elkton, Harmattan East, Carson Creek and Lookout Butte fields, where the gas is processed to recover the liquid hydrocarbons and the dry gas is returned to the formation to maintain pressure. When the bulk of the natural gas liquids is recovered, the gas will be reproduced. The very sour dry gas from the Pine Creek field is injected into the Windfall reservoir to partly replace extracted gas, which is processed and marketed from Windfall. These reinjections are conservation measures designed to allow maximum extraction of the liquid hydrocarbons in the reservoir.

Table 3 shows gross new production; that is, it excludes gas previously produced and reinjected. This table also shows net production which is gross production less gas flared or wasted.

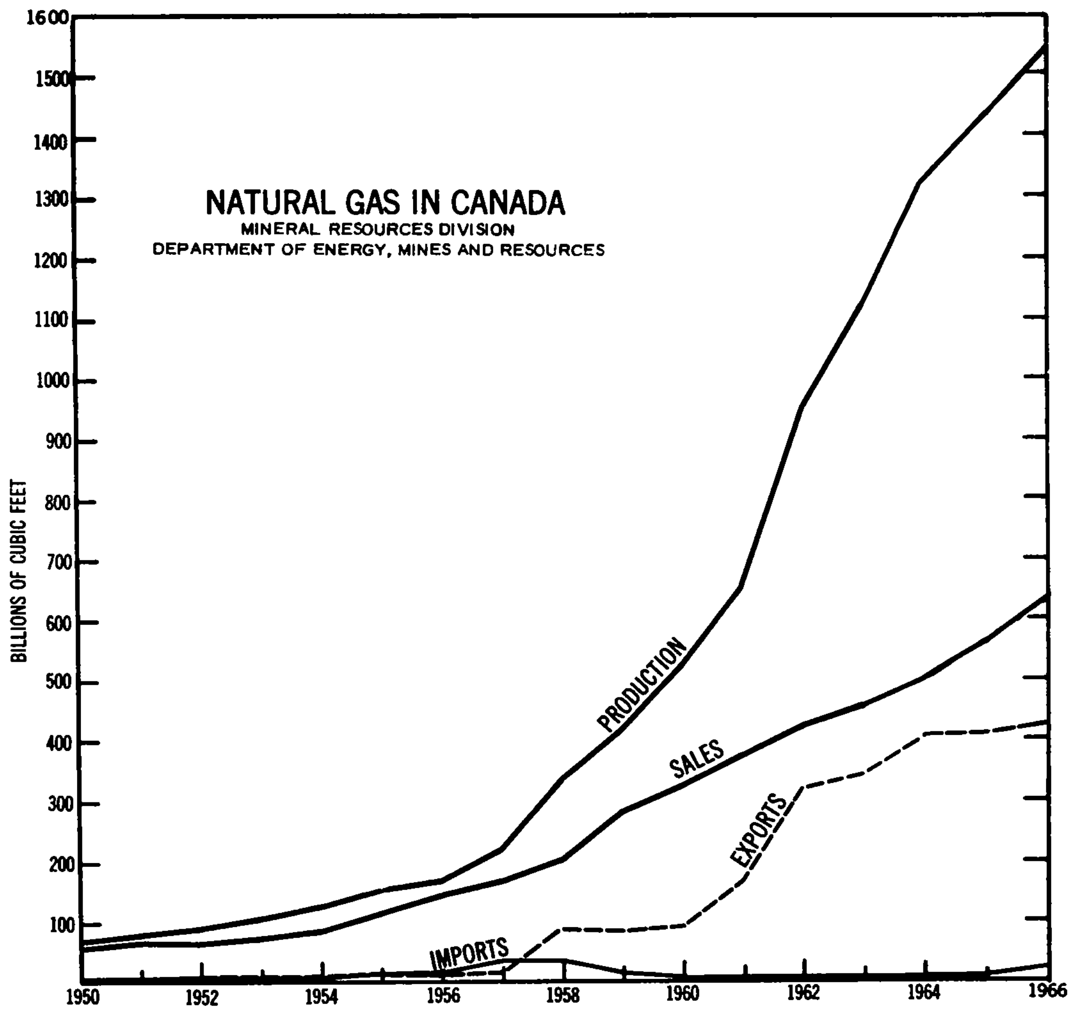


TABLE 3

Canada, Production of Natural Gas, 1965-66

(14.73 psia)

	1965r		1966P	
	Mcf	$	Mcf	$
Gross new production				
New Brunswick	105,359		96,712	
Ontario	12,619,867		15,260,935	
Saskatchewan	59,739,391		65,826,051	
Alberta	1,278,469,418		1,343,313,331	
British Columbia	170,588,242		198,343,569	
Northwest Territories	43,068		46,241	
Total, Canada	1,521,565,345		1,622,886,839	

TABLE 3 (cont'd)

	1965r		1966p	
	Mcf	$	Mcf	$
Waste and flared				
Saskatchewan	16,970,490		16,004,510	
Alberta	52,642,839		52,559,660	
British Columbia	9,503,946		11,041,181	
Total, Canada	79,117,275		79,605,351	
Net new production				
New Brunswick	105,359	99,617	96,712	91,383
Ontario	12,619,867	4,856,125	15,260,935	5,835,778
Saskatchewan	42,768,901	4,850,017	49,821,541	5,648,826
Alberta	1,225,826,579	162,426,142	1,290,753,671	170,507,751
British Columbia	161,084,296	14,375,470	187,302,388	16,714,226
Northwest Territories	43,068	18,088	46,241	19,524
Total, Canada	1,442,448,070	186,625,459	1,543,281,488	198,817,488
Processing shrinkage				
Saskatchewan	2,013,819		2,108,835	
Alberta	114,121,327		129,097,935	
British Columbia	5,932,505		6,053,424	
Total, Canada	122,067,651		137,260,194	
Net New Supply, Canada	1,320,380,419		1,406,021,294	

Source: Dominion Bureau of Statistics.
p Preliminary; r Revised

EXPLORATION AND DEVELOPMENT

ALBERTA

The most important additions to gas reserves in Canada were discovered in northwestern Alberta as a result of the intensive search for oil in the Middle Devonian Keg River reefs. Most of the discovery wells in the Rainbow Lake and Zama Lake areas have a thick gas cap associated with the Keg River oil, and many have significant gas occurrences in one or more of the overlying Muskeg, Sulphur Point or Slave Point formations. Some of the most noteworthy discoveries in this area were B.A. et al. South Rainbow 13-36-105-7W 6, B.A. West Rainbow 6-33-110-10W 6, and B.A. Zama Lake 6-33-113-7W 6. Ninety miles north of Rainbow, Placid Oil Company made two important discoveries near Bistcho Lake. Placid production tested 11 million cubic feet a day from the Muskeg formation and 5 million cubic feet a day from the Slave Point formation at the Placid et al. East Bistcho 10-20-123-2W 6 well. A second well, six miles to the southwest, also recovered commercial quantities of gas in the same formations.

In central Alberta, gas production was indicated below the producing Triassic sands in the Kaybob South oil field at the H.B. Union Kaybob South 11-1-62-20W 5 well which tested 14.2 million cubic feet a day with condensate from the Middle Devonian Swan Hills formation. In the Corrigal Lake area, three successful "follow-ups" have apparently established the existence of significant gas reserves in sub-cropping Upper Devonian formations. In early 1966, a triple zone gas discovery was made in the Brazeau River area when H.B. Brazeau River 10-18-46-13W 5 discovered a total of 94 feet of wet gas pay in the Cretaceous, Jurassic and Mississippian Shunda formations. Hudson's Bay Oil and Gas Company Limited drilled a second well 2 miles north which found 21 feet of pay in the Mississippian. These wells are immediately adjacent to The Alberta Gas Trunk Line Company pipeline.

In southern Alberta, Jefferson Lake Petrochemicals of Canada Ltd., extended the Crossfield Devonian Wabamun field two miles to the north, which further narrowed the gap between it and the Kathryn field. The step-out success Jefferson Lake et al·Crossfield 11-33-26-28W 4 had a maximum flow rate of 8 million cubic feet a day. The increasing demand for sulphur has made the southern extension to the Wabamun Olds-Okotoks trend a very attractive exploratory target as the Wabamun gas in this area averages 100 tons of sulphur per 10 million cubic feet of gas. There were several other gas discoveries reported in southern Alberta, most of which were smaller reservoirs occurring in Lower Cretaceous beds.

Gas field development drilling in Alberta increased from 100 wells in 1965 to 136 in 1966. Eighty-three previously capped gas wells were put on production this year, increasing the number of producing gas wells in Alberta to 1,527. However, the number of capped gas wells increased from 1,515 to 1,586 during 1966.

BRITISH COLUMBIA

A large proportion of exploratory drilling was carried out in the general area of established Triassic and Cretaceous gas and oil production in the area to the north and northwest of Fort St. John. A number of gas discoveries in the Triassic and Cretaceous formations were reported in this region but no major new pools have been indicated by the limited development drilling that followed the discoveries. Limited success was achieved in the northeastern corner of the province in the search for the thick, gas-bearing Devonian reefs that are productive in the Fort Nelson area. One of the more significant discoveries was the Pacific Shekilie b-24-A-94-I-16 well, located 40 miles southeast of Kotcho Lake and approximately 50 miles northwest of Alberta's Rainbow Lake pools, which was completed as a Slave Point gas well. To date, the areal extent of this field has not been detailed by follow-up drilling.

The total number of gas wells capable of production in the province increased to 570 from 530 in 1965 with the greatest increase being in the Laprise Creek field. New reserves were proven in the Clarke Lake field by the completion of four 'stepout' development wells.

On the West Coast, Shell Canada Limited carried out further marine seismic surveys covering its extensive offshore acreage. In the dockyards at Victoria, B.C. construction was under way on one of the world's largest semi-submersible drilling platforms which is scheduled to start drilling off the west coast in mid-1967 under contract to Shell. Total offshore acreage under federal government permits was 18 million acres.

SASKATCHEWAN AND MANITOBA

Exploratory drilling for gas represents only a small portion of the total exploratory footage in Saskatchewan and is mainly confined to a few western areas of the province where gas fields have been developed. Most of the province's gas production continues to come from solution gas associated with oil production. The main gas-producing area, not associated with oil production, is the Hatton field in southwestern Saskatchewan that is the eastward extension of Alberta's Medicine Hat field. A large proportion of the development drilling in 1966 was carried out in the Horsham pool at the north end of the Hatton field, with minor development taking place in the Milton and North Hoosier pools farther to the north in the Coleville-Smiley area. A total of 34 gas wells were completed in 1966, a considerable reduction from 57 completions in 1965.

There has never been a commercial gas discovery in Manitoba and again no exploratory work was undertaken with respect to gas in 1966.

YUKON AND NORTHWEST TERRITORIES

There were 28 exploratory wells drilled in the Yukon and Northwest Territories in 1966 for an aggregate footage of 121,620 feet. All were dry and abandoned. A significant gas show was encountered in the well Pan American Pointed Mountain P53-60.30-123-43, which is 30 miles northeast of the shut-in Devonian gas well Pan American Beaver River 73K. The well was started in 1966 and at year-end a Middle Devonian section was tested at a flow rate of over 18 million cubic feet a day from 330 feet of pay. The recently-signed contract between Pan American Petroleum Corporation and Westcoast Transmission Company Limited is expected to stimulate exploration in the southeastern corner of Yukon Territory. Under this contract, Pan American has agreed to sell 1.5 trillion feet of gas to Westcoast, the bulk of which will be provided by the substantial potential reserves of the Beaver River area that straddles the Yukon-British Columbia border.

EASTERN CANADA

In Ontario, both exploratory and development drilling declined to the lowest level in recent years as total footage drilled decreased to 268,792 feet, down 27.4 per cent from 1965. There were four new gas discoveries in Ontario from a total of 56 exploratory wells drilled. Three of the gas discoveries were in the Silurian. The fourth, Creesing #1 in Egremont Township of Grey County, discovered gas in a basal sand of the Ordovician Black River formation and indicated a potential new area for exploration. It is approximately 40 miles from the nearest production. Sixty-two development wells were drilled of which 39 were completed in the Silurian and one in the Ordovician as gas wells. Included in the 62 were 15 offshore wells in Lake Erie of which 13 were successful.

The first exploratory test related to the offshore play in Hudson Bay was drilled in 1966, following several seasons of geological and seismic studies. Sogepet Kaskattama Province No. 1, on the west shore of Hudson Bay approximately 50 miles west of the Manitoba-Ontario boundary, was drilled to 2,880 feet before being suspended for the winter. The operator reported residual oil staining and encouraging core analyses and it is planned to deepen the well to the basal Ordovician sands in the summer of 1967. Acreage in Hudson Bay under federal government permits amounted to 53.5 million acres, down slightly from 55.8 million acres in 1965.

In the Grand Banks area south of Newfoundland, two exploratory tests were drilled by the team of Pan American Petroleum Corporation and Imperial Oil Limited. The first test, Pan Am IOE Tors Cove, 225 miles south of St. John's, Newfoundland, was abandoned at a total depth of 4,834 feet. A second attempt 150 miles south of St. John's, Pan Am IOE Grand Falls A-1, was suspended at a depth of 5,250 feet after bad weather and rough seas late in the year made further drilling impractical. Total acreage under federal government permits increased to 124.6 million acres from 114 million acres the previous year. Tenneco Oil Company filed on 16 million acres off the coast of Labrador, an area that had been ignored previously by other companies.

The question of jurisdiction over offshore rights is scheduled for consideration by the Supreme Court of Canada in 1967. Most companies maintained both federal and provincial permits on disputed acreage. A further complication was introduced when the French government granted permits to a French company in an area south of Newfoundland now covered by permits from both the federal government and the province. The French claim is based on offshore rights associated with the French islands of St. Pierre and Miquelon, immediately south of Newfoundland.

TABLE 4

Canada, Production, Trade and Total Sales of Gas, 1956-66

(Mcf)

	Production	Imports	Exports	Sales in Canada
1956	169,152,586	15,695,359	10,828,338	143,725,649
1957	220,006,682	30,550,944	15,731,072	159,893,877
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
1966P	1,543,281,488	43,550,818	426,223,806	635,508,883

Source: Dominion Bureau of Statistics.

P Preliminary.

TABLE 5

Canada, Liquids and Sulphur Recovered from Natural Gas, 1956-66

	Propane (barrels)	Butane (barrels)	Condensate/ Pentanes Plus (barrels)	Sulphur (long tons)
1956	925,716	591,638	1,078,145	29,879
1957	1,111,355	747,709	1,121,440	89,916
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	4,353,871r	3,273,625r	21,759,526	1,281,999
1964	7,615,121r	5,656,888r	25,275,285r	1,472,583
1965	10,371,256	6,957,833	27,864,189	1,589,586
1966p	12,643,278	8,230,620	29,360,103	1,726,750

Sources: Dominion Bureau of Statistics and provincial government reports.

p Preliminary; r Revised.

In Quebec, seven exploratory wells were drilled in the St. Lawrence Lowland and one in Gaspe for a total footage of 9,677 feet. No gas shows were reported.

At Parson's Pond on the west coast of Newfoundland, an exploratory test, begun in 1965, was completed without finding commercial occurrences of gas.

TABLE 6

Canada, Wells Drilled, by Province, 1965-66

	Oil		Gas		Dry		Service*		Total	
	1965	1966	1965	1966	1965	1966	1965	1966	1965	1966
Western Canada										
Alberta	877	641	220	257	856	735**	3	34	1,956	1,667
Saskatchewan	697	540	57	34	519	594	11	34	1,284	1,202
British Columbia	113	45	41	51	93	116	2	2	249	214
Manitoba	26	26	—	—	38	35	—	2	64	63
Yukon and Northwest Territories	1	—	2	—	15	28	—	—	18	28
Sub-total	1,714	1,252	320	342	1,521	1,506	16	72	3,571	3,174
Eastern Canada										
Ontario	23	12	68	44	97	62	16	28	204	146
Quebec	—	—	—	—	2	8	—	3	2	11
Atlantic Provinces	1	—	—	—	2	2	—	3	3	5
Sub-total	24	12	68	44	101	72	16	34	209	162
Total, Canada	1,738	1,264	388	386	1,622	1,580	32	106	3,780	3,336

Source: Canadian Petroleum Association.

— Nil.

*Total service wells include 6 miscellaneous wells in Alberta but excludes potash and helium wells in Saskatchewan and Manitoba.

**Includes 8 suspended wells in 1966.

TABLE 7

Footage Drilled in Canada for Oil and Gas, by Province, 1965-66

	Exploratory		Development		All Wells	
	1965	1966	1965	1966	1965	1966
Alberta	4,451,934	4,149,247	5,754,130	4,095,797	10,206,064	8,245,044
Saskatchewan	1,621,479	1,920,943	2,938,629	2,352,123	4,560,108	4,273,066
British Columbia	489,039	687,455	592,017	345,120	1,081,056	1,032,575
Manitoba	93,694	75,747	70,826	68,123	164,520	143,870
Northwest Territories	119,581	121,620	–	–	119,581	121,620
Total, western Canada	6,775,727	6,955,012	9,355,602	6,861,163	16,131,329	13,816,175
Ontario	173,953	155,954	176,915	88,777	350,868	244,731
Quebec	11,963	9,677	–	–	11,963	9,677
Atlantic Provinces	4,917	14,384	2,941	–	7,853	14,384
Total, eastern Canada	190,833	180,015	179,856	88,777	370,689	268,792
Total, Canada	6,966,560	7,135,027	9,535,458	6,949,940	16,502,018	14,084,967

Source: Canadian Petroleum Association.

– Nil.

RESERVES

The Canadian Petroleum Association (CPA) in 1966 changed its basis for determining reserves and will now report 'proved remaining marketable' reserves instead of proved recoverable reserves as it has in the past. The previous totals included all known gas reserves, a portion of which were not readily available to markets for various reasons, such as remote geographical location, whereas the new estimates exclude reserves of this type. The effect of this change was to reduce the estimated proved recoverable reserves of 44.4 trillion (44 X 10^{12}) cubic feet at the end of 1965 to proved remaining marketable reserves of 40.4 trillion cubic feet. On the new basis, gas reserves in Canada were increased to 43.5 trillion cubic feet in 1966, after allowing for the year's production. This represents an increase of 3.1 trillion cubic feet or 7.7 per cent, up sharply from the 2.3-per-cent increase registered in 1965.

The Alberta Oil and Gas Conservation Board estimated that the province's total established reserves increased to 38.1 trillion cubic feet in 1966. Of this total, 36.3 trillion cubic feet are considered within economic reach, somewhat higher than the CPA estimate of proved marketable reserves of 35.1 trillion cubic feet for the province. This is to be expected, however, since the estimates are not derived in exactly the same way and the Conservation Board report includes some allowance for probable gas reserves. The net increase in Alberta reserves was 0.5 trillion cubic feet, after allowing for the year's production of 0.9 trillion cubic feet. The major part of the increase was derived from the upward revision of reserves assigned to fields as a result of additional development drilling or re-evaluation of reservoirs based on actual production performance. The most significant increases were in the Ferrier and Crossfield East fields and, to a lesser extent, in Kaybob South and Crossfield. However, these increases were partially offset by reduction in reserves resulting from reassessment of other fields, notably Pembina, Savanna Creek, Pine Creek and Gold Creek. Reserves assigned to new discoveries amounted to 0.2 trillion cubic feet and they will probably increase as development drilling is carried out.

Proved reserves in British Columbia increased almost 1 trillion cubic feet to 7.5 trillion, with the major portion of the increase due to revisions and extensions of existing fields.

TABLE 8

Canada, Estimated Year-end Marketable Reserves of Natural Gas, 1965-66
(millions of cubic feet)

	1965	1966
Alberta	33,098,588	35,135,103
British Columbia ...	6,290,484	7,265,690
Saskatchewan	708,294	729,278
Eastern Canada	187,231	202,704
Northwest Territories	69,930	117,320
Total	40,354,527	43,450,095

Source: Canadian Petroleum Association.

Smaller estimates of proved reserves were accredited to the Northwest Territories, Saskatchewan, Ontario and other areas in Eastern Canada. They amount in total to less than 3 per cent of proved Canadian reserves.

NATURAL GAS PROCESSING

Pipeline specifications and conservation requirements necessitate the processing of a large proportion of Canadian natural gas near the wellhead. In Alberta in 1966 only 15 per cent of the marketable gas produced in the province was non-processed dry gas. The remaining 85 per cent was from gas processing plants located in or near the source fields. Approximately 43 per cent of the marketable gas produced in Alberta was reprocessed at the large Pacific Petroleums, Ltd. plant, on the Alberta-Saskatchewan border, to remove gas liquids such as propane, butane and pentanes plus that were not removed at field plants.

In the past few years sales of sulphur and natural gas liquids have provided increasingly important sources of revenue for gas producers and have influenced the design and location of gas plant facilities. The natural gas liquids extracted from natural gas are not production-restricted as crude oil is by prorationing. Therefore, it is attractive for producers to recover as much condensate and pentanes plus as possible since these products are alternate oil refinery feedstocks. At the same time, the demand for propane and butane has been increasing and the wider markets being developed makes their recovery equally attractive.

Elemental sulphur is obtained by processing hydrogen sulphide, which is found in varying concentration in some natural gas at the wellhead. Expanding world demand for sulphur has outstripped world production resulting in depletion of stockpiles and strengthening prices from the depressed levels which had resulted from oversupply. Due to the processing capacity developed in western Canada in recent years to treat the ever-increasing volumes of gas required for domestic consumption and export, Canada has recently moved into second place among suppliers of elemental sulphur for world markets.

At the end of the year there were 98 gas plants in operation in Alberta, four in British Columbia, five in Saskatchewan and four in Ontario. Raw gas capacity of processing plants increased modestly, bringing total capacity in Canada to 6,336 million cubic feet daily. Approximately two thirds of the new capacity came from expansion of existing plants, reflecting the addition of deep-cut facilities to extract more liquid hydrocarbons from the raw gas and to recover more sulphur where this is feasible. Expansion of facilities were completed at plants in the Nevis, Westerose, Golden Spike, Carson Creek and Gilby fields, and at year-end a number of other projects were under way with completion scheduled for 1967. Six new plants in the small- to medium-size range were completed in 1966. A significant increase in sulphur capacity was made by the construction at Harmattan, Alberta of the new Canadian Superior Oil Ltd. plant which will treat 42 million cubic feet of sour raw gas a day from the Leduc formation. The gas contains 52 per per cent hydrogen sulphide and from it 805 long tons of sulphur a day may be recovered. Other new plants were constructed at Paddle River, Lone Pine Creek, Wintering Hills, Ferrier and Breton.

TRANSPORTATION

As is the case with oil, the economic movement of large volumes of natural gas is fundamental to the development of Canadian resources. The Alberta Gas Trunk Line Company, which carries virtually all gas for removal from Alberta, delivered a record 2.24 billion cubic feet of gas in one day in December 1966. In terms of crude oil, this amount is roughly

TABLE 9

Canada, Natural Gas Processing Plant Capacities by Fields, 1966
(millions of cubic feet a day)

Main Fields Served	Raw Gas Capacity	Residue Gas Produced
Alberta		
Acheson	6	5
Alexander, Westlock	36	35
Black Butte	10	10
Bonnie Glen, Wizard Lake	36	30
Boundary Lake South	25	22
Braeburn	16	15
Carbon	155	150
Carson Creek	100	re-inj.
Carstairs (2 plants)	230	206
Cessford (7 plants)	214	206
Chigwell (2 plants)	12	10
Countess	22	21
Crossfield (2 plants)	194	155
East Crossfield	39	35
Edson	309	280
Enchant	5	5
Gilby (6 plants)	95	89
Golden Spike	45	re-inj.
Harmattan-Elkton, Harmattan East	246	re-inj.
Harmattan-Elkton (2 plants)	47	19
Homeglen-Rimbey, Westerose	422	357
Hussar (2 plants)	90	90
Innisfail	15	10
Judy Creek, Swan Hills	55	40
Jumping Pound	110	90
Kaybob	70	68
Kessler	6	5
Leduc-Woodbend	35	31
Lone Pine Creek	30	24
Lookout Butte	43	re-inj.
Minnehik-Buck Lake	70	63
Morinville, St. Albert	25	24
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	82
Pembina (4 plants)	62	58
Pincher Creek	204	145
Prevo	5	4
Princess (3 plants)	19	19
Provost (3 plants)	105	99
Redwater	11	8
Retlaw	7	7
Samson	3	3
Savanna Creek	75	63
Sedalia	5	5
Sibbald	6	5
Sylvan Lake	22	20
Sylvan Lake, Hespero	50	43
Three Hills Creek	10	9
Turner Valley	100	85

TABLE 9 (cont'd)

Main Fields Served	Raw Gas Capacity	Residue Gas Produced
Alberta (cont.)		
Waterton	180	121
Wayne-Rosedale (3 plants)	37	35
Wildcat Hills	96	83
Willesden Green	9	8
Wimborne	55	43
Windfall, Pine Creek	215	132
Wintering Hills	15	15
Wood River	5	5
Worsley	55	52
Pipeline at Ellerslie*	70	66
Pipeline at Empress**	1,000	965
Saskatchewan		
Cantuar	25	24
Coleville, Smiley	60	59
Dollard	2	2
Smiley	4	3
Steelman	38	30
British Columbia		
Fort St. John	395	300
Boundary Lake (2 plants)	27	24
Clarke Lake	200	170
Ontario		
Port Alma (2 plants)	16	16
Corunna (2 plants)	6	6

Source: Natural Gas Processing Plants in Canada (Operators List 7), January 1967, Department of Energy, Mines and Resources.

**Plant reprocesses gas owned by Northwestern Utilities Limited.
**Plant reprocesses gas owned by Trans Canada Pipe Lines Limited.

equivalent to 385,000 barrels. The 1966 average for the company was 1.86 billion cubic feet a day, which was also a record.

There was relatively little gas pipeline construction in 1966; however this does not indicate that important developments were lacking. The current negotiations for increased volumes of gas removal from Alberta and British Columbia should, if successful, stimulate construction for a period in the future. It might be noted that pipeline mileage is not, in itself, the only criterion to measure the development of pipeline transportation. The addition of compressor capacity to eventually raise throughput to the optimum condition of the completed line is normally taking place in the plateau periods. There were, however, some significant additions to pipelines in 1966. Trans-Canada Pipe Lines Limited laid 89 miles of 34-inch pipe in Manitoba to complete the looping of its main line between Alberta and Winnipeg, Manitoba. Thus, the company now has two 34-inch lines from Alberta as far east as Winnipeg. The company also laid 40 miles of 16-inch pipe from the Alberta boundary near Macklin, Saskatchewan, to the Unity storage field of Saskatchewan Power Corporation, which transports and distributes all natural gas for Saskatchewan use. Seventeen miles of the 20-inch portion of the Trans-Canada system east of Toronto were 'looped' with 24-inch line. Modifications and additions were made to compressors that resulted in total horsepower being raised from 545,060 horsepower to 574,160 horsepower.

TABLE 10

Gas Pipeline Mileage in Canada, by Province, 1963-66

	1963r	1964	1965r	1966p
Gathering				
New Brunswick	6	6	6	6
Ontario	1,049	1,043	1,102	1,120
Saskatchewan	309	389	415	439
Alberta	2,920	3,071	3,057	3,134
British Columbia	409	409	418	427
Total	4,693	4,918	4,998	5,126
Transmission				
New Brunswick	13	13	13	13
Quebec	25	25	25	45
Ontario	3,265	3,365	3,390	3,509
Manitoba	631	731	919	944
Saskatchewan	2,832	3,081	3,288	3,433
Alberta	4,311	4,776	5,019	5,077
British Columbia	1,311	1,319	1,551	1,632
Total	12,388	13,310	14,205	14,653
Distribution				
New Brunswick	32	33	33	33
Quebec	1,203	1,263	1,295	1,326
Ontario	11,700	12,297	12,699	12,984
Manitoba	1,117	1,178	1,354	1,462
Saskatchewan	1,536	1,637	1,740	1,836
Alberta	3,224	3,383	3,487	3,565
British Columbia	3,647	3,843	4,053	4,263
Total	22,459	23,634	24,661	25,469
Total, Canada	39,540	41,862	43,864	45,248

Source: Dominion Bureau of Statistics.

p Preliminary; r Revised.

In Alberta, The Alberta Gas Trunk Line Company laid 31 miles of 16-inch pipe from the Provost field to connect at the Alberta-Saskatchewan border with the Trans-Canada line going to Unity, Saskatchewan. In addition to other smaller pipeline additions, compressors were added to both the Plains and Foothills divisions of Alberta Gas Trunk Line to raise compression by 15,500 horsepower to a total of 39,995 horsepower. Canadian Western Natural Gas Company Limited constructed a 45-mile, 16-inch pipeline to connect the Jumping Pound field to Calgary. Expansion of gathering systems and construction of short laterals made up the remainder of new construction in Alberta.

Saskatchewan Power Corporation expanded its main transmission system with 59 miles of 16-inch line from Unity to Biggar, and laid an additional 137 miles of pipeline in several smaller projects.

In northwestern Ontario, Northern and Central Gas Company Limited added the town of Atikokan to the Trans-Canada system by building a 52-mile, 10-inch lateral from a point on the main trunkline near English River. Farther east, Champion Pipe Line Corporation Limited, a subsidiary of Northern and Central, constructed a 61-mile, 8-inch lateral from Earlton, Ontario, to Noranda, Quebec.

No major projects were undertaken in British Columbia during the year.

MARKETS AND TRADE

Ten years ago the Canadian natural gas industry was just beginning its rise that would see it evolve as one of the more significant commodities of the mineral industry. Markets were waiting in Canada and the United States for the modern fuel being found in increasing quantities in the sedimentary basin of western Canada. At that time, the bulk of customer sales was in Alberta where most of the gas was also produced. Only one export line was in operation – the Canadian-Montana Pipe Line Company that drew gas from the sweet, dry gas area in the southeast corner of Alberta. However, two large-diameter pipelines were under construction that were instrumental in the rapid development of natural gas resources and in changing the industry from a subsidiary operation of oil to a production, transportation and marketing complex of national importance.

The changed conditions may be appreciated by the fact that Ontario now is the province having the largest gas sales although the unit cost of gas there is almost three times that in Alberta, the source of nearly all Ontario's gas requirements. Indeed, Ontario accounted for 38 per cent of all sales in Canada in 1966. There has been continued expansion of sales in all provinces in successive years with British Columbia registering the largest increases during the past two years. Sales, provincially, are listed in Table 11.

The value of natural gas exports exceeded $100 million for each of the last three years but in 1966 they had reached only $108 million. This serves to illustrate the comparatively slow rate of export growth but if all export applications are approved there will be a marked increase in the near future. Nevertheless, the growth of exports in the past decade has been impressive as they increased from 26 million cubic feet a day in 1956 to 1,170 million cubic feet a day in 1966. Gas authorized for export by the National Energy Board, after allowing for operation of contracts approved in 1966, amounted to about 1,330 million cubic feet daily, as averaged over the year. This volume is attributed to pipelines as follows with quantities being approximate: 330 million to Trans-Canada, 480 million to Westcoast, 435 million to Alberta and Southern and 85 million feet a day to Canadian-Montana. Gas exports take place by pipeline at Huntingdon and Kingsgate in British Columbia; at Caraway, Aden, and Coutts in Alberta; Emerson in Manitoba; Cornwall in Ontario and Phillipsburg in Quebec.

TABLE 11

Canada, Sales of Natural Gas, by Province, 1966p

	Mcf	$	Average $/Mcf	Number of Customers Dec. 31/66
New Brunswick	62,037	187,206	3.02	2,057
Quebec	32,520,822	32,465,027	0.99	216,715
Ontario	240,084,871	210,575,311	0.87	714,314
Manitoba	37,617,213	25,553,415	0.68	103,486
Saskatchewan	65,008,673	28,716,968	0.44	122,687
Alberta	184,848,263	59,564,857	0.32	268,272
British Columbia	75,372,743	59,149,418	0.78	199,248
Total, Canada	635,514,622	416,212,202	0.65	1,626,783
Previous Totals				
1962	412,061,509	257,589,445	0.62	1,308,085
1963	451,598,298	287,584,177	0.64	1,397,138
1964	504,503,388	327,982,720	0.65	1,459,619
1965	573,016,494	369,307,232	0.64	1,569,539

Source: Dominion Bureau of Statistics.

p Preliminary.

TABLE 12

Canada, Supply and Demand of Natural Gas
(MMcf)

	1965r	1966p
Supply		
Gross new production	1,521,564	1,622,886
Field waste and flared	−79,117	−79,605
Processing shrinkage	−122,067	−137,260
Net new supply	1,320,380	1,406,021
Removed from storage	37,481	38,042
Returned to formation*	−247,665	−263,180
Net storage supply	−210,184	−225,138
Total net domestic supply	1,110,196	1,180,883
Imports	15,673	43,551
Total supply	1,125,869	1,224,434
Demand		
Exports	403,909	426,224
Domestic sales		
Residential	187,311	195,261
Industrial	284,669	324,532
Commercial	101,036	115,722
Total domestic sales	573,016	635,515
Field and pipeline use		
In production	80,071	88,804
Pipeline	53,077	63,878
Line pack changes	550	379
Total field, etc. use	133,698	153,061
Gas unaccounted for	15,246	9,634
Total demand	1,125,869	1,224,434
Total domestic demand	721,960	798,210
Average daily demand	1,977	2,186

Source: Dominion Bureau of Statistics and Provincial reports.
p Preliminary; r Revised
*Bulk of this relates to pressure maintenance.

Regulatory agencies in Canada and the United States approved several export applications allowing for additional volumes of natural gas exports. In the United States the Federal Power Commission authorized Montana Power Corporation to increase imports from 30 million to 50 million cubic feet a day. Pacific Gas Transmission Company was authorized to increase imports by 200 million cubic feet daily to 615 million cubic feet in two equal yearly increments, beginning in November 1966. This gas will be supplied by Alberta and Southern Gas Co. Ltd. by increasing existing contracts. In December, Alberta and Southern and Canadian-Montana Pipe Line Company, applied for permits to export additional quantities of gas all of which will be supplied by Alberta and Southern. Starting in November 1968, Alberta and Southern would increase average daily exports by 106 million cubic feet, with a further increase to 213 million cubic feet a day in November 1969. Daily volumes requested by Canadian-Montana would amount to a further 10 million cubic feet starting in November 1968 and rising to 20 million cubic feet a day in November 1969.

In October, Westcoast Transmission Company Limited received a one-year temporary permit to export an additional 100 million cubic feet daily to El Paso Natural Gas Company to alleviate the growing gas shortage in the Pacific Northwest area of the United States. Westcoast and El Paso are seeking approval of a new contract that would provide for total exports of 600 million cubic feet a day by December 1969 with options for El Paso to purchase an additional 300 million cubic feet daily starting in the fall of 1970. An increase in price would be a feature of the new contract. Approval of this contract, coupled with steadily increasing domestic demand in British Columbia, would necessitate major expansion of the Westcoast system and stimulate exploitation of the large gas reserves in northeastern British Columbia and adjacent areas of the Yukon and the Northwest Territories.

In August, Trans-Canada Pipe Lines Limited received final approval from the Canadian government for a projected 36-inch pipeline, to be built in partnership with a United States company, across the northern United States from Emerson, Manitoba, to Sarnia, Ontario. Actual construction and operation would be carried out by a new subsidiary, Great Lakes Gas Transmission Company Limited. Approval for the project was contingent upon guarantees by Trans-Canada regarding volumes of gas to be transported in Canada and eventual looping of the northern Ontario section of the existing line. The project has encountered severe opposition in lengthy hearings before the Federal Power Commission and a final decision is not expected until mid-1967.

Imports of gas into Canada averaged 119 million cubic feet daily in 1966, valued at $17.6 million for the year, which was almost triple the 1965 average although the total volume represented just over three per cent of total Canadian supply. Virtually all imports came into Ontario with a minor amount entering Alberta. Undoubtedly, imports will continue to increase to meet the growing demand in the heavily populated and industrialized areas of southwestern Ontario until large volumes of Canadian gas are made available by the Great Lakes project or by the provision of expanded facilities along an all Canadian route.

1

Nepheline Syenite

J.E. REEVES*

Production of nepheline syenite in 1966 continued to reflect the healthy growth of the industry. Total shipments were about eight per cent greater than in 1965. Exports, upon which the industry depends, increased by nearly seven per cent. The statistics indicate a renewed dependence on markets in the United States, which took about 92 per cent of exports in 1966, the highest proportion in several years. Shipments to European countries were very much reduced. Canadian markets consumed increased amounts.

PRODUCERS

The source of nepheline syenite in Canada is the large Blue Mountain deposit in Methuen Township, northeast of Peterborough, Ontario. Two companies operate quarries and dry processing plants, principally for the production of glass-grade nepheline syenite. Each also produces fine-ground, high-quality grades and lower-quality byproducts with a relatively high iron content. Near the end of 1966, Industrial Minerals of Canada Limited announced that it would spend $500,000 to increase the capacity of its plant to 800 tons of product a day. The plant of International Minerals & Chemical Corporation (Canada) Limited has a rated capacity of 700 tons a day.

OTHER CANADIAN OCCURRENCES

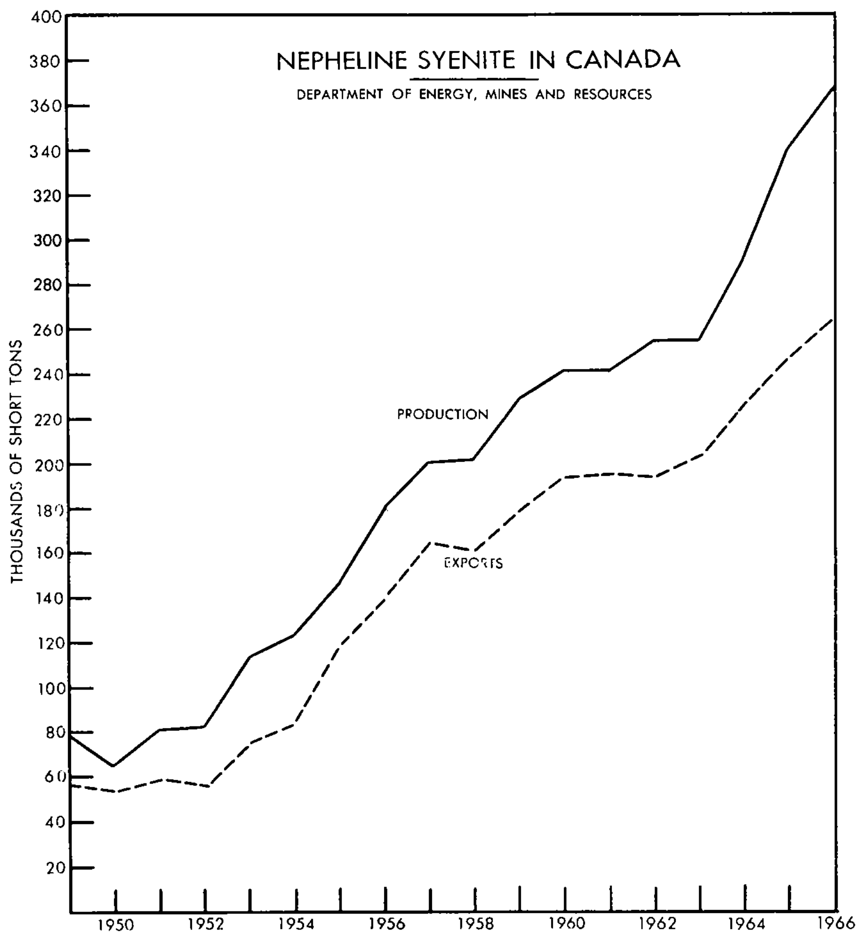
Nepheline-bearing rocks occur in many places in Canada, but, apart from the Blue Mountain nepheline syenite, none is known that can be beneficiated sufficiently to yield a high-quality feldspathic raw material suitable for the ceramics industry.

In the Bancroft area of southeastern Ontario a discontinuous band of nepheline gneiss and nepheline pegmatite, in some places containing a relatively high nepheline content, extends for many miles. From 1937 to 1942 these rocks were mined in small quantity but proved unsuitable for use in glass and various other ceramic products. A variable nepheline content, and an excess of iron-bearing minerals make the production of uniform-quality products difficult.

Nepheline syenite occurs in several places in southern British Columbia, notably in national parkland in the Ice River area near Field and in the vicinity of Big Bend on the Columbia River.

Nepheline is common in the alkaline rock complexes in northern Ontario and southern Quebec but is nowhere of any known commercial significance.

* Mineral Processing Division, Mines Branch.



FOREIGN PRODUCTION

Norway and the USSR also produce nepheline-bearing ceramic raw materials. On Stjernøy, an island off the northern coast of Norway, a large deposit of nepheline syenite, similar in appearance to the Blue Mountain rock, is being mined to produce high-quality products containing more than 24 per cent alumina (Al_2O_3), about 17 per cent combined potash (K_2O) and soda (Na_2O) and 0.08 per cent iron (in terms of Fe_2O_3). At Kirovsk in the Kola Peninsula, the USSR mines an apatite-nepheline rock associated with an alkaline rock complex and produces a nepheline concentrate containing about 29 per cent Al_2O_3, 11 per cent Na_2O, 9 per cent K_2O and 3 to 4 per cent Fe_2O_3. It is used in the manufacture of green glass and as a source of aluminum.

TECHNOLOGY

Nepheline syenite is a quartz-free rock consisting essentially of nepheline (a sodium aluminum silicate) and feldspar (sodium and potassium aluminum silicates). The Blue Mountain deposit contains approximately 50 per cent soda feldspar, about 20 to 25 per cent of both nepheline and potash feldspar and small quantities of the iron-bearing minerals magnetite, biotite and hornblende. Large parts of the

TABLE 1

Nepheline Syenite–Production, Exports and Consumption, 1965-66

	1965		1966P	
	Short tons	$	Short tons	$
Production (shipments)......	339,982	3,415,387	366,422	4,069,317
Exports				
United States	208,217	2,381,102	242,206	2,754,000
Britain....................	17,403	257,148	6,313	105,000
Venezuela.................	3,690	48,541	6,043	70,000
Puerto Rico	1,450	20,913	2,953	43,000
Belgium-Luxembourg........	1,303	28,478	2,234	52,000
Australia..................	2,703	60,224	1,129	26,000
Italy......................	2,330	45,436	831	11,000
Dominican Republic	331	4,464	552	7,000
Peru......................	520	11,485	510	11,000
Netherlands	8,765	99,850	463	10,000
Other countries	488	11,061	390	9,000
Total................	247,200	2,968,702	263,624	3,098,000

	1964	1965
Consumption*		
Glass.....................	33,247	37,076
Whiteware	6,619	7,608
Glass fibre	3,415	3,129
Rubber....................	815	1,220
Mineral wool...............	372	675
Porcelain enamel...........	574	352
Paint	182	139
Other	152	465
Total................	45,376	50,664

Source: Dominion Bureau of Statistics.
* Available data
P Preliminary.

deposit have comparatively little mineralogical variation. This consistency and the relative ease with which the iron-bearing minerals can be removed by high-intensity, dry magnetic separators make the production of uniform high-quality products possible.

Ground and beneficiated nepheline syenite is commercially valuable because of its comparatively high alumina and alkali content and its relatively low melting temperature. Products from the Blue Mountain deposit contain between 23 and 24 per cent Al_2O_3, about 15 per cent total alkali (with a soda-potash ratio of about 2:1) and no more than 0.08 per cent Fe_2O_3.

TABLE 2

Production and Exports, 1957-66
(short tons)

	Production	Exports
1957	200,016	164,342
1958	201,306	160,081
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
1966P	366,422	263,624

Source: Dominion Bureau of Statistics.
P Preliminary.

USES AND SPECIFICATIONS

The glass industry is the dominant consumer of nepheline syenite, accounting for nearly three quarters of the total consumption in Canada. Nepheline syenite is important as a source of alumina and alkalis and because it lowers the melting temperature of the glass batch. All Canadian producers of container and flat glass have substituted nepheline syenite for feldspar. The particle size specification is minus 30 plus 200 mesh, US Standard. For clear glass, the iron content, expressed as Fe_2O_3, must be less than 0.1 per cent.

Nepheline syenite is used to a smaller extent in the whiteware industry as both a body and glaze ingredient. Because of its lower fusion temperature, many Canadian manufacturers of sanitary ware, wall tile and pottery have substituted it for feldspar. The particle size must be mainly minus 325 mesh and the iron content less than 0.1 per cent Fe_2O_3.

Because of its relatively low fusion temperature, fine-ground nepheline syenite is used as a frit ingredient for porcelain enamels. Specifications are similar to those for whitewares. Small quantities of fine-ground material are finding increasing acceptance as a filler in paints and foam rubber products.

Lower-grade, lower-priced byproducts are used to some extent in glass fibre, in glaze for brick and tile, in the body and glaze of sewer pipe and in ground-coat enamels—in all of which the higher iron content is of little importance. Some crude is used in the manufacture of mineral wool.

PRICES

The price of glass-grade nepheline syenite is $10 a short ton, in bulk, f.o.b. plant. *Canadian Chemical Processing* of October 1966 quoted prices for nepheline syenite, in bags and car lots, f.o.b. works, of $11.50 to $28.50 a short ton.

Nickel

A.F. KILLIN*

Nickel consumption in the non-communist world at 420,000 tons increased about 11 per cent from 1965. Production, hampered by labour problems in Canada and New Caledonia, did not keep pace with consumption and the shortfall was met by drawing down inventories and by releases from United States stockpiles. Faced by an increasing demand, nickel producers have instituted large-scale expansion programs in their producing areas. They, and other companies, have increased their exploration efforts in many parts of the world to find new deposits. A lack of skilled labour in Canada and the time-lag between initiation and completion of expansion programs will probably mean a shortfall in production in 1967. Some relief will be obtained in the United States by further stockpile releases and there is possibility of increased nickel sales by the USSR in Europe and Japan.

Production in Canada in 1966 decreased to 234,061 tons valued at $399,735,582 from the 259,182 tons valued at $430,402,105 in 1965. The International Nickel Company of Canada, Limited estimated that 40,000 tons of nickel production was lost owing to labour strikes and slowdowns at its Sudbury, Ontario, mines and plants.

Consumption of nickel in Canada increased an estimated 1,500 tons in 1966 and exports of the 3 major nickel products decreased 8,551 tons to 249,929 tons valued at $390,397,000. Exports of nickel in concentrates and matte were 83,586 tons, 1,259 tons more than in 1965; in oxide sinter, 33,631 tons, 7,325 tons less than in 1965 and in anodes, cathodes, shot, etc., 132,712 tons, 2,485 tons less than in 1965.

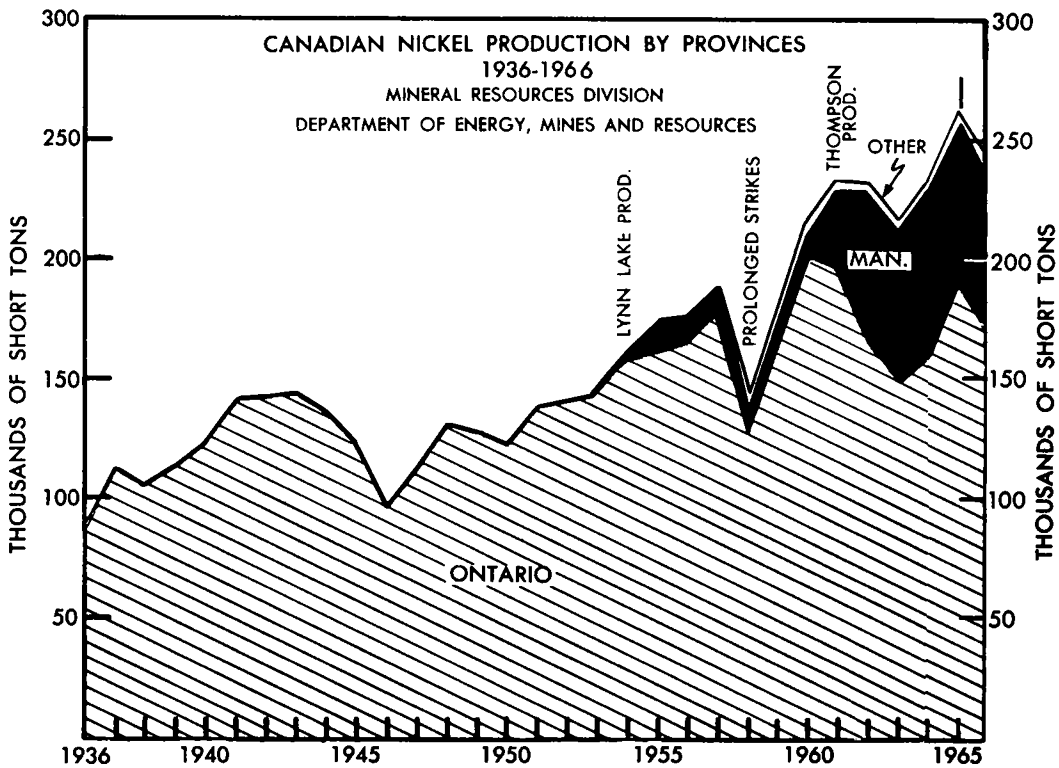
CANADIAN OPERATIONS AND DEVELOPMENTS

Canada's 7 nickel producers supplied over 70 per cent of the non-communist world's nickel in 1966. The 2 largest nickel-producing companies in the world are The International Nickel Company of Canada, Limited (Inco) and Falconbridge Nickel Mines, Limited. They produced about 90 per cent of Canada's output in 1966. Both companies and Sherritt Gordon Mines, Limited, Canada's third largest producer, were active in the search for new deposits in Canada and abroad, and each carried out extensive research projects on production, process technology and product development.

QUEBEC

Production of nickel at 4,297 tons valued at $7,364,544 was 1,271 tons and $2,281,638 higher than in 1965. Lorraine Mining Company Limited at Belleterre processed slightly more than 500 tons of ore a day and produced a bulk nickel-copper concentrate for shipment to Inco's Sudbury, Ont., smelter. Extensive underground exploration by drifting and drilling was continued.

*Mineral Resources Division.



Marbridge Mines Limited, owned by Marchant Mining Company Ltd. and Falconbridge Nickel Mines, produced about 500 tons of ore a day at its mine and mill near Malartic. Production from the No. 2 ore zone increased mill heads and a higher grade bulk concentrate was shipped to Falconbridge, Ontario, for smelting. A third ore zone, lying between the No. 1 and No. 2 zones, was discovered and will be explored in 1967.

New Quebec Raglan Mines Limited, the successor company to a merger between Raglan Quebec Mines Limited and Bilson Quebec Mines Limited (subsidiary of Falconbridge), continued diamond drilling on its extensive property in the Wakeham Bay – Cape Smith area of the Ungava Peninsula. Indicated ore reserves were 15,585,000 tons averaging 1.78 per cent nickel and 0.71 per cent copper. Supplies and equipment were being moved into the area in preparation for a program of underground exploration in 1967.

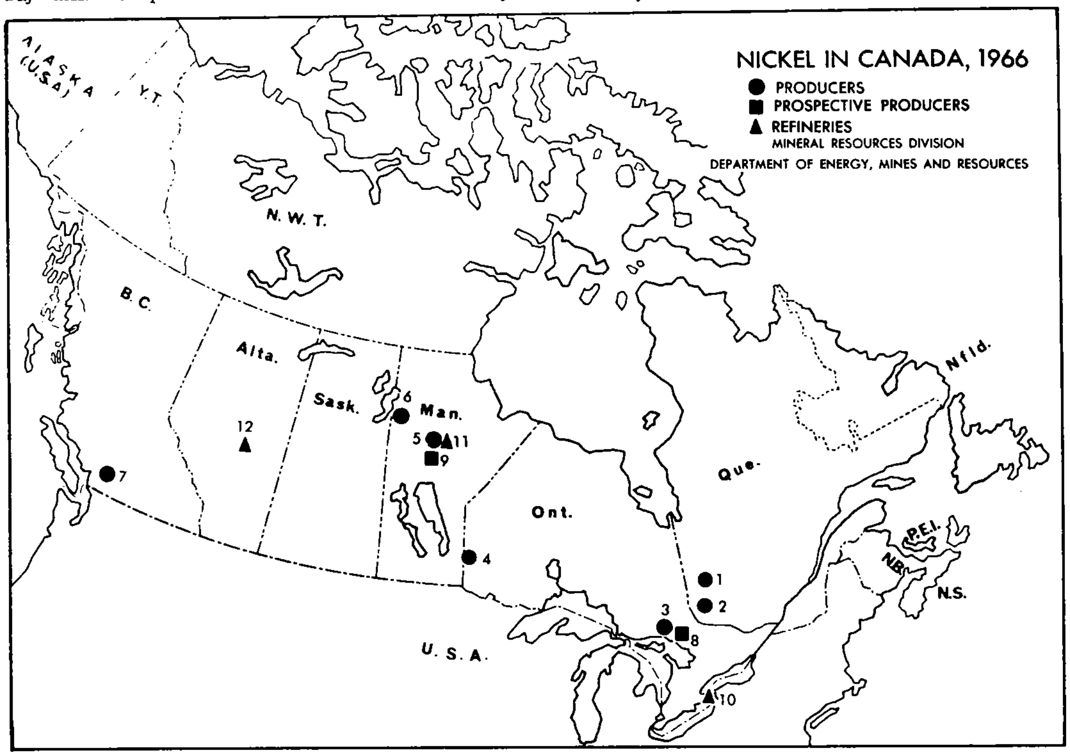
ONTARIO

Nickel production in 1966 was reduced to 169,878 tons valued at $291,170,674 from 191,283 tons and $316,332,366 in 1965. The decrease was caused by strikes, slowdowns and lack of sufficient skilled labour at the Sudbury area mines and plants of Inco.

Inco continued its major expansion program in the Sudbury area that will see the Copper Cliff North mine in production in 1967, the Kirkwood mine in 1968, the Little Stobie and Coleman mines in 1969; a 22,500-ton-a-day mill completed in 1967 at the Stobie mine to treat ore from expanded production there and from the Little Stobie, and completion of the 7,150-foot No. 9 production shaft (2,337 feet deep at the end of 1966) at the Creighton mine. In the smelter, a start was made on replacement of the multi-hearth roasters by fluid-bed roasters and on the revision of the matte separation facilities to increase capacity and efficiency. The company started shaft sinking preparatory to underground exploration of its nickel property at Shebandowan in western Ontario. Shaft sinking will start in 1967 at a large low-grade deposit north of Garson, near Sudbury, to explore and sample the occurrence.

Falconbridge operated 6 mines in the Sudbury area. The company was also developing the Strathcona mine and building a 6,000-ton-a-day mill for production in late 1967 or early 1968, and was exploring the Longvac South deposit north of the Strathcona.

For the treatment of the nickel-copper ores of the Sudbury area, Inco operated smelters at Copper Cliff and Coniston and a nickel refinery at Port Colborne. Falconbridge operated a smelter at Falconbridge and shipped the resulting nickel-copper matte to its refinery in Norway.



PRODUCERS

(numbers refer to numbers on map)

1. Marbridge Mines Limited
2. Lorraine Mining Company Limited
3. *Sudbury area*
   Falconbridge Nickel Mines, Limited (6 mines, 1 smelter)
   The International Nickel Company of Canada, Limited (10 mines, 2 smelters)
4. Metal Mines 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. *Sudbury area*
   Falconbridge Nickel Mines, Limited (Strathcona mine)
   The International Nickel Company of Canada, Limited (4 mines)
   Kidd Copper Mines Limited
9. *Thompson area*
   The International Nickel Company of Canada, Limited (3 mines)

REFINERIES

10. The International Nickel Company of Canada, Limited (Port Colborne)
11. The International Nickel Company of Canada, Limited (Thompson)
12. Sherritt Gordon Mines, Limited (Fort Saskatchewan)

TABLE 1

Nickel – Production, Trade and Consumption, 1965-66

	1965		1966p	
	Short Tons	$	Short Tons	$
Production[1]				
All forms				
Ontario	191,283	316,332,366	169,878	291,170,674
Manitoba	63,212	106,196,353	58,171	98,260,854
Quebec	3,026	5,082,906	4,297	7,364,544
British Columbia	1,661	2,790,480	1,715	2,939,510
Total	259,182	430,402,105	234,061	399,735,582
Exports				
Nickel in ores, concentrates, matte or speiss				
Britain	47,067	77,025,888	44,364	74,094,000
Norway[2]	32,810	49,887,419	37,167	59,467,000
Japan	2,124	2,072,463	1,605	1,765,000
United States	326	449,145	450	629,000
Total	82,327	129,434,915	83,586	135,955,000
Nickel in oxide sinter				
United States	27,069	38,593,770	18,931	27,420,000
Britain	7,388	10,564,385	4,929	7,081,000
West Germany	2,333	3,661,098	2,690	4,230,000
Sweden	469	732,001	2,000	3,136,000
Belgium and Luxembourg	1,001	1,572,092	1,532	2,382,000
France	976	1,532,399	1,473	2,313,000
Italy	473	743,010	1,087	1,713,000
Australia	741	1,052,022	562	807,000
Austria	300	471,739	164	259,000
Netherlands	6	9,245	154	245,000
Mexico	95	150,130	69	113,000
Other countries	105	164,969	40	62,000
Total	40,956	59,246,860	33,631	49,761,000
Nickel and nickel alloy scrap				
United States	861	539,226	919	604,000
Britain	22	19,643	95	127,000
Netherlands	11	9,752	56	116,000
France	20	12,847	53	81,000
Norway	30	27,258	29	26,000
Japan	25	2,200	14	19,000
Other countries	77	43,373	17	37,000
Total	1,046	654,299	1,183	1,010,000
Nickel anodes, cathodes, ingots, rods				
United States	110,137	162,749,253	101,700	156,962,000
Britain	15,135	22,244,989	20,248	29,978,000
West Germany	2,218	3,601,545	3,205	5,219,000
Japan	1,902	3,158,612	1,624	2,752,000
France	1,309	2,170,941	1,392	2,254,000
Sweden	499	809,278	924	1,511,000
Italy	422	686,418	607	995,000
Australia	1,129	1,718,095	571	915,000
Belgium and Luxembourg	151	253,932	494	779,000
Brazil	244	400,643	354	583,000
Argentina	345	614,955	293	505,000
India	909	1,510,332	257	432,000
Mexico	244	404,167	244	404,000
Other countries	553	949,997	799	1,392,000
Total	135,197	201,273,157	132,712	204,681,000

Table 1 (cont'd)

	1965		1966P	
	Short Tons	$	Short Tons	$
Nickel and nickel-alloy fabricated materials, n.e.s.				
United States	2,296	4,437,245	3,446	6,770,000
West Germany	22	38,990	89	143,000
India	52	91,344	68	114,000
Republic of South Africa	350	931,615	67	209,000
Japan	24	40,518	59	101,000
New Zealand	50	214,712	38	151,000
Britain	43	145,514	36	75,000
Mexico	32	54,572	20	36,000
Other countries	311	636,180	53	153,000
Total	3,180	6,590,690	3,876	7,752,000
Imports				
Nickel in ores, concentrates and scrap[4]				
United States			12,247	14,989,000
Britain			8,704	1,464,000
French Oceania			5,646	6,608,000
Other countries			80	81,000
Total			26,677	23,142,000
Nickel anodes, cathodes, ingots, rod and shot				
United States	90	228,079	18,097	29,110,000
Norway	12,082	20,790,906	10,789	18,470,000
West Germany	—	—	30	73,000
Total	12,172	21,018,985	28,916	47,653,000
Nickel alloy ingots, blocks, rods and wire bars				
United States	610	1,800,080	718	2,246,000
West Germany	4	16,583	20	62,000
Other countries	...	949	...	1,000
Total	614	1,817,612	738	2,309,000
Nickel and nickel alloy fabricated materials, n.e.s.				
United States	2,154	6,660,215	1,731	5,922,000
West Germany	34	84,419	156	746,000
Britain	53	204,176	95	327,000
Other countries	23	90,227	10	41,000
Total	2,264	7,039,037	1,992	7,036,000
Consumption[3]	8,924		8,608	

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.

[4]Not available as a separate class prior to 1966.

Symbols: P preliminary; — nil; ... less than one ton; n.e.s. not elsewhere specified.

Ore reserves increased in the Sudbury district with Inco reporting reserves at the year-end of 324,868,972 tons containing 9,481,964 tons of nickel and copper (also includes reserves at Thompson, Man.), and Falconbridge reporting 55,715,500 tons containing a combined nickel-copper content of 1,172,000 tons.

TABLE 2

Nickel — Production, Trade and Consumption, 1957-66

(short tons)

	Production[1]	Exports				Imports[2]	Consumption[3]
		In Matte etc.	In Oxide Sinter	Refined Metal	Total		
1957	187,958	73,694	1,706	103,258	178,658	2,091	4,532
1958	139,559	67,659	1,393	85,168	154,220	2,155	4,099
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
1966P	234,061	83,586	33,631	132,712	249,929	28,916	8,608

Source: Dominion Bureau of Statistics.

[1]Refined metal and nickel in oxide and salts produced plus recoverable nickel in matte and concentrates exported. [2]Nickel in bars, rods, strips, sheets and wire; nickel and nickel-silver in ingots; nickel chromium in bars. [3]To 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;

Metal Mines Limited, Ontario's third largest nickel producer, operated its mine and mill at Gordon Lake at below mill capacity because of a lack of skilled miners. Exploration and development of the D ore-zone, discovered in 1965, was also hampered but exploration to date has maintained ore reserves at the property. Concentrates are sold to Inco and smelted at Sudbury.

Kidd Copper Mines Limited leased the Aer nickel property near Worthington in the Sudbury area. The workings were unwatered and a 1,000-ton-a-day mill was built. Tune-up at the property started in November and it was expected that full production would be reached in the second quarter of 1967. Concentrates will be shipped to Falconbridge for smelting.

Canadian Nickel Company Limited, the exploration arm of Inco, optioned the Texmont Mines Limited property in Bartlett and Geikie townships, 20 miles southwest of Timmins where exploration by underground workings and surface and underground diamond drilling has indicated over 4 million tons of 1 per cent nickel. Canadian Nickel is continuing the exploration and can earn a 50-per-cent interest in the mine by putting it into production.

Great Lakes Nickel Corp. Limited owns 29 claims in Pardee township, 40 miles southwest of Port Arthur. Surface diamond drilling indicated a multi-million ton deposit containing low values in copper (0.39%) and nickel (0.19%). Feasibility tests were under way to establish the economics of a large-scale mining operation.

MANITOBA

Nickel production from the Thompson mine of Inco and the Lynn Lake mine of Sherritt Gordon Mines, Limited, totalled 58,171 tons valued at $98,260,854 in 1966, 5,041 tons and $7,935,499 less than in 1965. The decrease in production is attributable to a decrease in the rate of mining at Lynn Lake owing to a shortage of skilled miners.

Inco continued production from the Thompson mine and was shaft sinking and developing at the Soab and Birchtree mines. The Soab is scheduled for production in late 1967 and the Birchtree in 1968. Plans were announced to mine the Pipe Lake deposit some 20 miles south of Thompson. The ore will be mined by open pit and will require the removal of 100 feet of clay overburden. A 45-mile railroad will be built from Pipe Lake to Thompson. The Thompson mill, smelter and refinery will be expanded to treat ore from the 3 new mines.

TABLE 3
Producing Companies, 1966

Company and Location	Mill Capacity (tons ore/day)	Ore Produced 1966 (1965) (short tons)	Grade (%) Ni	Cu	Developments
Quebec					
Lorraine Mining Company Ltd., Belleterre	400	186,363 (162,533)	0.57	1.24	Underground exploration by development and diamond drilling.
Marbridge Mines Ltd., Malartic	350 (milled at Canadian Malartic Gold Mines Limited)	128,500 (125,000)	3.22	..	Continued exploration and development of known orebodies.
Ontario					
Falconbridge Nickel Mines, Ltd., Falconbridge (Falconbridge, East, Hardy, North, Onaping and Fecunis mines)	3,000 (Falconbridge) 1,500 (Hardy) 2,400 (Fecunis)	2,101,000 (2,246,918)	1.55	0.78	Routine exploration and development at producing mines. Exploration of new ore at depth in Onaping mine. Development of Strathcona mine for production. Preparation for shaft sinking at Longvac South orebody.
The International Nickel Company of Canada, Ltd., Copper Cliff (Creighton, Frood-Stobie, Garson, Levack, Crean Hill, MacLennan, Murray, Totten mines and MacLennan, Ellen and Clarabelle open pits)	30,000 (Copper Cliff) 12,000 (Creighton) 6,000 (Levack)	14,625,200 (16,704,143)	..	..	Continued sinking No. 9 shaft Creighton mine, shaft sinking and underground development at the Coleman, Copper Cliff North, Kirkwood and Little Stobie mines. Shaft sinking for underground exploration at Shebandowan. Building 22,500-ton-a-day mill at Stobie mine and modernizing Copper Cliff smelter.
Kidd Copper Mines Limited, Worthington, Aer Nickel mine	1,000	..	..	..	Mill tune-up in 1966. Production scheduled for 1967
Metal Mines Limited, Werner Lake Division, Gordon Lake	700	.. (184,364)	..	..	Exploration and development of orebody discovered in 1965.
Manitoba					
The International Nickel Company of Canada, Ltd., Thompson, Thompson mine.	6,000	2,900,000 (..)	..	..	Developing the Soab and Birchtree mines for production. Expansion of Thompson mill, smelter and refinery. Preliminary planning for production from Pipe Lake open pit mine.
Sherritt Gordon Mines, Limited, Lynn Lake	3,500	1,205,318 (1,363,583)	..	..	Continued exploration and development of O and N zones.
British Columbia					
Giant Mascot Mines, Ltd., Hope	1,250	327,164 (330,954)	0.66	0.33	Development of known ore. Diamond drilling for new orebodies.

Source: Company reports.
.. Not available.

TABLE 4

Prospective Producing Companies*, 1966

Company and Location	Type of Ore	Mill Capacity (tons ore/day)	Production To Start	Destination of Concentrates
Ontario				
Falconbridge Nickel Mines, Ltd., Strathcona mine, Sudbury	Ni, Cu	6,000	1967–68	Own smelter
The International Nickel Company of Canada, Ltd., Sudbury,				
Copper Cliff North	Ni, Cu	Treated at central mill	1967	Own smelter
Kirkwood	Ni, Cu	Treated at central mill	1968	Own smelter
Coleman	Ni, Cu	Treated at central mill	1969	Own smelter
Frood-Stobie expansion and Little Stobie	Ni, Cu	22,500 at Frood-Stobie	1969	Own smelter
Manitoba				
The International Nickel Company of Canada, Ltd., Thompson,				
Soab	Ni, Cu	Treated at Thompson	1967	Thompson smelter
Birchtree	Ni, Cu	Treated at Thompson	1968	Thompson smelter
Pipe Lake open pit	Ni, Cu	Treated at Thompson	1970	Thompson smelter

Source: Company reports.

*Includes only companies with announced production plans.

Sherritt Gordon's production from Lynn Lake decreased. The company continued to explore for more ore on the property by underground development and diamond drilling. Sherritt imported matte from New Caledonia to keep its refinery at Fort Saskatchewan, Alta., operating near capacity and announced that custom ores would be accepted at the refinery for treatment.

Falconbridge continued exploration and feasibility studies on the Wabowden Lake properties of Bowden Lake Nickel Mines Limited.

BRITISH COLUMBIA

Giant Mascot Mines, Limited, British Columbia's only nickel mine, produced concentrates containing 1,715 tons of nickel valued at $2,939,510, an increase from 1965 of 54 tons and $149,030. The company maintained ore reserves but of higher grade because of the discovery of a new, high-grade orebody. The mine is near Hope and the bulk nickel-copper concentrate was trucked to Vancouver for shipment to a smelter in Japan.

TABLE 5

World Production of Nickel

(short tons)

	1964	1965
Canada	228,496	259,182
USSR	90,000	95,000
New Caledonia	51,130	53,063
Cuba	16,300	16,300
United States	12,185	13,510
Republic of South Africa	2,700	3,400
Finland	3,490	3,256
Other countries	4,899	89
Total	409,200	443,800

Source: American Bureau of Metal Statistics Yearbook, 1965; for Canada, Dominion Bureau of Statistics.

WORLD DEVELOPMENTS

A strike at the mines of Société Le Nickel in New Caledonia lasted for 3 weeks and prevented the company from achieving its planned rate of expansion. The construction in 1966 of a new power plant and a new electric furnace will allow the company to expand nickel production from 35,000 tons a year to 66,000 tons. Le Nickel participated with Hellenic Chemical Products and Fertilizers Company to bring a nickel-iron plant into production at Larymna, Greece. The first unit of the 8-million-pound-a-year nickel plant started production on January 3, 1966. Le Nickel planned the construction of an electrolytic nickel refinery in Sardinia, was investigating ore deposits in Venezuela and the Philippines, and entered into an agreement with 4 Japanese companies to build a nickel oxide plant at Tsuruga, Japan.

Japan continued to import nickel ores, concentrates and matte. Concentrates were obtained from Giant Mascot Mines in British Columbia, ore from Indonesia and matte from New Caledonia. Tokyo Nickel Company, formed by Inco and 2 Japanese companies, built a refinery in Japan to produce nickel oxide sinter 75. A shortage of nickel developed in Japan in the latter half of 1966 and Japanese companies paid up to $1.55 a pound for electrolytic cathodes on the ''free'' market.

Exploration in Australia continued at an accelerated pace during the year. Western Mining Corporation Limited was exploring a high-grade nickel discovery at Kambalda, Western Australia, about 30 miles south of Kalgoorlie. The company was building a 300-ton-a-day mill for production in mid-1967. At Wingellina in Western Australia, close to the common boundaries of the Northern Territory and South Australia, South Western Mining Limited, a subsidiary of Inco, was exploring a number of nickel-silicate deposits in the Blackstone Range. A 500-ton bulk sample of the nickel-bearing material was shipped to Canada for metallurgical testing. Inco was also exploring for nickel in Northern Queensland, Australia, in partnership with The Broken Hill Proprietary Company Limited of Australia. Inco continued exploration of nickeliferous laterite deposits in the British Solomon Islands Protectorate.

In Guatemala, Exploraciones y Exploitaciones Mineras Izabal, S.A. (Eximbal), a majority owned subsidiary of Inco, continued development and engineering studies on a lateritic nickel deposit near Lake Izabal. The mine and plant is scheduled to produce about 25 million pounds a year of nickel in ferronickel.

Inco obtained mining leases covering 5,000 acres in northern Minnesota from the United States government. The company was carrying out engineering studies to test the feasibility of mining an extensive orebody containing less than 1 per cent combined copper and nickel.

Sherritt Gordon Mines, Limited, was exploring for nickel in Guyana in the Warirs region.

Open-pit mining of nickel ores in the Goles Mountain range of Yugoslavia was scheduled to start in 1967. Output will be about 3,500 tons of nickel a year.

In August, the United States government ordered the 3 major suppliers – Inco, The Hanna Mining Company and N.C. Trading Company of New York – to set aside 25 per cent of their monthly deliveries, based on the average of the first 6 months of 1966, for defence orders. This set-aside rate applied until December when it was reduced to 12.5 per cent.

Most of the 164 million pounds of nickel-bearing material purchased in 1965 by North American producers from the US stockpile was distributed to consumers by the end of 1966. The US government also authorized a further disposal of 12,250 tons of nickel from the strategic stockpile in 1966. Deliveries of this material will extend into 1967.

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United States Nickel Stockpile, 1965-66

Period	Stockpiles	Inventories (short tons) Beginning of Period	End of Period	Net Change During Period	Stockpile* Objective	Excess Over Stockpile Objective
Dec. 1965	National	166,195	161,579	-4,616	—	—
	Defence Prod. Act	39,339	39,117	-222	—	—
	Total	205,534	200,696	-4,838	50,000	150,696
Jan. 1966	National	161,579	157,770	-3,809	—	—
	Defence Prod. Act	39,117	38,938	-179	—	—
	Total	200,696	196,708	-3,988	50,000	146,708
Dec. 1966	National	86,109	83,399	-2,710	—	—
	Defence Prod. Act	13,959	13,702	-257	—	—
	Total	100,068	97,101	-2,967	50,000	47,101
Year 1966	National	161,579	83,399	-78,180	—	—
	Defence Prod. Act	39,117	13,702	-25,415	—	—
	Total	200,696	97,101	-103,595	50,000	47,101**

Source: Joint Committee on Reduction of Nonessential Federal Expenditures Congress of the United States.
*Stockpile objective reduced to 20,000 s.t. Jan. 15, 1967.
**Excess at year-end, net change — 103,595 s.t.

CONSUMPTION AND USES

Nickel's suitability as an alloying agent and its resistance to corrosion are its chief advantages in almost all of its uses. Stainless steel remains the largest single outlet for nickel followed closely by nickel plating and high-nickel alloys. Consumption in stainless steel and plating increased more than 10 per cent from 1965 and in high-nickel alloys it increased 26 per cent. The increased consumption of these alloys results from their suitability for chemical, marine, electronic, nuclear and aerospace applications.

Electrolytic nickel use is increasing in the plating industry with the trend towards the use of this material in plating baskets instead of conventional electroplating anodes. The use of nickel oxide as a raw material for nickel salts, electronic components and base-coat enameling frits is increasing. There is a growth in the consumption of high-purity nickel powders for manufactures including strip, engineering components and dispersion-strengthened nickel and nickel alloys. An expanding use for nickel is in the manufacture of coinage. In 1966, six countries introduced pure nickel coins and 19 countries introduced cupro-nickel coins. Canada has announced that its 10¢, 25¢ and 50¢ pieces would be made of nickel in 1968 instead of silver.

Tables 6 and 7 list the consumption of nickel by use and by countries in 1965 and 1966.

TABLE 6

Nickel Consumption by Use, 1965-66

(millions of pounds)

	1965	1966[e]
Stainless steels........	253	280
Nickel plating	120	135
High-nickel alloys.....	103	130
Constructional alloy steels	95	98
Iron and steel coatings	80	88
Copper and brass products	34	29
Other	75	80
Total	760	840

Source: The International Nickel Company of Canada, Limited.
[e] Estimated.

PRICES

There were 2 prices for nickel in 1966, the official price, quoted f.o.b. Canadian shipping points, and a free market price. Press reports are available of consumers in Europe and Japan paying up to £1500 a long ton for electrolytic nickel. The official price is listed. The price was raised in November for the first time since 1962.

TABLE 7

Nickel Consumption by Country, 1965-66

(millions of pounds)

	1965	1966[e]
United States	370	422
Europe* and Britain	285	305
Japan	67	69
Canada	18	21
Other	20	23
Total	760	840

Source: The International Nickel Company of Canada, Limited.

[e] Estimated; *Excluding communist bloc countries.

Nickel Prices Canada and United States, 1966

Cents a Pound

	Canada		United States*	
	Jan. 1 – Oct. 31	Nov. 1 – Dec. 31	Jan. 1 – Oct. 31	Nov. 1 – Dec. 31
Inco, electrolytic, f.o.b., Port Colborne, Ont. and Thompson, Man.	84	92.15	77.75	85.25
Falconbridge, electrolytic, f.o.b., Thorold, Ont.	84	92.15	77.75	85.25
Sherritt Gordon, briquettes, f.o.b., Niagara Falls, Ont. and Fort Saskatchewan, Alta.	84	92.15	77.75	85.25
Nickel oxide sinter 75 (Ni-Co content), points in Ontario (freight allowed)	81.50	87.80		
Points outside of Ontario (less freight allowance of 1.25¢ a pound)	81.50	87.80		
Buffalo, NY, or other established US points of entry				
Nickel oxide sinter 75			75.25	81.00
Nickel oxide sinter 90			–	81.25

*US price does not include duty of 1.25 cents a pound, suspended from September 1965 until July 1, 1967.

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
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

TARIFFS (cont'd)

	British Preferential (%)	Most Favoured Nation (%)	General (%)
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 powder form, for use in Canadian manufactures..........................	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	free	free	free
Articles of 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

Ore, matte, and oxide...	free
Unwrought, waste and scrap (duty suspended until June 30, 1967)	free
Bars, plates, sheets and strip, all the foregoing wrought of nickel (whether or not cut), pressed, or stamped to nonrectangular shapes: not cut, pressed, nor stamped to nonrectangular shapes..................	(% ad val.)
Plates and sheets, clad...	24
Other:	
not cold worked...	10
cold worked	14
Rods, angles, shapes and sections, all the foregoing wrought of nickel; nickel wire	
Rods and wire:	
not cold worked...	10
cold worked	14
Angles, shapes and sections	18
Nickel powders and flakes	
Flakes	10¢ per lb.
Powders (duty suspended until June 30, 1967)	free
Pipes and tubes and blanks thereof, pipe and tube fittings, all the foregoing of nickel	
Pipes and tubes and blanks thereof:	
not cold worked...	6.25
cold worked	8.75
Pipe and tube fittings	18
Electroplating anodes, wrought and cast of nickel	10

MODERN MINING COMMUNITY: Lynn Lake, Manitoba, showing part of the townsite with school and recreation buildings in foreground and mine and mill buildings in background.

Niobium (Columbium) and Tantalum

G.P. WIGLE*

St. Lawrence Columbium and Metals Corporation began mining pyrochlore, near Oka, Quebec, in 1961 and continues as Canada's only producer of columbium. The company reported that production in 1966 was 2.6 million pounds of columbium pentoxide (Cb_2O_5) in concentrates. St. Lawrence Columbium operates one of two mines in the world that produces columbium concentrates as a primary product, the other is in Brazil.

Production of columbium concentrates and ferrocolumbium from the large, high-grade (4% Cb_2O_5) pyrochlore deposits near Araxa, Brazil, was doubled to an annual rate of 7 million pounds of Cb_2O_5. Companhia Brasileira de Metalurgia e Mineração, formerly DEMA, became the largest single producer of columbium at its mine near Araxa in the state of Minas Gerais, Brazil. Its production in 1966 was 8.8 million pounds of pyrochlore concentrates and 500 tons of ferrocolumbium.

The principal sources of columbium and tantalum have been the columbite-tantalite minerals from pegmatites, placer deposits, and tin recovery operations, notably in Nigeria. Major sources are now the pyrochlore deposits in Brazil and Canada.

CANADIAN PRODUCTION

St. Lawrence Columbium has expanded production each year since it began operation. In 1966 the mill treated 406,698 tons of ore averaging 0.468 per cent Cb_2O_5 compared with 383,553 tons averaging 0.430 per cent Cb_2O_5 in 1965. The company's sales in Canada increased to nearly 8 per cent from the previous year's 4.6 per cent; sales to the United States decreased while shipments to Europe increased.

Masterloy Products Limited continued to be the only Canadian producer of ferrocolumbium. Its production in 1966 was 142 tons of ferrocolumbium on a 60 per cent Cb-content basis.

Suppliers of ferrocolumbium have noted that the market for this material in Canada remains small but shows signs of growth in certain applications such as oil and gas transmission piping.

*Mineral Resources Division.

TABLE 1

Canada, Niobium (Columbium) and Tantalum Production, Trade and Consumption, 1965-66

	1965		1966p	
	Pounds	$	Pounds	$
Production (shipments)				
Columbium pentoxide (Cb_2O_5)	2,333,967	2,528,051	2,600,000	3,150,000
Imports[1] from United States				
Columbium and columbium alloys wrought and unwrought, waste and scrap	3	1,920	–	–
Tantalum and tantalum alloys, wrought and unwrought, waste and scrap	721	160,204	1,533	180,326
Tantalum and tantalum alloy powder	–	–	2,730	99,939
Exports[2] to United States				
Columbium ore and concentrates	1,860,631	958,244	1,524,279	869,678
Consumption by steel industry				
Ferrocolumbium and ferrotantalum-columbium (Cb and Ta-Cb content)	58,000		..	

Source: Dominion Bureau of Statistics.
[1] From US Department of Commerce , Exports of Domestic and Foreign Merchandise, Report FT 410. Values in US currency. [2] From United States Department of Commerce, Imports of Merchandise for Consumption, Report FT 125. Values in US currency.
p Preliminary; – Nil; .. Not available.

CANADIAN OCCURRENCES

NORTHWEST TERRITORIES

There are many columbium-tantalum occurrences in the Yellowknife area of Great Slave Lake where columbite-tantalite has been noted in many pegmatite dikes in association with beryl, spodumene and amblygonite.

Exploration and development was planned for the 1967 season on the PEG tantalum prospect, in the upper Ross Lake area, optioned to International Bibis Tin Mines Limited. The work was to be carried out by CIBA Company Limited, a subsidiary of the pharmaceutical and chemical company, of the same name,of Basle, Switzerland.

BRITISH COLUMBIA

The placer deposits on Bugaboo, Vowell and Forster creeks, about 45 miles southeast of Golden, contain columbium-bearing gravel. Concentrates from the locality were examined in 1956 but the project for recovery was discontinued as uneconomical.

MANITOBA

Tantalite is associated with the lithium-bearing pegmatites in the Bernic Lake area. A significant occurrence is on the property of Chemalloy Minerals Limited. Chemalloy and Kilcherr, A.G. of Basle, Switzerland, have jointly arranged for unwatering the Bernic Lake mine to explore and develop the tantalum potential of the property along with the cesium and lithium potential.

ONTARIO

The columbium-uranium deposits of Nova Beaucage Mines Limited are six miles west of North Bay in an area covering the Manitou Islands of Lake Nipissing. Considerable exploration and development work was done in

TABLE 2

Production of Columbium in Pyrochlore Concentrates
by St. Lawrence Columbium & Metals Corporation 1963-66
(pounds)

	1963	1964	1965	1966
Concentrates	2,941,303	4,150,388	4,541,745	5,147,529
Contained Cb_2O_5	1,521,701	2,163,135	2,333,967	2,639,689
Concentrates shipped	2,692,935	4,222,424	4,510,182	5,114,801
Per cent Cb_2O_5 in concentrates	51.76	52.1	51.4	51.5

Source: Company report.

1956 and reserves were reported at 2.9 million tons averaging 0.69 per cent Cb_2O_5 and 0.042 per cent uranium oxide (U_3O_8).

Dominion Gulf Company carried out exploration and development on two areas of columbium mineralization in Chewett township in 1957-58. One area is estimated to contain 20 million tons of material averaging 0.5 to 0.8 per cent Cb_2O_5.

Consolidated Morrison Explorations Limited and associated companies hold exploration concessions in the James Bay Lowlands area of Ontario, south of Moosonee, on which large tonnages of columbium-bearing materials have been discovered and partly outlined by diamond drilling. A drilling program started in November 1966 was aimed at providing more detailed information. Early estimates indicated 40,000 tons, or more, per vertical foot averaging 0.52 per cent columbium pentoxide.

QUEBEC

Large pyrochlore deposits near the town of Oka, 20 miles west of Montreal, are controlled by Quebec Columbium Limited, Columbium Mining Products Ltd., and St. Lawrence Columbium and Metals Corporation.

St. Lawrence Columbium mined and milled 406,698 tons of ore averaging 0.468 per cent Cb_2O_5. Shaft sinking and underground lateral development were undertaken in preparation for the change from pit to underground mining. Ore reserves within 1,000 feet of the shaft and above the 1,000-foot level were 2.9 million tons averaging 0.46 per cent columbium pentoxide.

WORLD PRODUCTION

Non-communist world production of columbium and tantalum concentrates in 1966 amounted to some 10,859 tons, of which 10,409 were columbium concentrates (columbite or pyrochlore) and 450 tons were tantalum concentrate (tantalite).

Brazil became the leading producer of columbium concentrates following the increase of production to an annual rate of 7 million pounds of Cb_2O_5 from the Araxa deposits of pyrochlore, in 1966. The large high-grade deposit is jointly owned by Brazilian interests and Molybdenum Corporation of America (Molycorp).. Brazil's production in 1966 supplied 51 per cent of the United States imports of columbium concentrates.(1)

Nigeria had been the perennial leader in the production of columbium and, in contrast to the newer producers of columbium-bearing pyrochlore, its columbite concentrates are a coproduct of tin mining operations.

Columbium and/or tantalum concentrates are also produced in Mozambique, Republic of the Congo (Kinshasa), Malaysia, Southern Rhodesia, Malagasy, Portugal, Uganda, Australia and other countries.

(1) US Bureau of Mines Commodity Data Summaries, January 1967.

TABLE 3

Non-Communist World Production of Columbium-Tantalum Concentrates (short tons)

	1965	1966[e]
Nigeria	2,873	2,825
Canada	2,270[r]	2,574
Brazil	1,796	4,400
Republic of the Congo (Kinshasa)	102	125
Mozambique	154	180
Norway	93	–
Malaysia	51	75
Communist-bloc	..	..
Other Countries	501	680
Total	7,840	10,859

Source: US Bureau of Mines Commodity Data Summaries, January 1967; Company reports.
[e] Estimated; .. Not available; [r] Revised;–Nil.

CONSUMPTION AND USE

Columbium (Niobium) is extracted commercially from the minerals columbite and pyrochlore; tantalum from the mineral tantalite. Columbite and tantalite have the theoretical compositions (Fe Mn) O. Cb_2O_5 and (Fe Mn) O.Ta_2O_5. The two elements are similar refractory metals with closely related properties and uses. They are closely associated in ore occurrences and replace one another in widely variable proportions in the respective minerals. Concentrates from different sources show wide variations in composition from high-columbium low-tantalum to mixtures of the opposite extreme. An important source of these elements now is the pyrochlore-microlite series of minerals, which also contain oxides of many other elements including the rare earths and radioactive elements. Pyrochlore is the columbium-rich member of the series; microlite is the tantalum-rich member.

The United States is the largest consumer of columbium and tantalum with the major part of its wholly-imported supply used to make ferrocolumbium and ferrotantalum-columbium. Both metals are finding increasing use in nuclear research and in high-temperature alloys for jet engines, turbines and rocket-engine parts. Tantalum is extensively used in high-performance capacitors, and in electronic equipment, chemical equipment, alloys and carbides. Columbium is principally used as ferrocolumbium in alloy and stainless steels, high-temperature alloys, carbon steels and nickel-base alloys.

The United States imported 5,200 tons of columbium and tantalum concentrates compared with 3,044 tons in 1965.(1) Brazil, Nigeria and Canada were the principal suppliers.

Canada's consumption in 1965, of columbium and tantalum in the form of the ferroalloy additives was 58,000 pounds of combined elements (Cb,Ta). The principal Canadian suppliers of ferrocolumbium are Union Carbide Canada Limited, Metals and Carbon Division; Metallurgical Products Company Limited; Masterloy Products Limited; and Metallurg (Canada) Ltd.

Among the more important Canadian users of columbium and tantalum products are Atlas Steels Division of Rio Algom Mines Limited; The Algoma Steel Corporation, Limited; Black Clawson-Kennedy Ltd.; Dominion Foundries and Steel, Limited; and Crucible Steel of Canada Ltd.

PRICES

The following quotations are from *E & M J Metal and Mineral Markets* of December 26, 1966, in U.S. currency.

Pyrochlore, per lb Cb_2O_5 f.o.b. mine or mill

Canadian spot	\$1.18-\$1.25
long term	1.12-1.15
Brazilian, c.i.f. U.S. ports long term	1.00

Columbium ore

Columbite per lb pentoxide, Cb_2O_5 and Ta_2O_5, c.i.f. U.S. ports

ratio	*spot*	*long term*
10 to 1	\$1.05-\$1.15	\$1.03
8.5 to 1	\$1.20 (nominal)	

(1) US Bureau of Mines Commodity Data Summaries, January, 1967.

PRICES (Cont.)

Ferrocolumbium, per lb Cb, ton lots, f.o.b. shipping point		
low alloy grades	$3.02	
standard grade	$3.17-$3.24	
high purity grades	$3.82- 4.50	
Columbium metal		
99.5-99.8% per lb.		
	Powder, roundel	*Ingot*
Metallurgical	$11-$22	$16-$27
Reactor	12- 23	17.50-28
Tantalum metal		
f.o.b. shipping point, depending on size of lot		
powder	$30-$49	
sheet (depending on grade)	47- 60	
rod (depending on grade)	52- 65	

TARIFFS

	British Preferential (%)	Most Favoured Nation (%)	General (%)
Canada			
Columbium and tantalum ores and concentrates ...	free	free	free
Ferrocolumbium, ferrotantalum, ferrotantalum-columbium	free	5	5
Columbium metal or tantalum metal in pure form, in lumps, powder, blocks,ingots	free	15	25
Columbium metal or tantalum metal if in alloy form, in rods, sheet or any semi-process form........	15	20	25
United States (%)			
Columbium and tantalum ores and concentrates ...	free		
Columbium metal			
Unwrought, other than alloys; waste and scrap*	10		
Unwrought, alloys	15		
Wrought	18		
Tantalum			
Unwrought, waste and scrap*.................	10		
Wrought	18		
Unwrought alloys	15		
Ferrocolumbium and ferrotantalum...............	10		

* Duty on scrap suspended to June 30, 1967.

Petroleum

W.G. LUGG*

Most sectors of the Canadian petroleum industry had an excellent year in 1966 featured by continued oil exploration and development successes in the Rainbow Lake-Zama Lake region of northwestern Alberta and a record value of production that exceeded $900 million for all liquid hydrocarbons. Production of crude oil and natural gas liquids exceeded the million-barrel-a-day mark for the first time. Canadian crude oil producers supplied 58 per cent of the total crude oil requirements of Canadian refineries in 1966. Imports of crude oil and products rose to 596,000 barrels a day, an increase of 7 per cent from 1965. Exports to the United States in 1966 increased 13 per cent to 363,000 barrels a day with most of the increase being absorbed by midwestern United States.

The important discoveries made in 1965 at Rainbow Lake in northwestern Alberta led to increased exploration activity in the Zama Lake and Steen River areas, 50 miles to the north and northeast. A considerable amount of success was attained at Zama Lake where the geological setting is apparently similar to that of Rainbow Lake.

The remarkable wildcat success ratio attained in these areas is attributed mainly to the recent rapid advances in seismic technology. The successful application of new field and processing techniques relative to Rainbow Lake halted the downward trend in geophysical activity that began in 1958. The long-term outlook now for exploration geophysics appears to be excellent as most companies believe that large areas of the western Canada sedimentary basin will have to be re-evaluated in the light of the more sophisticated geophysical tools that are now available.

Oil reserves again increased, due mainly to the application of secondary recovery schemes to established fields and the discovery of new reserves at Rainbow Lake. The experimental projects, designed to economically extract synthetic oil from the large reserves of heavy crude oil in the Cold Lake-Lloydminster trend showed some progress but no significant technological breakthrough was reported. Total pipeline construction decreased for the second year in a row and although there was a small increase in refinery capacity no new refineries were built.

PRODUCTION

Gross production of liquid hydrocarbons in 1966 averaged 1,038,000 barrels a day, an increase of 11 per cent from 1965. Of the 1966 daily output, 901,000 barrels were crude oil, 80,000 barrels were condensate and pentanes plus and 57,000 barrels were butane and propane. Alberta accounted for 68 per cent of the 1966 total, Saskatchewan contributed 25 per cent, British Columbia 5 per cent and the remaining 2 per cent came from fields in Manitoba, Ontario, the Northwest Territories and New Brunswick in descending order of output.

*Mineral Resources Division.

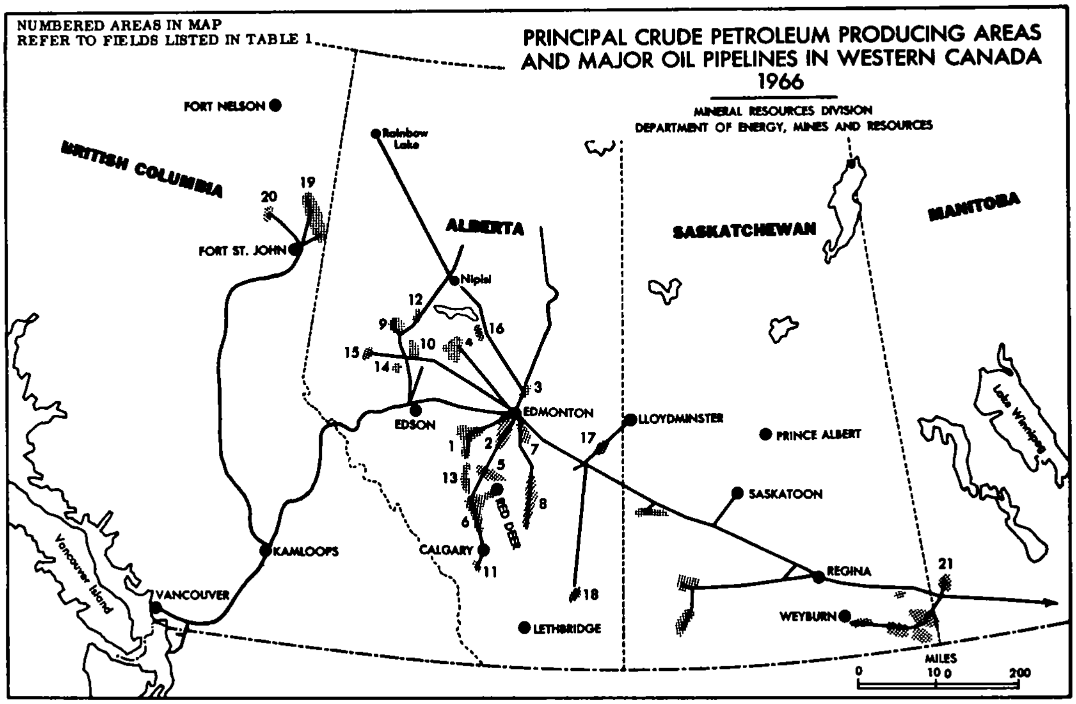


TABLE 1

Production of Crude Oil by Province and Field, 1965–66
(number in parentheses gives location of field on the accompanying map)

	1965		1966p	
	Barrels	Bbl/Day	Barrels	Bbl/Day
Alberta				
Pembina (1)	38,714,572	106,067	37,838,589	103,667
Swan Hills (4)	17,575,549	48,152	20,526,026	56,235
Redwater (3)	14,203,474	38,913	15,374,988	42,123
Golden Spike (2)	8,226,887	22,539	13,579,674	37,204
Judy Creek (4)	8,981,907	24,607	9,884,281	27,080
Swan Hills South (4)	7,392,135	20,252	8,860,426	24,275
Leduc-Woodbend (2)	9,365,185	25,658	8,104,503	22,204
Bonnie Glenn (2)	6,320,983	17,317	7,373,031	20,200
Fenn-Big Valley (8)	4,968,002	13,610	5,692,806	15,596
Virginia Hills (4)	4,070,981	11,153	4,501,737	12,333
Mitsue (16)	2,200,386	6,028	4,315,098	11,822
Wizard Lake (2)	3,332,817	9,131	4,169,738	11,424
Sturgeon Lake South (9)	3,065,919	8,399	3,455,280	9,466
Willesden Green	2,265,168	6,206	3,043,627	8,338
Snipe Lake	2,539,781	6,958	2,892,290	7,924
Kaybob (10)	2,972,566	8,144	2,807,395	7,691

TABLE 1 (cont.)

	1965		1966p	
	Barrels	Bbl/Day	Barrels	Bbl/Day
Alberta (cont.)				
Nipisi	320,894	879	2,759,159	7,559
Carson Creek North (4)	2,207,218	6,047	2,599,517	7,121
Rainbow	–	–	2,565,305	7,028
Joarcam (7)	2,737,142	7,499	2,493,600	6,831
Acheson (2)	2,061,706	5,648	2,327,818	6,377
Harmattan East (6)	2,122,158	5,814	1,890,532	5,179
Medicine River (13)	1,810,697	4,960	1,836,718	5,032
Wainwright (17)	1,253,503	3,434	1,810,154	4,959
Innisfail (6)	1,766,305	4,839	1,797,974	4,926
Joffre (5)	2,215,808	6,070	1,721,893	4,717
Westerose (2)	1,396,429	3,826	1,631,692	4,470
Bantry (18)	1,421,344	3,894	1,605,859	4,399
Harmattan-Elkton (6)	1,479,060	4,052	1,542,734	4,226
Stettler (8)	1,392,745	3,815	1,319,480	3,615
Gilby (5)	1,750,326	4,795	1,314,415	3,601
Simonette (15)	1,004,008	2,750	1,173,048	3,213
Sundre (6)	1,028,067	2,816	1,064,093	2,915
Garrington (13)	1,455,723	3,988	1,042,861	2,857
Turner Valley (11)	1,078,982	2,956	1,017,775	2,788
Other fields and pools	23,599,594	64,656	25,639,189	70,244
Total	188,298,021	515,885	211,573,305	579,652
Total value	$474,385,000		$545,225,966	
Saskatchewan [1]				
Total unit and non-unit areas	87,775,205	240,480	93,208,999	255,367
Total value	$200,478,568		$212,889,131	
British Columbia				
Boundary Lake (19)	5,335,522	14,618	5,710,838	15,646
Peejay (19)	2,770,105	7,589	3,796,316	10,401
Milligan Creek (19)	2,165,494	5,933	3,475,633	9,523
Other fields and pools	3,199,636	8,766	3,655,394	10,014
Total	13,470,757	36,906	16,638,181	45,584
Total value	$29,759,595		$36,665,786	
Manitoba				
North Virden-Scallion (21)	2,056,552	5,634	2,356,616	6,456
Virden-Roselea (21)	1,035,739	2,838	1,171,252	3,209
Other fields and pools	1,854,218	5,080	1,703,036	4,666
Total	4,946,509	13,552	5,230,904	14,331
Total value	$12,252,503		$12,957,358	
Ontario	1,279,321	3,505	1,323,721	3,626
Total value	$4,093,318		$4,236,503	

TABLE 1 (cont.)

	1965		1966p	
	Barrels	Bbl/Day	Barrels	Bbl/Day
Northwest Territories	644,998[2]	1,767	749,653[2]	2,054
Total value	$614,941		$714,408	
New Brunswick	4,103	11	6,836	18
Total value	$5,744		$9,592	
Total, Canada	296,418,914	812,106	328,731,599	900,634
Total value	$721,589,669		$812,698,744	

Sources: Dominion Bureau of Statistics and provincial government reports.

1. Saskatchewan lists production by formations rather than by fields.
2. Excludes stock reinjected into the reservoir.

p Preliminary.

TABLE 2
Production of Natural Gas Liquids by Province, 1965–66

	1965		1966p	
	Barrels	Bbl/Day	Barrels	Bbl/Day
Alberta				
Propane	9,336,792	25,580	11,557,891	31,665
Butane	6,141,445	16,826	7,387,586	20,240
Pentanes plus	26,085,824	71,468	27,360,178	74,959
Condensate	546,418	1,497	734,734	2,013
Other natural gas liquids	344,333	943	956,359	2,620
Total	42,454,812	116,314	47,996,748	131,497
Saskatchewan				
Propane	675,688	1,851	751,072	2,058
Butane	338,398	927	342,061	937
Pentanes plus	252,736	692	251,056	687
Total	1,266,822	3,470	1,344,189	3,682
British Columbia				
Propane	358,776	983	334,315	916
Butane	477,990	1,310	500,973	1,372
Pentanes plus	947,429	2,596	974,564	2,670
Condensate	31,782	87	39,571	108
Total	1,815,977	4,976	1,849,423	5,066
Canada				
Propane	10,371,256	28,414	12,643,278	34,639
Butane	6,957,833	19,063	8,230,620	22,550
Pentanes plus	27,285,989	74,756	28,585,798	78,317
Condensate	578,200	1,584	774,305	2,121
Other natural gas liquids	344,333	943	956,359	2,620
Total	45,537,611	124,760	51,190,360	140,247
Returned to formation	577,307	1,581	1,179,468	3,231
Total net production	44,960,304	123,179	50,010,892	137,016

Source: Provincial government reports.

p Preliminary.

The rise in production was greatest in Alberta, which accounted for over 25 per cent of the increase in output of crude oil and virtually all (98 per cent) of the increased output of natural gas liquids. The continued strong demand for natural gas, which must usually be processed, contributed to the increase in natural gas liquids output but demand for these was also a contributing factor. The total volume of natural gas liquids produced in Canada in 1966 was 47,921,000 barrels, valued at $99.2 million. Despite Alberta's large share of production, oil fields in total were operated at less than 50 per cent of their potential because of lack of markets.

Production from older fields in Alberta continued to decline, due in part to the increasing effects of the changed prorationing regulations which give higher production allowables to fields having larger recoverable reserves and higher producing potential. Initial production from the Rainbow Lake fields and increasing production from the Nipisi and Mitsue Gilwood sandstone pools is also adversely affecting the production allowables of the older fields such as Pembina and Leduc. This trend will become more pronounced in 1967 when 45,000 barrels a day of synthetic crude oil production from the Athabasca tar sands project is added to Alberta's rapidly expanding supply picture.

TABLE 3

Value of Natural Gas Liquids by Province, 1965–66
($ thousands)

	1965	1966[P]
Alberta	86,769	93,439
Saskatchewan	2,290	2,414
British Columbia	3,319	3,399
Total, Canada	92,378	99,252
Volume (thousand bbl.)	43,862	47,921

Source: Dominion Bureau of Statistics and provincial government reports.

[P]Preliminary.

RESERVES

At the end of 1966 Canada's recoverable reserves of liquid hydrocarbons amounted to 9.05 billion barrels, according to the estimates of the Canadian Petroleum Association. This represents a 24.3-year supply at the 1966 rate of production and a 17 per cent increase in reserves from the 1965 year-end total. The growth of reserves would have been greater if the Zama Lake oil occurrences had been fully taken into account. All of the well data at Zama Lake is still on the confidential list so none of the recently discovered oil from this area has thus far been counted in the provincial reserve total.

According to the year-end statistics of the Alberta Oil and Gas Conservation Board, the province's remaining recoverable reserves of crude oil have been estimated at 6.76 billion barrels and of natural gas liquids at 1.26 billion barrels. The largest new additions to recoverable reserves were recorded at Rainbow Lake, where the combined total of the three designated pools, Rainbow A, B and F, was set at 285 million barrels. The official recovery factors for these three fields varied from 45 per cent to 55 per cent. These reserves will no doubt be increased by several million barrels when all of the recent discoveries in this area reach their maximum development and when enhanced recovery schemes are fully implemented.

The oil reserves of the Athabasca bituminous sands are not included in provincial reserve estimates but it has been estimated that 15 to 45 billion barrels may be economically extracted by mining methods such as the one presently being used by Great Canadian Oil Sands Limited. There are other extractive processes presently under study which may eventually greatly increase this estimate.

The Alberta Board's estimate of 1.26 billion barrels of recoverable reserves of natural gas liquids consists of 49.1 per cent pentanes plus, 30.6 per cent propane and 20.3 per cent butane.

The Canadian Petroleum Association set Saskatchewan's recoverable reserves of liquid hydrocarbons at 706 million barrels at the end of 1966. The 36-million-barrel increase was due mainly to the increased use of secondary recovery mechanisms and also, in part, to extensions of existing fields. New discoveries contributed only 4 million barrels of additional reserves to the provincial total. Manitoba's recoverable reserves were raised by 17 million barrels to 58.3 million barrels in 1966. The increase was the result of revisions and extensions of existing reserves.

TABLE 4

Crude Oil Production, Trade and Refinery Receipts, 1956–66
(barrels)

	Production[1]	Imports[2]	Exports[2]	Refinery Receipts[3]		
				Domestic	Imported	Total
1956	171,981,413	106,469,685	42,908,086	125,592,074	106,305,532	231,897,606
1957	181,848,004	111,905,371	55,674,228	126,914,237	111,905,372	238,819,609
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	199,456,553	143,946,481	343,403,034
1965	296,418,914	144,184,281	108,010,297	208,838,613	144,000,656	352,839,269
1966p	328,731,599	146,076,898	123,691,342	220,183,324	158,546,823	378,730,147

Source: Dominion Bureau of Statistics.

1. Crude petroleum and natural gas production (Alberta field condensate is excluded from the statistics for 1960, 1961 and 1962). 2. Trade of Canada. 3. Refined petroleum products (refinery receipts include condensate and pentanes plus).

p Preliminary.

TABLE 5

Reserves of Crude Oil, 1965–66

Province or Region	At end of 1966 (thousand barrels)	Per Cent of Total		Net Change Since 1965 (thousand barrels)
		1965	1966	
Alberta	6,720,500	85.2	86.3	+1,000,817
Saskatchewan	696,785	9.9	8.9	+35,113
British Columbia	263,784	3.5	3.4	+31,962
Northwest Territories	47,125	0.7	0.6	–775
Manitoba	58,330	0.6	0.7	+17,259
Eastern Canada	5	0.1	0.1	–3,862
Total	7,791,757	100.0	100.0	+1,080,514

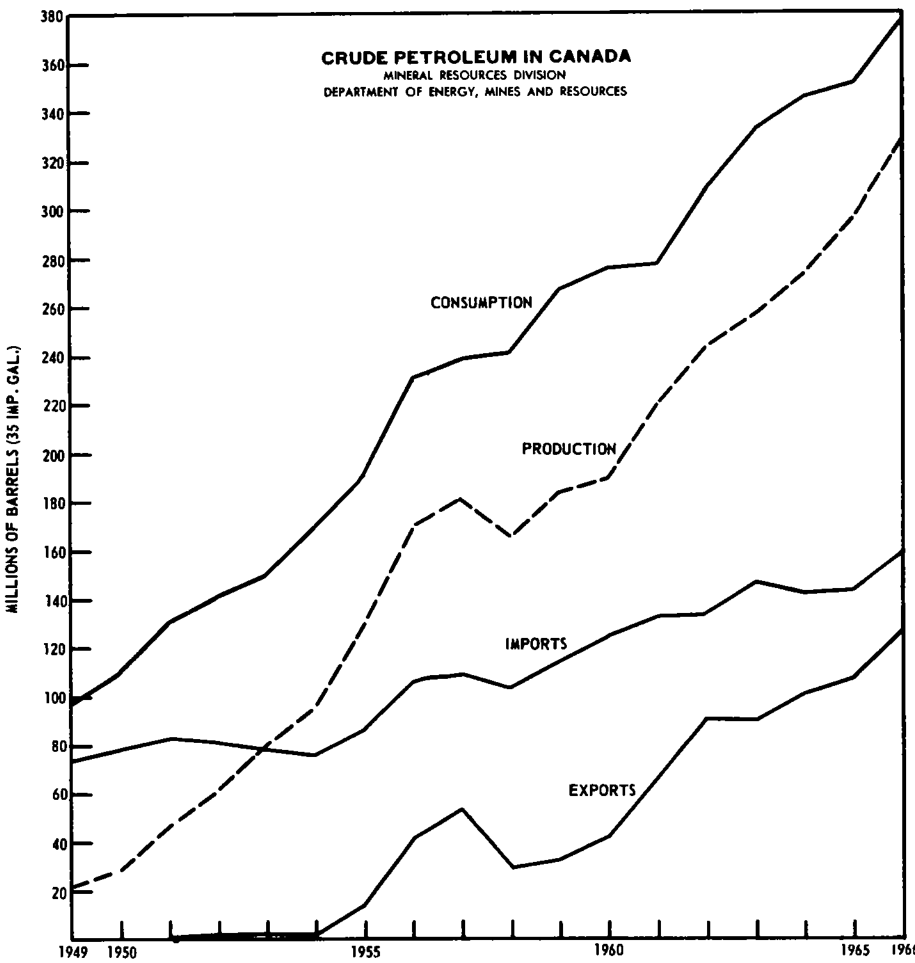
Source: Canadian Petroleum Association.

TABLE 6

Reserves of Liquid Hydrocarbons at End of 1966

	Natural Gas Liquids (thousand barrels)	Crude Oil Plus Natural Gas Liquids (thousand barrels)	Per Cent of Total
Alberta	1,208,609	7,929,109	87.6
Saskatchewan	9,233	706,018	7.8
British Columbia	41,025	304,809	3.4
Other areas	–	110,682	1.2
Total	1,258,867	9,050,618	100.0

Source: Canadian Petroleum Association.
– Nil.



EXPLORATION AND DEVELOPMENT

ALBERTA

There was a pronounced reduction in drilling in Alberta during 1966 due, in part, to the increasing use of wider spacing units for oilfield development, the result of which has been to reduce the number of wells required to develop a field. The new prorationing regulations, which are to become fully operative in 1969, have reduced the exploration company's incentive to develop marginally economic land and, as a result, exploration activity has been concentrated in less accessible areas where costs are higher but rewards are greater. Consequently, the smaller, less economically attractive prospects have been largely ignored and since this type of venture significantly contributed to exploratory and development drilling in previous years, aggregate drilling footage has declined.

The total number of wells drilled in Alberta in 1966 decreased to 1,667, a drop of 14.6 per cent from 1965. Total footage drilled was down 20 per cent, from 10.2 million feet to 8.2 million feet. Both development and exploratory drilling decreased in 1966, with development drilling dropping 30 per cent from last year's total of 5.7 million feet and exploratory drilling decreasing 9 per cent from 4.5 million feet. Fewer wells were drilled in both categories.

The Rainbow Lake area in northwestern Alberta continued to retain the interest of exploration companies. The oil accumulations are associated mainly with Middle Devonian Keg River pinnacle reefs which developed in a local salt basin behind the main Presqu'île barrier reef. The reefs grew during Muskeg time and are completely enclosed in off-reef Muskeg evaporites. They are of limited areal extent and are overlain by porous, locally productive Muskeg, Sulphur Point and Slave Point limestones and dolomites which are also Middle Devonian in age. The reservoir has thick pay sections, excellent rock permeabilities and porosities and high recovery factors. By the end of 1966, twelve separate Keg River oil pools had been discovered in the Rainbow district. Imperial Oil Enterprises Ltd., Pan American Petroleum Corporation and the team of Banff, Aquitaine and Mobil have been the principal operators in the district.

The geological conditions encountered at Rainbow Lake are apparently duplicated at Zama Lake, 45 miles to the northeast. Several Middle Devonian discoveries have been reported in the area, the first being Hudson Bay – B.A. Zama North (16-19-116-4W6). Four miles to the north, Hamilton Brothers–Canadian Gas Company Ltd. discovered Middle Devonian oil in the well, Hamilton et al. Zama Lake North (13-7-117-4W6). Both of these wells are reported to have obtained commercial production from the Keg River formation. Recently, several other discoveries have been announced in the same general area but their significance will not be apparent until they are released from the confidential list of wells.

Two wet gas finds were made by Placid Oil Company at Bistcho Lake, 80 miles northeast of Rainbow Lake. The well, Placid et al. Bistcho (10-20-123-2W6), tested gas and condensate from the Slave Point and Muskeg formations of Middle Devonian age; gas with some oil was reportedly found in the Muskeg formation at Placid East Bistcho (12-25-122-3W6). Hudson's Bay Oil and Gas Company Limited drilled a successful test at Beatty Lake, northeast of Bistcho Lake where commercial Middle Devonian oil production was reported to have been found.

TABLE 7

Wells Drilled

	Oil		Gas		Dry		Service[1]		Total	
	1965	1966	1965	1966	1965	1966	1965	1966	1965	1966
Alberta	877	641	220	257	856	735*	3	34	1,956	1,667
Saskatchewan	697	540	57	34	519	594	11	34	1,284	1,202
British Columbia	113	45	41	51	93	116	2	2	249	214
Manitoba	26	26	–	–	38	35	–	2	64	63
Yukon & Northwest Territories	1	–	2	–	15	28	–	–	18	28
Total, Western Canada	1,714	1,252	320	342	1,521	1,508	16	72	3,571	3,174
Ontario	23	12	68	44	97	62	16	28	204	146
Quebec	–	–	–	–	2	8	–	3	2	11
Atlantic Provinces	1	–	–	–	2	2	–	3	3	5
Total, Eastern Canada	24	12	68	44	101	72	16	34	209	162
Total, Canada	1,738	1,264	388	386	1,622	1,580	32	106	3,780	3,336

Source: Canadian Petroleum Association.
– Nil; *Alberta total includes 8 suspended wells in 1966. [1]. Excludes potash and helium wells.

TABLE 8

Oil Wells in Western Canada at End of Year, 1965–66

	Producing Wells		Wells Capable of Production	
	1965	1966	1965	1966
Alberta	8,736	8,886	12,771	13,162
Saskatchewan	5,384	5,681	6,192	6,480
Manitoba	748	737	889	905
British Columbia	412	440	497	529
Northwest Territories	31	31	60	60
Total	15,311	15,775	20,409	21,136

Source: Provincial government reports and Department of Indian Affairs and Northern Development.

Exploration activity has shifted to the Steen River area, thirty miles to the east of Zama Lake. It was encouraged partly by favourable stratigraphy and by the presence of non-commercial hydrocarbon shows in previously drilled wells. Middle Devonian formations are again the exploration target but preliminary drilling has had no apparent success.

The Loon Lake producing area in north-central Alberta, just south of the Red Earth field, has been officially designated a dual-zone field. The producing horizons are the Granite Wash sandstone and the Slave Point formation. The field continued to be developed at a slow pace, due largely to the unpredictable nature of the subsurface geology. The Nipisi oil field in central Alberta was one of the most active development areas in Alberta in 1966. The productive area expanded by 24,320 acres, mainly to the northwest where several wells were completed in the Gilwood "B" pool. At the Utikuma Lake field, immediately north of the Nipisi field, the development tempo lagged to some degree, as the field limits appear to be largely defined. The Deer Mountain-House Mountain fields, incorporated into the Swan Hills field in 1965, were given separate field status again in 1966 at the request of Texaco Canada Limited and Home Oil Company Limited. Reservoir and geological data submitted by these two companies indicated no effective communication between the north section and the rest of the Swan Hills producing area.

In west-central Alberta, the Crimson Lake Cardium field, discovered in 1965, continued to expand with several successful development wells being drilled. The limits of the Ferrier pool may be extended three miles to the south by the rumored Cardium discovery, Southeastern Ferrier (12-15-38-7W5). Triad Oil Co. Ltd. reported a commercial oil discovery in the Devonian Beaverhill Lake formation at its well, Triad Ante Creek (2-23-66-25W5), and one successful followup well was drilled.

In southern Alberta, several Lower Cretaceous oil fields were discovered. Although most of them are still on the confidential list, preliminary information suggests that their reserve potential is not large. On the Bashaw Leduc reef complex in south-central Alberta, the Clive field which produces oil from both the Leduc and Nisku formations, was extended 4 miles to the south. Following the successful completion of two Kerr-McGee Oil Industries, Inc. stepouts, more than 18 successful follow-up wells were drilled, most of which are dual producers.

The numerous experimental heavy oil recovery schemes continued to show progress with several oil companies being active in this sphere. The object of these schemes is to develop a commercial method of extracting heavy gravity crude oil from the large potential reserves trapped in Lower Cretaceous sandstones of the Lloydminster-Cold Lake trend. Some of the experimental projects are apparently close to being commercially feasible, although casing damage and excess sand production still pose major production problems.

The $240-million Athabasca bituminous sands project of Great Canadian Oil Sands Limited is nearing completion. The plant is scheduled to begin commercial production late in 1967 with the maximum allowable rate set at 45,000 b/d. The first of two giant bucket wheel excavators arrived at the site and was expected to be in production before March 1967. The two excavators will handle 100,000 tons a day of sands when fully operative. The Japanese have shown considerable interest in obtaining synthetic crude oil from the Athabasca project. Under the existing regulations, 'tar' sand production for export, would not be included in the existing allowable of 45,000 barrels a day because it would not be competing with prorated conventional Alberta crude oil.

Pressure maintenance and water flood projects continued to play a major role in enlarging Canada's recoverable reserves of crude oil. Enhanced recovery projects, primarily waterflood, are estimated to account for 3 billion barrels of the total recoverable reserves of 7.8 billion barrels. Two major waterflood projects were completed in Alberta in 1966. One of these was the waterflood complex at the House Mountain field, which required 31 miles of pipe to transport water from Lesser Slave Lake to the field. The other was the 57-mile extension to the existing waterflood system in the Swan Hills oil field.

Sun Oil Company Limited, Whitehall Canadian Oils Ltd. and Fargo Oils Ltd. have added three new waterflood schemes to the already imposing list of secondary recovery schemes at Pembina. The use of waterflood for secondary recovery in the heavy oil belt of eastern Alberta and western Saskatchewan is rapidly expanding, stimulated by Husky Oil Canada Ltd.'s success with this method at Lloydminster. By the end of 1966, Alberta had a total of 1,573 water injection wells and 128 gas and LPG injection wells.

A fundamental research group called the Petroleum Recovery Research Institute has been set up in Calgary to carry on research aimed at increasing recovery of conventional crude oil. It was sponsored by the Alberta Government and private companies and is designed to conduct a more basic research program that will not overlap with the programs already being carried out by industry.

SASKATCHEWAN

The upward trend in drilling of the past three years was reversed in 1966 as total footage drilled declined 6.2 per cent to 4,273,006 feet, due mainly to a reduction in development drilling.

Interest in the deeper horizons in the province was revived by the discovery of commercial Devonian oil production 90 miles south of Regina in September 1966. Miami-H.B. Hummingbird (10-26-2-19W2), which is 11 miles west of the closest production in the Lake Alma Mississippian pool, discovered commercial light gravity oil in the Upper Devonian Birdbear (Nisku) formation in addition to two productive zones in the Mississippian Ratcliffe beds. The well was deepened to the Ordovician but failed to find production there. The Red River formation produces Ordovician oil 15 miles to the southeast at CDR Scurry S. Lake Alma (1-14-1-17W2). Limited non-commercial Ordovician production was also obtained 2½ miles southeast of the discovery well at Imperial Hummingbird (6-13-2-19W2). Detailed well information has not been released but development is continuing in Section 26 with dual wells being drilled on some locations to produce the Mississippian and Devonian 'pay' zones.

The continuing exploratory success in the Rainbow Lake and Zama Lake areas of northeastern Alberta has stimulated interest in the Middle Devonian Winnipegosis formation, the Saskatchewan equivalent of the prolific Keg River reefs. The accessibility of drilling locations and relatively shallow drilling depths on the prospective trend in central and western areas of the province, combined with favourable market conditions for oil production, make this exploratory target attractive in Saskatchewan. A large number of companies acquired acreage on the subsurface trend of this formation during 1965 and 1966 and the major portion of the available acreage is now under permit. Limited exploratory drilling was carried out in the general Meadow Lake – Prince Albert area during the year but more subsurface information is required to guide future exploratory drilling. However, operators have been encouraged by hydrocarbon shows, porosity development, and the geologic setting outlined to date although no commercial production has been obtained. The renewed interest in the deeper formations generated by the Hummingbird discovery and the potential of the Winnipegosis reefs is given further impetus by provincial regulations which allow a royalty free period for Devonian or lower production until 1970, in addition to other incentives. It seems probable, therefore, that evaluation of deeper formations should increase significantly in the near future.

In the southeast, along the established trend of Mississippian production, several exploratory tests were completed as potential Mississippian oil wells. However, based on the limited data available and the followup development drilling to date, it appears that no major new pools were discovered.

In southwestern Saskatchewan, a new Jurassic Upper Shaunavon oil discovery was made at SMUS Covington (2-34-12-18W3), which is 6 miles southeast of the Gull Lake Pool. The new pool has been partially outlined by 7 oil wells and 3 dry holes. The significance of a number of other exploratory test wells in this general area, has not been determined as yet.

Development drilling was most active in the Midale, Innes, Willmar, Queensdale, Flat Lake and Oungre pools in southeastern Saskatchewan. In the southwest, the Gull Lake, South Gull Lake, Delta and North Premier pools were being actively developed. In the Coleville region the main development was in the North Hoosier field. Extensive development drilling was carried out in the Lloydminster heavy oil region, particularly in the Waseca and Aberfeldy areas.

Waterflood projects increased to 58 by the end of 1966, reflecting the increased use of pressure maintenance and unitization early in the productive life of fields in order to increase ultimate oil recovery.

BRITISH COLUMBIA

Total footage drilled decreased by 4.1 per cent to 1,032,575 feet as substantial increases in exploratory drilling were offset by sharply reduced development drilling.

A large part of the exploratory drilling was carried out in the general area of Triassic and Cretaceous oil and gas production north and northwest of Fort St. John, particularly in the Peejay-Weasel area, and southeast of the Blueberry pool where the new Inga oil field is being developed. The initial well in the Inga area, Tenneco-Canadian Superior et al. Inga (13-7-88-23W6), discovered multiple gas zones in the Lower Cretaceous and Upper Triassic formations. Subsequent exploratory drilling to the north and southeast established commercial oil production in a thin Upper Triassic sandstone. Development drilling in this area outlined a northwest southeast productive trend approximately 9 miles long and 5 miles wide; development is continuing.

As in Saskatchewan, the highly successful development of the Devonian carbonates of the Rainbow Lake and Zama Lake regions of northwestern Alberta stimulated seismic activity and influenced land prices in adjacent areas of British Columbia. However, evaluation of the Middle Devonian units by drilling was conducted on a limited scale and no commercial oil discoveries were reported. Limited deep exploratory drilling was carried out in the northeastern corner of the province in the search for the gas-bearing Devonian reefs, which are productive at Clarke Lake, Kotcho and Yoyo.

The number of oil wells in the province capable of production increased from 497 to 529 with the largest increase being in the Peejay field. Waterflood projects increased to six, with the start of water injection into the Wildmint field in June. Volumes of water injected increased substantially at the Boundary Lake and Peejay projects.

On the West Coast, Shell Canada Limited carried out further marine seismic surveys. In the dockyards at Victoria, construction was well advanced on one of the world's largest semi-submersible drilling platforms, which is scheduled to start drilling offshore in mid-1967 under contract to Shell. Total offshore acreage under federal government permits was 18 million acres.

EASTERN CANADA

In Ontario, both exploratory and development drilling declined to the lowest level in recent years as total footage drilled decreased to 250,379 feet, down 28.6 per cent from 1965. A total of 146 wells were drilled of which 12 were completed as oil wells, including two

Silurian and two Cambrian discoveries. One of the Cambrian discoveries, Pere Marquette et al. Middlesex Ekfrid (3-8-RVS), extended the Willey oil field approximately 1½ miles to the northwest. Of the eight development wells completed, one was Devonian, four were Silurian and three were Cambrian. All development wells completed offshore in Lake Erie were gas wells.

The first exploratory drilling in the Hudson Bay area began in 1966, following several years of preliminary geological and seismic studies. Sogepet Kaskattama Province No. 1, on the west shore of Hudson Bay approximately 50 miles west of the Manitoba–Ontario boundary, was drilled to 2,880 feet before being suspended for the winter. The operators reported residual oil stains and encouraging core analyses; it is planned to deepen the well to the basal Ordovician sandstones in the summer of 1967. Offshore acreage in Hudson Bay, under federal permits, amounted to 53.5 million acres, down from 55.8 million acres in 1965.

In the Grand Banks area south of Newfoundland, two offshore exploratory tests were drilled by Pan American Petroleum Corporation and Imperial Oil Limited. The first test, Pan Am IOE Tors Cove, 225 miles south of St. John's, Newfoundland, was abandoned at a total depth of 4,834 feet. A second well 150 miles south of St. John's, Pan Am IOE Grand Falls A–1, was suspended at a depth of 5,250 feet after bad weather and rough seas late in the year made further drilling impractical. Although no information has been released, results were apparently sufficiently encouraging to warrant continuing exploration in this costly venture. Total acreage off the east coast under federal permits increased to 124.6 million acres, from 114 million acres the previous year. Tenneco Oil Company filed on 16 million acres off the coast of Labrador, an area which had previously been ignored by other companies.

The question of jurisdiction over offshore rights is scheduled for consideration by the Supreme Court of Canada in 1967. Most companies maintained both federal and provincial permits on disputed acreage. A further complication was introduced when the French government granted permits to a French company in an area south of Newfoundland which is now covered by federal and provincial permits. The French claim is based on offshore rights associated with the French islands of St. Pierre and Miquelon, immediately south of the Newfoundland coast.

In Quebec, seven exploratory wells were drilled in the St. Lawrence Lowland and one in Gaspe with total footage drilled being 12,681 feet. Small oil shows were reported from some of the wells in the St. Lawrence Lowland.

At Parson's Pond on the west coast of Newfoundland, a well begun in 1965 by the Jubilee-Nalco group was completed at a depth of 4,300 feet. Numerous minor oil shows were reported, which is characteristic of wells drilled in this area, but there was nothing of commercial significance.

MANITOBA

With the exception of production, all phases of Manitoba's oil industry declined in 1966. Aggregate drilling amounted to 143,870 feet, down 12 per cent from 1965. Most of the decrease was due to the slowdown in exploratory drilling, which at 55,663 feet, declined 32 per cent from 1965. Development drilling totalled 80,037 feet and was confined mainly to the Routledge and North Virden fields. Exploratory drilling was limited to 19 wells in 1966 and all were abandoned. None of the wells tested the Winnipegosis formation, the stratigraphic equivalent of the Keg River reefs of northwestern Alberta. Production increased 5.7 per cent from 13,552 barrels a day in 1965 to 14,331 barrels a day. The production gain was due mainly to secondary recovery procedures.

YUKON AND NORTHWEST TERRITORIES

Exploration in the Northwest and Yukon Territories continued at the same pace in 1966 as in 1965. Twenty-eight exploratory wells were drilled for a total footage of 121,620 feet compared with 119,581 feet and eighteen wells drilled in 1965. Most of the drilling was near the southern edge of the Northwest Territories, probably attracted by the nearby oil and gas discoveries made at Bistcho and Zama Lakes. Exploration in the Yukon and Northwest

Territories has always been hampered by poor accessibility and complex geology. However, as more geological and geophysical information becomes available, Middle Devonian equivalents of the Alberta Keg River reefs may become a major exploration target.

Land acquisition and seismic activity continued at a fairly brisk pace and a number of exploratory tests have been scheduled for 1967 by major oil companies.

TRANSPORTATION

A total of 1,049 miles of oil pipeline was added to systems compared with 340 miles in 1965, bringing the operational pipeline total in Canada to 13,133 miles. In Alberta, the initial stage of the Rainbow Pipe Line Company Ltd.'s line, consisting of 240 miles of 20-inch pipe, from the south end of the Rainbow field to the Nipisi field was completed in March. As a temporary measure, it was connected to the existing 8-inch Mitsue pipeline and Rainbow Lake crude oil began flowing through it in April at about 15,000 barrels a day. To augment this supply, an agreement was made with Peace River Oil Pipe Line Co. Ltd. whereby Peace River contracted to move an additional 5,000 barrels a day of Rainbow crude through its pipeline to Edmonton from the Nipisi terminal. Rainbow Lake production at year-end was below the maximum field allowable due to lack of transportation. This situation will be corrected when the permanent southern extension of the Rainbow pipeline, from Nipisi to Edmonton, is completed. Ninety miles of this 24-inch line was finished in 1966 and the remaining 94 miles are scheduled for completion

TABLE 9

Mileage of Pipelines for Crude Oil, Natural Gas Liquids and Products, 1955–66

Year-end	Miles	Year-end	Miles
1955	5,079	1961	9,554
1956	6,051	1962	10,037
1957	6,873	1963	10,607
1958	7,148	1964	11,744
1959	7,945	1965	12,084
1960	8,435	1966[p]	13,133

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

TABLE 10

Deliveries of Crude Oil and Propane, by Company and Destination, 1965–66

(millions of barrels)

Company and Destination	1965	1966
Interprovincial Pipe Line		
Western Canada	38.7	39.0
United States	52.5	65.0
Ontario	112.5	116.8
Total	203.7	220.8
Trans Mountain Oil Pipe Line		
British Columbia	25.7	30.0
State of Washington	54.0	61.2
Westridge Terminal	—	0.3
Total	79.7	91.5

Source: Company annual reports.

TABLE 11

Crude Oil Refining Capacity, by Regions, 1965–66

	1965		1966	
	Bbl/Day	%	Bbl/Day	%
Atlantic Provinces	125,500	11.6	125,500	11.0
Quebec	328,700	30.3	373,700	32.8
Ontario	322,400	29.8	324,400	28.5
Prairies and Northwest Territories	206,150	19.0	214,750	18.9
British Columbia	100,400	9.3	100,400	8.8
Total	1,083,150	100.0	1,138,750	100.0

Source: Department of Energy, Mines and Resources, Petroleum Refineries in Canada (Operators List 5), January 1967.

TABLE 12

Crude Oil Received at Canadian Refineries, 1965 and 1966 by Source of Supply

(barrels)

Location of Refineries	Year	Canada	Middle East	Trinidad	Venezuela	Africa	Total Received
Atlantic Provinces	1965	4,345	15,091,676	–	22,678,228	–	37,774,249
	1966P	6,305	15,548,098	–	17,842,927	2,856,528	36,253,858
Quebec	1965	–	37,533,588	4,358,183	62,836,934	849,156	105,577,861
	1966P	–	40,747,797	4,776,633	60,670,469	15,574,861	121,769,760
Ontario	1965	109,356,595	–	–	652,891	–	110,009,486
	1966P	113,644,877	–	–	529,510	–	114,174,387
Prairies	1965	69,105,636	–	–	–	–	69,105,636
	1966P	71,347,729	–	–	–	–	71,347,729
British Columbia	1965	29,449,211	–				29,449,211
	1966P	34,473,696	–				34,473,696
Northwest and Yukon	1965	665,556	–				665,556
Territories	1966P	710,717	–	–	–	–	710,717
Total	1965	208,581,343	52,625,264	4,358,183	86,168,053	849,156	352,581,999
	1966P	220,183,324	56,295,895	4,776,633	79,042,906	18,431,389	378,730,147

Source: Dominion Bureau of Statistics.

P Preliminary; – Nil.

in the spring of 1967. At that time, throughput will be raised to 50,000 barrels a day with an additional increase of 50,000 barrels daily planned for 1969. The ultimate capacity of this line, with full pump facilities, is rated at 250,000 barrels a day.

The remaining 140 miles of the Great Canadian Oil Sands Limited's 226-mile, 16-inch synthetic crude oil pipeline from its plant north of Fort McMurray to Edmonton, was completed in mid-1966; it was started in the fall of 1965. This line is scheduled to be used to carry fuels to the plant site for 'start-up' operations prior to becoming operational in late 1967. Hudson's Bay Oil and Gas Company Limited completed a 195-mile, 12-inch, condensate pipeline from Sundre to Pincher Creek to link up with its condensate line to the United States. Small diameter pipeline construction had another good year as numerous gathering lines were laid. Included in this group was the construction of 60 miles of small diameter crude oil gathering line by Producers Pipelines Ltd. in southeast Saskatchewan. Banff Oil Ltd. laid a total of 37 miles of 8-inch and 4-inch gathering line in the Rainbow Lake oilfield. Hudson's Bay Oil and Gas Company Limited added 45 miles of 3-inch and 4-inch extension to the crude oil gathering system in the Gilby, Medicine River, Leafland and Sylvan Lake field areas.

Interprovincial Pipe Line Company began the initial stage of its major pipeline expansion program, planned for 1967, by installing the first of several new pumping units. Interprovincial has contracted for the addition in 1967 of 312 miles of 34-inch diameter loop to its main pipeline in Alberta, Saskatchewan and Manitoba. It will also add 57 miles of 20-inch parallel pipe to its existing facilities in Ontario.

There were no significant changes in pipeline rates in 1966. Transportation charges on the Interprovincial Pipe Line Company and Trans Mountain Oil Pipe Line Company pipelines were unchanged. The Edmonton to Port Credit tariff continued at 51 cents a barrel and the tariff from Edmonton to Burnaby, British Columbia remained at 40 cents a barrel.

PETROLEUM REFINING

Crude oil refining capacity of the 40 operating refineries in Canada reached 1,138,750 barrels a day in 1966, a 5 per cent increase from that of 1965. No new refineries were built in 1966 but the refining capacities of several existing plants were raised. The largest additions to plant refining capacity occurred in Quebec where The British American Oil Company Limited raised the capacity of its Montreal East Refinery by 22,500 barrels a day to 67,500 barrels a day and Canadian Petrofina Limited expanded its plant from 30,000 to 52,500 barrels a day. Imperial Oil Enterprises Ltd. increased the capacity of its Regina plant from 22,500 to 27,400 barrels a day. Minor increases were made by several other refineries.

Imperial Oil Enterprises Ltd. remained the largest refiner in Canada. The company's nine refineries comprise 33 per cent of Canadian refinery capacity. The British American Oil Company Limited replaced Shell Canada Limited as Canada's second largest refiner as recent modifications to its Montreal plant increased British American's capacity to 17 per cent of the Canadian total. Shell Canada Limited's six plants now constitute 15 per cent of the total.

Several new refineries are scheduled for construction in the next few years. The most important of these is the 60,000-barrel-a-day refinery that British American has plans to build in the Hawkesbury area, Cape Breton Island. Union Oil Company of Canada Limited has begun construction of a 7,500-barrel-a-day refinery in Prince George, British Columbia. It is anticipated this plant will go on stream in 1967 and was designed to meet the growing demand for refined petroleum products in northern British Columbia. Northeastern British Columbia crude oil will provide the feedstock for the Prince George refinery. Supreme Oil and Gas Ltd. recently purchased a modern 10,000-barrel-a-day refinery in the United States and will re-assemble it in Edmonton. This plant is designed to process both synthetic oils and natural crudes; initial production is scheduled for late 1967.

MARKETING AND TRADE

Receipts of crude oil and equivalent at Canadian refineries averaged 1,037,000 barrels a day, 7.4 per cent more than in 1965. Imported crude oil benefited by this increase to a greater extent than did domestic although both sources of supply made better than average gains. Canadian petroleum constituted 58.1 per cent of domestic refinery consumption in 1966, down 1 per cent from the previous year. Canadian producers supplied 603,000 barrels daily to Canadian refineries in 1966, an increase of 5.3 per cent from 1965. Over eighty per cent of the increase in refinery demand for domestic crude occurred in Ontario and British Columbia. Increases in demand from the Prairie Provinces were negligible.

TABLE 13

Regional Consumption of Petroleum Products, by Province, 1966

(thousand barrels)

	Motor Gasoline	Kerosene, Stove Oil, Tractor Fuel	Diesel Fuel Oil	Light Fuel Oils No. 2 and 3	Heavy Fuel Oils No. 4, 5 and 6
Newfoundland	1,792	1,184	2,064	1,579	2,789
Maritimes	8,490	2,743	3,217	6,963	10,022
Quebec	32,128	6,289	7,542	27,080	35,602
Ontario	48,835	3,776	7,678	31,346	30,053
Manitoba	6,870	1,048	2,938	2,169	980
Saskatchewan	9,548	1,466	3,720	1,703	642
Alberta	13,763	457	4,734	1,217	779
British Columbia	13,451	1,685	6,434	5,004	8,726
Northwest and Yukon Territories	159	113	415	237	118
Total	135,036	18,761	38,742	77,298	89,711

Source: Dominion Bureau of Statistics.

96411—23½

TABLE 14

Imports of Refined Petroleum Products, 1965–66

(millions of barrels)

	1965	1966P
Heavy fuel oil	30.88	32.49
Light fuel oil	9.63	7.69
Stove oil	2.70	2.13
Motor gasoline	1.96	2.57
Aviation gasoline	0.16	0.15
Diesel fuel	6.49	5.96
Lubricating oil	1.73	1.96
Petroleum coke	1.73	2.10

Source: Dominion Bureau of Statistics.

P Preliminary.

The daily average demand for imported crude oil at Canadian refineries in 1966 was 434,000 barrels, up 10 per cent from 1965. Middle East and African countries continued to expand their export market in Canada, mainly at the expense of Venezuela. Middle East nations increased their exports to 155,000 barrels a day in 1966. Although Venezuela was still the largest exporter of crude oil to Canada, the volume of its exports declined from 236,000 barrels a day in 1965 to 217,000 barrels a day. The Middle Eastern sources were Iran, Saudi Arabia, Iraq, Kuwait and the Trucial States. Nigeria significantly expanded its share of the Canadian market, increasing its exports from about 3,000 barrels daily in 1965 to about 36,000 barrels daily. Libya provided in the order of 14,000 barrels a day. All refinery feedstocks in Quebec and the Atlantic Provinces continued to be imported crude, except for a minor amount from New Brunswick delivered by rail to Halifax. Quebec refineries accounted for the entire increase in imported crude oil.

Imports of petroleum products averaged 162,000 barrels a day in 1966, no change from 1965. Fuel oil and diesel fuel from Venezuela and the Netherlands-Antilles, and heavy fuel oil from the United States comprised most of the product imports. Total value of oil imports, both finished and crude, was approximately $500 million.

Exports of crude oil and equivalent reached 339,000 barrels a day, an increase of 14.5 per cent from 1965. Although this is an impressive gain, imports continued to exceed exports by almost 100,000 barrels a day. All exported crude oil went to the United States. Shipments of Canadian crude to the United States west coast region via Trans Mountain pipeline, rose 13.3 per cent to 168,000 barrels daily in 1966. Most of the remainder of Canada's

TABLE 15

Supply and Demand of Oils, 1965–66

(thousand barrels)

	1965r	1966P
SUPPLY		
Production		
Crude oil	296,419	328,732
Natural gas liquids	45,193	50,011
Gross production	341,612	378,743
Returned to field	4,922	9,192
Net production	336,690	369,551
Imports		
Crude oil	144,184	158,547
Products	59,062	59,069
Total imports	203,246	217,616
Change in stocks		
Crude and natural gas liquids	-1,153	-1,968
Refined oil products	-2,570	-8,170
Total change	-3,723	-10,138
Oils not accounted for ...	+3	-2,747
Total supply	536,216	574,282
DEMANDS		
Exports		
Crude oil	108,010	123,691
Products	8,724	8,831
Total	116,734	132,522
Domestic sales		
Motor gasoline	128,542	136,148
Middle distillates	142,197	146,939
Heavy fuel oil	78,175	84,112
Other products	41,971	44,387
Total	390,885	411,586
Uses and losses		
Refinery	27,214	28,388
Field, plant and pipeline	1,383	1,786
Total	28,597	30,174
Total demand	536,216	574,282

Source: Dominion Bureau of Statistics and provincial government reports.

r Revised; P Preliminary.

crude oil exports were delivered to the United States mid-continent by Interprovincial Pipe Line Company. Exports to this region increased 24 per cent in 1966 to 178,000 barrels a day. The large increase was made possible by a marked shortage of crude oil in the Great Lakes region of United States that developed in the second half of the year. This crude deficiency will probably persist in 1967-68 until additional pipeline facilities are provided.

Exports of products averaged 18,000 barrels a day in 1966 with most of them going to the United States. The main commodities exported were butane, propane, heavy fuel oil and gasoline. Exports to Japan of tanker-borne refrigerated, liquid propane commenced in 1966 from Westridge terminal, near Vancouver. This was the first of several shipments totalling 28.5 million barrels which The British American Oil Company has contracted to supply Japan with over a 10-year period.

The rapidly increasing crude oil reserves in Alberta have prompted the Canadian oil industry to seek new market outlets for their excess productive capacity. The majority of the Canadian producers believe that the logical place for market expansion is in the Chicago area of the United States. Early in 1967, Interprovincial Pipe Line Company, with industry support, proposed the construction of a 700-mile, 34-inch loop via Chicago from Superior, Wisconsin to Sarnia. This pipeline would alleviate the tight crude-supply situation that has existed in the Chicago area and at the same time meet Canada's increased requirements. Canadian crude oil, landed in Chicago would be competitive with domestic sources of supply.

The 'Capline' pipeline project, which is designed to serve the same area, was formally finalized in the United States at about the same time. This pipeline will transport South Louisiana crude oil to the United States Midwest, short of Chicago. Construction of the line will begin in 1967 and will be jointly owned and operated by nine major producing companies. Initial throughput of this line will be 417,000 barrels a day.

There is no tariff on crude oil entering Canada. A United States import tax of 5¼ cents a barrel is levied on Canadian crude testing under 25° A.P.I. gravity and 10½ cents a barrel on oil testing at or above that gravity.

Phosphate

C.M. BARTLEY*

Phosphate raw materials are not produced in Canada, but substantial amounts are imported and processed into fertilizers and industrial products for domestic use and export. In the past 10 years imports of phosphate rock have tripled and consumption has doubled. Exports of phosphatic fertilizers have increased and in 1966 reached a value of nearly $23 million.

In 1966, phosphate rock imports reached a new high of 2.18 million tons, some 400,000 tons more than 1965. In addition to raw phosphate materials, considerable amounts of calcium phosphates, normal and triple superphosphate fertilizers and phosphate chemicals are imported. Most of these phosphate materials are obtained from the United States but smaller amounts of phosphate rock are imported from African countries and naturally low-fluorine phosphate rock, for feed supplements, is brought from the Netherland Antilles. Other phosphate imports originate in European countries and Japan.

The rapid expansion of phosphate trade and processing in Canada conforms to world-wide trends in fertilizer expansion and is favourably influenced by several factors. These are: low-cost back-haul movement of Florida phosphate rock to Vancouver, the availability of elemental sulphur, byproduct sulphuric acid from smelter gas and pyrites, and natural gas in western Canada. In eastern Canada low-cost sulphuric acid, obtained from byproduct smelter gas and pyrites at several locations, makes phosphate fertilizer production attractive, particularly under the present conditions of rising demand.

The rising cost and depleted supply of elemental sulphur have become one of the main obstacles in efforts to expand phosphate fertilizer production in many parts of the world. The availability of sulphur, in the elemental form or as a byproduct of base metal operations, has thus become an important consideration. In addition, these sulphur supplies are both adequate and reliable and, in the case of smelter fumes, there is also increasing public and governmental pressure to recover the sulphur gases to reduce air pollution. For these reasons byproduct sources of sulphuric acid will become increasingly important in Canada.

*Mineral Processing Division, Mines Branch.

TABLE 1

Phosphate — Trade and Consumption

	1965		1966P	
	Short Tons	$	Short Tons	$
Imports				
Phosphate rock				
United States	1,689,133	13,733,955	2,077,845	17,853,000
Morocco	—	—	82,432	1,172,000
French Africa, n.e.s.	—	—	11,343	142,000
Netherlands Antilles	6,163	257,435	9,721	434,000
Total	1,695,296	13,991,390	2,181,341	19,601,000
Calcium phosphates				
United States	16,718	1,582,300	17,784	1,755,000
Japan	1,410	92,563	2,287	157,000
Belgium and Luxembourg	1,470	84,453	1,542	98,000
Total	19,598	1,759,316	21,613	2,010,000
Phosphate fertilizers —				
Normal superphosphates				
United States	90,275	1,775,990	70,687	1,452,000
Triple superphosphate				
United States	52,919	2,878,935	45,438	3,099,000
Phosphate chemicals —				
Potassium phosphates				
United States	1,919	603,649	1,800	527,000
Sodium phosphate, tribasic				
United States	708	119,232	944	161,000
France	—	—	22	2,000
Total	708	119,232	966	163,000
Sodium phosphates, n.e.s.				
United States	6,289	1,187,713	7,204	1,365,000
West Germany	60	23,049	173	42,000
Britain	—	—	1	1,000
Total	6,349	1,210,762	7,378	1,408,000
Exports				
Nitrogen phosphate fertilizers				
United States		19,457,046		22,782,000
Malaysia-Singapore		—		7,000
Total		19,457,046		22,789,000

	1964	1965
Consumption		
Phosphate rock, available data		
Fertilizers [1]	1,277,610	1,431,597
Chemicals	169,562	172,254
Other [2]	1,399	3,064
Total	1,448,571	1,606,915

Source: Dominion Bureau of Statistics.

[1] Includes small amount used for making animal feed supplements.
[2] Pig iron, detergents and soaps, ceramics, etc.

P Preliminary; — Nil; n.e.s. Not elsewhere specified.

PHOSPHATE OCCURRENCES AND PAST PRODUCTION IN CANADA

From 1850 to 1900, phosphate in the form of apatite – typically $3[Ca_3(PO_4)_2]\,CaF_2$ – was produced on a fairly large scale at several places in Ontario and Quebec. The start of large, low-cost production from Florida deposits of sedimentary phosphate rock in the early 1890's made apatite mining uneconomic and since that time sedimentary phosphate, mainly imported from the United States, has served Canadian needs.

The Quebec and Ontario apatite deposits mined were generally small, irregular, coarse-grained occurrences of apatite with pink calcite and phlogopite mica, associated with pyroxenite. Their irregular nature and variable apatite content made them workable only under the low-cost hand mining and processing methods of the 1890's. Currently rising demands for phosphate raw materials and concern about the depletion of sedimentary phosphate sources under present high production rates have encouraged investigation of large apatite deposits, including some in Canada, as future sources of phosphate

In addition to the previously worked deposits, several alkaline rock complexes in Ontario and Quebec contain comparatively abundant apatite and, under favourable conditions, are potential sources. The Nemegos deposit near Chapleau, Ontario, controlled by Multi-Minerals Limited, is one on which considerable investigation has been done. This deposit contains apatite, magnetite and other minerals and some, in addition to the apatite, may be recoverable. The company has developed an acid leaching process which is being tested in a pilot plant by the West German company, Klockner-Humbolt-Deutz A.G. The ore is similar in some respects to the Kola deposit, a large-scale source of phosphate in the USSR.

The niobium-mineral deposits in the Oka area near Montreal contain small amounts of apatite which may be recoverable as a byproduct. Some ilmenite-magnetite deposits associated with anorthosite in eastern Quebec contain appreciable amounts of apatite which may be recoverable as a byproduct should these deposits be brought into production.

The most promising source of phosphatic raw material in Canada appears to be the phosphate rock occurrences along the British Columbia-Alberta boundary. Although large, high-grade occurrences have not been discovered, many exposures of phosphate are known and new discoveries may be made. Alternatively, new beneficiation methods might serve to make the occurrences more attractive. Although the presently known occurrences do not appear to be competitive with sources in the United States, the availability of Alberta sulphur as a source of acid for treatment of the rock offers a considerable incentive for exploration and research into improved methods of beneficiation.

THE CANADIAN PHOSPHATE INDUSTRY

Continued growth in the consumption of phosphate fertilizers in Canada and favourable conditions for export, have resulted in a steady expansion of productive capacity. Between 1963 and 1966 substantial additions to capacity were brought on stream and others were due for completion during 1967 to bring total capacity to about 820,000 tons P_2O_5 per year. New construction, announced and being planned, will increase the total appreciably by 1970.

TABLE 2

Phosphate Rock, Imports and Consumption, 1957–66
(short tons)

	Imports	Consumption
1957	723,220	772,715
1958	744,164	728,906
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
1966p	2,181,341	..

Source: Dominion Bureau of Statistics.

p Preliminary; .. Not available.

The Canadian phosphate industry is divided geographically into western and eastern sections which are similar in purpose and techniques but differ in operational detail. In western Canada most of the phosphate rock used is obtained from Montana and other western states, although rock for the Sherritt Gordon Mines, Limited plant at Fort Saskatchewan, Alberta, is imported from Florida via Vancouver using a back-haul arrangement with a bulk-carrier exporting potash from Vancouver. Sulphuric acid for western Canadian fertilizer is derived from elemental sulphur at several plants, but Cominco Ltd. uses smelter gas at Trail and pyrites (pyrrhotite) at Kimberley for its production and ships phosphoric acid from the Kimberley plant to Regina. In eastern Canada, phosphate rock is obtained from Florida and Africa and almost all the sulphuric acid for fertilizer manufacture is made from smelter gas and pyrites. Although both sections of the industry depend on imported phosphate rock, they enjoy strong positions by virtue of having reliable and relatively low-cost sources of sulphuric acid.

The increases in capacity started in the mid-1960's and now being completed have brought supply into temporary balance with demand. However, both agricultural and fertilizer industry officers predict continued growth in fertilizer demand in Canada and reports of additional increases by present producers and plans for large new plants by Imperial Oil Limited and Shell Canada Limited indicate a new round of expansion.

The ammonium phosphate section of the J. R. Simplot fertilizer complex at Brandon, Manitoba began operating in February 1967 and other sections are to start later. Phosphate rock and phosphoric acid are obtained from company facilities in the United States. The plant has a capacity of about 80,000 tons P_2O_5 per year.

In eastern Canada, Canadian Industries Limited started a new plant near Sarnia, Ontario in 1966, and St. Lawrence Fertilizers Ltd. began production at Valleyfield, Quebec. Brunswick Fertilizer Corporation Limited at Belledune, New Brunswick, was expected to reach production late in 1967. Electric Reduction Company of Canada, Ltd. have begun construction of an elemental phosphorus plant at Long Harbour, Newfoundland. A long term contract for electric power at favourable rates was a deciding factor in the location of the plant. Some 500,000 tons of phosphate rock will be imported annually from Florida and two specialized ships will transport elemental phosphorus from Newfoundland to company plants at Port Maitland, Ontario, and in the United Kingdom.

Several factors appear to offer favourable conditions for the continued development of the phosphate fertilizer industry in western Canada. Natural gas is available as fuel (and also as a source of nitrogen fertilizer), sulphuric acid can be produced from elemental sulphur or smelter gas and pyrites, and phosphate rock is readily available – both from western United States and from Florida. The back-haul import of phosphate rock in ships moving Saskatchewan potash out of Vancouver is particularly significant because as potash exports increase it appears likely that increasing amounts of phosphate rock will be moved to the west coast of Canada in these ships. The favourable raw material base and expanding domestic markets provides the opportunity for an industry capable of competing for export markets.

WORLD PRODUCTION

World production of phosphate, as sedimentary rock and apatite, again increased substantially in 1966 to reach a new high of almost 80 million tons, more than 9 per cent more than in 1965. Aggressive expansion of the phosphate industry in the United States contributed most of the new material, although most countries expanded production as well.

Sources of phosphatic material are mainly sedimentary phosphate rock deposits which occur in many parts of the world. Apatite concentrates provide less than 20 per cent of total production and guano is a minor source. Phosphate production in 1965 and 1966 is shown in Table 3. The main sources of apatite are the USSR, North Viet Nam, Brazil and North Korea. Production from Peru is in the form of guano.

TABLE 3

World Phosphate Rock Production
'000 Metric Tons

	1965	1966
USA	26,864	31,350
USSR	13,988	15,800
Morocco	9,825	
Tunisia	3,050	12,600
Algeria	110	
Togo	966	
Senegal	1,025	2,245
South Africa	610	
Rhodesia	15	1,140
Uganda	16	
Egypt	594	
Jordan	828	2,140
Israel	414	
Nauru, Ocean Island	1,871	
Christmas Island	843	3,660
Makatea	308	
Others	2,756	2,995
Total	64,083	71,930

Source: "Phosphorus and Potassium" No. 28.

TECHNOLOGY

Phosphorus is one of the elements essential to the life and health of plants and animals, and this need has resulted in world-wide production of phosphatic raw materials for conversion into fertilizers. The raw materials are chemically graded in terms of P_2O_5 or bone phosphate of lime (BPL) with the formula $Ca_3(PO_4)_2$ (1 BPL = 0.458 P_2O_5).

Phosphorus occurs naturally in mineral forms which are relatively insoluble in soil acids and therefore only slightly and slowly available to plants. The phosphate fertilizer industry developed to convert the naturally occurring forms into more soluble forms so that plants can assimulate the phosphorus. There are various methods of converting insoluble forms to soluble products depending on the raw material available and the cost of conversion. The two main processing methods are; acidulation (referred to as the "wet process"), and thermal (usually the "electric furnace process"). The acidulation process has been the most widely used for phosphate fertilizers but, under certain conditions, thermal processes have been used. Current changes in the technology and economics of these processes suggest that thermal processes may become more important in future fertilizer production.

Any strong acid, such as sulphuric, nitric or hydrochloric, may be used to acidulate phosphate rock, but sulphuric acid has been most commonly used for technical and economic reasons. Normal superphosphate, containing 18 to 22 per cent available P_2O_5, is produced by treating phosphate rock with sulphuric acid. Triple superphosphate, containing 45 to 48 per cent P_2O_5, results from treating phosphate rock with phosphoric acid. Phosphoric acid can be produced by treating phosphate rock with sulphuric acid, or by producing elemental phosphorus by the electric furnace process and converting it to phosphoric acid.

A phosphate fertilizer may be used singly but more often is applied with the other main nutrients, nitrogen and potash, in mixtures or combinations. For example, a phosphate fertilizer may be mechanically mixed with nitrogen and potash fertilizers or appear in such combinations as mono- or diammonium phosphate. The latter has become increasingly popular because it contains as much available phosphate as triple superphosphate and also carries 11 to 18 per cent nitrogen.

The trend towards concentrated fertilizer, to reduce shipping and handling costs, and to serve specific needs, crops, or soils, has resulted in changes in processing, handling and marketing. Fertilizers move in bulk, in packages and as liquids. Some dealers provide all the ingredients, mix them to serve specific needs and apply them to the customer's land using specialized bulk handling equipment. This increasing sophistication at the consumer end of the industry has been balanced at the producer end. Many major companies have expanded capacity and at the same time have broadened the scope of their activities to become producers of all the main fertilizer ingredients. Large oil, sulphur and chemical companies have acquired fertilizer raw material sources and are building plants and making marketing arrangements. These activities indicate the broad expansion trends in the industry and the confidence of major companies in predictions of greater fertilizer needs in the future.

96411—24½

The current shortage and increased price of elemental sulphur have become the main obstacles to the expansion of phosphate fertilizer production by the wet process when sulphur is used as a source of sulphuric acid. For this reason other sources of sulphuric acid, such as byproduct smelter gas and pyrites (pyrite and pyrrhotite) are being expanded, the use of other acids is being considered and the possibility of using thermal processes as a means of producing phosphate fertilizers has been suggested. In Canada smelter gas is utilized as a source of sulphuric acid for fertilizers at Trail, British Columbia, Port Maitland, Ontario and at Valleyfield, Quebec and late in 1967, will be used at Belledune, New Brunswick. Pyrites are sources of acid at Kimberley, British Columbia and Copper Cliff, Ontario, and other projects are being considered. Where smelter gas or pyrites are available, they often offer attractive sources of sulphur dioxide for sulphuric acid because, as byproducts or waste-products, both are low cost. There are usually credits for process steam or iron-oxide and a reliable, long-term supply at predictable prices is particularly desirable when sulphur supply and prices are uncertain.

The furnace process, used mainly to produce elemental phosphorus for industrial and chemical phosphates, is now being considered as a possible means of producing phosphate fertilizers because of the uncertain sulphur supply and some developments in technology. The decreasing cost of electric power from projected large atomic energy electric plants makes the process attractive under favourable conditions of raw material supply and markets for power and fertilizer.

Two sources of phosphate will contribute increasing amounts of raw material in the future as some of the present sources of sedimentary phosphate rock become depleted. Apatite, now used mainly in USSR and Europe, will become a more important source in parts of the world where sedimentary phosphate is limited. Nodules of phosphate (and other minerals) have been found on the sea bottom of some continental shelf areas. Very large reserves are available and methods of recovery by various dredging techniques are being developed.

USES AND SPECIFICATIONS

Phosphate is produced mainly for conversion into fertilizers. A minor amount of the raw material is fine ground and applied directly to the soil but the major part of production is processed to make the phosphorus more readily available by plants. Approximately 10 per cent of the raw material is converted to elemental phosphorus, phosphorus chemicals and feed supplements for livestock and poultry.

Phosphorus chemicals are consumed by a wide variety of industries. The main use is in the manufacture of soaps and detergents. Large and increasing amounts are used as leavening agents in baking powders, cake mixes and similar applications. Other phosphorus chemicals are used in water-conditioning, metal treatments, plastic and paper making, pharmaceutical preparations, paints, munitions, fireworks and many other products.

For fertilizer use, phosphate rock should contain at least 65 per cent BPL but may contain up to 77 per cent, depending on the raw material and the process used. Phosphate rock treated by the electric furnace process can be of lower grade but must have no excess calcium, a maximum of 3 per cent Fe_2O_3 plus Al_2O_3 and be coarser than 5 mesh.

PRICES AND TARIFFS

According to Oil, Paint and Drug Reporter of December 1966, the following prices apply:

Phosphate rock, Florida land pebble, run of mine, washed, dried, unground, bulk carload, f.o.b. mines, per short ton

66–68% BPL –	$ 6.50
68–70	7.50
70–72	8.15
74–75	9.20
76–77	10.20

Phosphate rock, Curacao, bulk, f.o.b. Atlantic and Gulf ports, per ton – $46.75

Defluorinated phosphate, feed grade, various U.S. sources, 14–19% P, per ton – $57.00 – $92.35

Phosphate rock enters Canada duty free.

Platinum Metals

A.F. KILLIN*

The platinum group metals (platinoids) – platinum, palladium, rhodium, ruthenium, iridium, and osmium, are recovered in Canada as byproducts from the refining of nickel-copper ores and the volume of recovery varies with the production of these ores. The production of the platinoids in 1966 was 385,741 ounces valued at $31,231,607, a reduction of 77,386 ounces and $4,878,192 from 1965. The decrease in production was caused by work stoppages at the mines and plants of The International Nickel Company of Canada, Limited at Sudbury, Ontario.

There are 4 major platinum producing areas in the world: the USSR, Republic of South Africa, Canada, and Colombia. The United States produces minor amounts of the platinum metals. The USSR does not publish production figures for platinum metals which makes it difficult to accurately define the pattern of world production. The United States Bureau of Mines estimates that the USSR produces about 56 per cent of the world total followed by South Africa and Canada. The Bureau estimates world production in 1966 at 3,010,000 ounces, 50,000 ounces more than in 1965. Production in the USSR is estimated at 1,700,000 ounces, the same as in 1965. The Republic of South Africa produced over 600,000 ounces of platinum group metals in 1966. The 316,000 ounces of platinoids released in 1966 for domestic sale by the General Services Administration in the United States was a major addition to non-communist world supplies. Consumption statistics on a world basis are not available but for the non-communist world, consumption exceeded mine output. The deficit was again satisfied by the United States stockpile releases and sales by the USSR. As in previous years the USSR pattern of sales was unpredictable.

There were 2 prices quoted for platinum in 1966, the producer price quoted by Engelhard Industries, Inc. and Johnson, Matthey & Co., Limited, and the free market price quoted by dealers and merchants. Most of the platinum and platinum group metals produced in the non-communist world were sold at the producer price. Metal reclaimed from scrap and the Russian metal were sold at the dealer's price. When supplies from the USSR were withdrawn in October the dealer price rose to $175 but eased to a range of $150 to $155 an ounce when Russia resumed selling.

High prices and fluctuating supply have prompted research by industry in an attempt to find substitute materials for the platinoids and to find ways of reducing consumption. The unique properties of the platinoids have, however, prevented any large scale substitution. Demand will exceed supply for some time and attempts by producers in the non-communist world to increase production will remain vulnerable to the marketing actions of the USSR.

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*Mineral Resources Division.

TABLE 1

Platinum Metals — Production and Trade, 1965-66

	1965		1966P	
	Troy Ounces	$	Troy Ounces	$
Production[1]				
Platinum, palladium, rhodium, ruthenium, iridium	463,127	36,109,799	385,741	31,231,607
Exports				
Platinum metals in ores and concentrates				
Britain	471,238	26,245,128	423,882	24,188,000
Norway	21,894[r]	1,798,153[r]	7,841	668,000
United States	4,440	175,114	—	—
Total	497,572[r]	28,218,395[r]	431,723	24,856,000
Platinum metals				
Britain	156	18,103	6,428	533,000
United States	53,039	1,847,008	1,131	193,000
Other countries	255	19,748	45	3,000
Total	53,450	1,884,859	7,604	729,000
Re-exports[2]				
Platinum metals, refined and semiprocessed	321,950	11,389,395	..	..
Imports				
Platinum lumps, ingots, powder and sponge				
Britain	47,605	4,914,710	9,565	1,087,000
United States	880	97,742	1,769	196,000
Total	48,485	5,012,452	11,334	1,283,000
Other platinum group metals in lumps, ingots, powder and sponge				
Britain	181,424	8,263,018	183,296	13,479,000
United States	3,694	186,076	3,223	168,000
Total	185,118	8,449,094	186,519	13,647,000
Total, platinum and platinum group metals				
Britain	229,029	13,177,728	192,861	14,566,000
United States	4,574	283,818	4,992	364,000
Total	233,603	13,461,546	197,853	14,930,000
Platinum crucibles				
United States	19,923	1,867,699	22,858	2,262,000
Britain	38	3,785	220	23,000
Total	19,961	1,871,484	23,078	2,285,000
Platinum metals, fabricated materials, not elsewhere specified				
Britain	2,999	316,531	12,979	1,370,000
United States	3,531	267,440	8,114	584,000
Netherlands	—	—	526	19,000
Total	6,530	583,971	21,619	1,973,000

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 change or alteration.

Symbols: P Preliminary; r Revised; —Nil; .. Not available for publication.

PRODUCTION

CANADIAN

The platinoids contained in Canadian ores (0.025 ounce per ton or less) are collected in the nickel-copper sulphide matte resulting from the nickel smelting process. Nickel-copper matte anodes are purified by electrolysis and the precious metals released are collected as sludge from the electrolytic tanks. This sludge is purified, then shipped to refineries in Britain and the United States for the recovery of the individual platinum metals.

Most of Canada's platinum metals are produced from ores mined in the Sudbury area of Ontario. Nickel ores containing platinoids are also mined in Quebec, Ontario, Manitoba and British Columbia. Nickel-copper concentrates from British Columbia are exported to Japan and there is no production of precious metals from these concentrates in Canada. The Sherritt Gordon and International Nickel mines in Manitoba have not reported for publication the platinoids recovered.

Metal Mines Limited at Gordon Lake, Ontario, and 2 mines in Quebec, Marbridge Mines Limited at Malartic and Lorraine Mining Company Limited at Belleterre, shipped their nickel-copper concentrates to Sudbury for treatment by The International Nickel Company of Canada, Limited (Inco) and Falconbridge Nickel Mines, Limited.

TABLE 2

World Production of Platinum-Group Metals

(troy ounces)

	1964	1965p	1966e
USSR.......	1,500,000	1,700,000	1,700,000
Republic of South Africa	606,000e	756,000e	820,000[1]
Canada.....	376,238	452,063	425,000
United States	40,487	35,026	30,000
Colombia ...	20,647	11,040	20,000
Other countries .	6,628	5,871	15,000
Total...	2,550,000	2,960,000	3,010,000

Source: United States Bureau of Mines, *Minerals Yearbook 1965*, and Commodity Data Summaries, January 1967.

pPreliminary; eEstimated

[1]May include material from inventory.

TABLE 3

Platinum Metals — Production and Trade, 1957-66

	Production[1]			Exports		Imports[4]
	Platinum (troy oz.)	Other Platinum Metals (troy oz.)	Total (troy oz.)	Domestic[2] $	Re-exports[3] $	$
1957	199,565	216,582	416,147	17,638,093	10,081,412	15,430,931
1958	146,092	154,366	300,458	15,014,321	4,893,616	8,641,360
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	30,103,254r	11,389,395	13,461,546
1966p	..	..	385,741	25,585,000	..	14,930,000

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 from Britain. [4]Imports, mainly from Britain, of refined and semiprocessed platinum metals derived from Canadian concentrates and residues, most of which is re-exported.

Symbols: pPreliminary; .. Not available for publication; r Revised.

In the Sudbury area, Inco operated the Frood-Stobie, Creighton, Garson, Levack, Murray, Crean Hill, MacLennan and Totten underground mines and the Clarabelle, MacLennan and Ellen open pits. Also in the Sudbury area, Inco operated the Coniston and Copper Cliff smelters and a copper refinery at Copper Cliff; it operated a nickel refinery at Port Colborne, Ontario. Precious metal sludges from the Port Colborne refinery were shipped to Britain for separation and refining of the platinoids. Inco continued a major expansion program in the Sudbury area that will see the Coleman, Kirkwood, Copper Cliff North and Little Stobie mines and a 22,500-ton-a-day mill in operation by 1969. Expansion is also being undertaken at Inco's Manitoba operations with 3 new mines being developed. Falconbridge Nickel Mines, Limited operated the Falconbridge, East, Onaping, Hardy, Fecunis and North mines, the Falconbridge, Hardy and Fecunis mills and a smelter in the Sudbury area. The smelter produced a nickel-copper matte, containing precious metals, that was shipped to the company's refinery at Kristiansand, Norway. Falconbridge was preparing the Strathcona mine and mill for production in 1968 at 6,000 tons of ore a day and was exploring the Longvac South orebody north of the Strathcona.

FOREIGN

South Africa

Rustenburg Platinum Mines Limited, the non-communist world's largest platinoid producer, continued expansion of its mining and smelting facilities. Production in 1966 was in excess of 600,000 ounces and the company plans production of 750,000 ounces a year by 1969. Rustenburg continued production from the Brakspruit property adjoining the Rustenburg mine. Matte produced from the Brakspruit ore was delivered to the owners, a consortium headed by the Rand Mines Group; it was refined by Engelhard Industries International Ltd. of the United States.

USSR

Platinoids in the USSR are derived mainly from the mining of deposits in the nickel-bearing basic and ultrabasic rocks of the Norilsk region of Siberia. Small amounts of placer platinum are recovered from the southern Urals. The United States Bureau of Mines estimates Russian production at 1.7 million troy ounces in 1966.

United States

Primary platinum production was obtained from placer deposits in Alaska and as a byproduct of the refining of gold and copper.

Colombia

Placer deposits in the Choco district on the west side of the Colombian Andes are the source of 23,000 to 30,000 ounces of platinum each year. Production is static, hampered by climatic, financial and political conditions.

Other

Small amounts of platinoids are recovered as byproducts of base and precious metal refining or from placer deposits in Ethiopia, Japan, Australia and Sierra Leone.

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

TABLE 4

Producing and Developing Mines, 1966

Company	Producing	Ore Produced 1965	Ore Produced 1966	Ore Reserves and Grade Dec. 31, 1966	Developing
Falconbridge Nickel Mines, Limited	6	2,344,000	2,101,000	55,717,500 s.t. containing 1,172,000 s.t. of nickel and copper	Strathcona, Longvac South
The International Nickel Company of Canada, Limited	12	19,750,000	17,550,000	324,868,972 s.t. containing 9,481,964 s.t. of nickel and copper	Sudbury – Copper Cliff North, Little Stobie, Kirkwood, Coleman, Thompson – Soab, Pipe Lake, Birchtree
Metal Mines Limited	1	184,374	..	..	–
Marbridge Mines Limited	1	125,313	134,824	..	–
Lorraine Mining Company Limited	1	162,533	186,362	210,383 s.t. @ 1.32% Cu and 0.57% Ni	–
Giant Mascot Mines, Limited	1	330,954	327,164	754,033 s.t. @ 0.92% Ni and 0.32% Cu	–

Source: Company reports. ..Not available –Nil

laser crystals. Wear resistance of the platinum metals makes them ideal for use as spinnerets for the production of glass, rayon and other synthetic fibres. Platinum and platinum alloys are used for the cathodic protection of ships' hulls and as inert anodes in electro-deposition. Palladium is used as contacts in automatic electric switching gear and in dentistry. Wear resistance and beauty of finish are the qualities that create a demand for the platinum metals in the manufacture of high-quality jewelry.

PRICES

Prices of platinum metals a troy ounce varied during the year. The following table summarizes the price changes as quoted in the United States by *E & MJ Metal and Mineral Markets*.

TABLE 5

Prices of Platinum – Group Metals, 1966

	$/troy ounce
Iridium	
January 1 to February 28	110 – 115
March 1 to April 19	125 – 130
April 20 to June 19	140 – 145
June 20 to December 31	170
Osmium	
January 1 to October 2	300 – 350
October 3 to December 31	300 – 450
Palladium	
January 1 to June 9	32 – 34
June 10 to October 2	33 – 35
October 3 to December 31	35 – 37
Platinum	
January 1 to December 31	100
Dealers (average)	143 – 146
Rhodium	
January 1 to February 28	182 – 185
March 1 to December 31	197 – 200
Ruthenium	
January 1 to December 31	55 – 60

TARIFFS

	British Preferential	Most Favoured Nation	General
Canada			
Platinum wire and platinum bars, strips, sheets, plates; platinum, palladium, iridium, osmium, ruthenium and rhodium in lumps, ingots, powder, sponge or scrap	free	free	free
Platinum crucibles	free	free	free
Platinum retorts, pans, condensers, tubing and pipe, and preparations of platinum for use in manufacture of sulphuric acid	free	free	free
Platinum and black oxide of copper for use in manufacture of chlorates and colours	free	10%	10%

United States

Platinum, including gold- or silver-plated platinum but not rolled platinum	
Unwrought	
Metals of the platinum group separately, native combinations of such metals and artificial combinations of such metals containing by weight not less than 90% of the metal platinum	free
Other, including alloys of platinum	40% ad val.
Semimanufactured	
Bars, plates and sheets, all not under 0.125 inch thick wholly of metals of the platinum groups separately, wholly of native combinations of metals of the platinum group, or wholly of artificial combinations thereof containing by weight not less than 90% of metal platinum	free
Other, including alloys of platinum	40% ad val.

Potash

C.M. Bartley*

Potash deposits of economic interest were discovered in Saskatchewan in the course of oil exploration drilling during the 1940's. Subsequent drilling and investigation indicated the extent and quality of the occurrences and efforts to exploit them began in 1951 at Unity. The depth of the deposits and shaft-sinking problems made development difficult and costly but over the next ten years construction methods were developed to overcome the problems and continuous production started in 1962. At the end of 1966 two shaft mines and one solution mine, the world's first, were in full production. Shipments from these plants totalled more than 2 million tons of potash (K_2O) in 1966. ($K_2O \times 1.58 = KCl$ (potassium chloride), $KCl \times 0.63 = K_2O$)

This substantial production will increase many-fold by 1970 as several new mines and plants, now under construction, come on stream. At the end of 1966, 10 shafts and 6 refineries were under construction. These plants will increase production capacity from its current level of about 3.4 million tons of product (KCl concentrate) per year to about 12 million tons per year by 1970. In addition, another shaft will be started in January 1967 and it is expected that at least two more shafts and one or more refineries will be started, or announced, in 1967.

PRODUCTION, TRADE AND CONSUMPTION

Production of potash increased in 1966 to more than 2 million tons (K_2O equivalent) valued at $76.6 million. Compared to 1965, shipments increased 37 per cent and value of production about 35 per cent. Production was obtained from two shaft mines and one solution mine in southern Saskatchewan. Sylvinite ore, a mixture of sylvite (KCl) and halite (NaCl) is mined through shafts from depths of 3,100 to 3,500 feet and beneficiated on surface to produce a concentrate of KCl grading more than 60 per cent K_2O. The solution mine recovers a brine containing KCl and NaCl from a depth of more than 5,000 feet. The brine is evaporated to remove water and KCl is crystallized to a concentrate grading more than 62 per cent K_2O. The product is shipped, mainly in bulk, in covered hopper or box cars, to consumers in Canada and the United States, and also to Vancouver and Fort William for export. Almost all of this material is used to produce fertilizer.

A very large proportion of Canadian potash production is exported, mainly to the United States. In 1966 the value of exports exceeded $76.3 million.

Potash, for fertilizer and chemical use, also is imported into Canada. Since the start of Canadian production in 1962, imports of

*Mineral Processing Division, Mines Branch.

potassium chloride fertilizer potash have decreased substantially. In 1966 imports at 66,600 tons were about 15,000 tons lower than in 1965. However, imports of potassium sulphate fertilizers, which are not yet produced in Canada, increased substantially. Imports of chemical potash increased slightly in 1966 to 4,054 tons.

Consumption of potash in Canada has been increasing steadily and in 1966 was estimated at 206,000 tons KCl, a 6 per cent increase over 1965.

TABLE 1

Potash — Production and Imports, 1965-66

	1965		1966P	
	Short Tons	$	Short Tons	$
Production (shipments) K_2O equivalent	1,491,301	55,970,527	2,045,000	76,670,000
Exports — Fertilizer potash				
Potassium chloride (muriate of potash)[1]				
United States	..	..		53,389,000
Japan	..	..		11,713,000
Netherlands	..	..		5,378,000
New Zealand	..	..		3,387,000
Taiwan	..	..		754,000
Other countries	..	..		1,744,000
Total	..	..		76,365,000
Imports — Fertilizer potash				
Potassium chloride				
West Germany	16,347	510,720	14,634	430,000
France	6,553	190,179	8,657	231,000
United States	30,913	919,590	4,822	158,000
Britain	—	—	33	1,000
Total	53,813	1,620,489	28,146	820,000
Potassium sulphate				
United States	15,054	614,436	14,875	640,000
France	22	993	6,853	253,000
Italy	3,517	161,174	3,478	166,000
West Germany	—	—	150	6,000
Total	18,593	776,603	25,356	1,065,000
Potash fertilizer, not elsewhere specified				
United States	9,051	154,472	13,161	229,000
Total, potash fertilizers	81,457	2,551,564	66,663	2,114,000
Potash chemicals				
Potassium carbonate	565	102,502	790	147,000
Potassium hydroxide	1,814	340,375	1,648	319,000
Potassium nitrates	1,465	196,977	1,616	210,000
Total, potash chemicals	3,844	639,854	4,054	676,000

Source: Dominion Bureau of Statistics.
[1] Available as a separate class commencing 1966 only.
P Preliminary; .. Not available; — Nil.

TABLE 2

Potash Consumption
(short tons)

	1964	1965
Consumption (available data)		
Muriate of potash (KCl)		
Fertilizers and chemicals	191,577	192,709
Other[1]	747	1,242
Total	192,324	193,951

Source: Dominion Bureau of Statistics.
[1] Cleansers, soaps, gypsum products, medicinals and miscellaneous minor uses.

POTASH MINERALS AND THEIR SOURCES

The term 'potash', applied to materials containing potassium in useful amounts, is derived from 'pot ashes'. In early days, solutions leached from wood ashes in iron pots were a source of potassium compounds. Soluble potash minerals found in German salt deposits were recognized as valuable for fertilizer in 1827, and minerals have since been the source of potassium for fertilizer and for chemical use. The potassium content of the minerals is stated in terms of K_2O because it was thought that potassium was effective as fertilizer only in this form. The present trend to high-analysis fertilizers makes this practice cumbersome because plant nutrient values sometimes total more than 100 per cent. Consideration is being given to stating nutrient values of potash and phosphate in terms of per cent potassium (K) and phosphorus (P), as is done with nitrogen, rather than as K_2O and P_2O_5.

The common and most useful potassium-bearing minerals, with chemical formulae and potassium content expressed as percentages of K_2O and K, are as follows:

Mineral	Formula	Percentages Equivalent K_2O	K
Sylvite	KCl	63.3	52
Carnallite	$KCl.MgCl_26H_2O$	17.0	14
Langbeinite	$K_2SO_42MgSO_4$	22.0	19
Kainite	$KCl.MgSO_43H_2O$	18.9	13
Nitre	KNO_3	46.5	39

Minerals valued for their potassium content occur almost entirely as bedded evaporite deposits associated with common salt (NaCl) or in natural brines (as in the Dead Sea) where soluble salts are being concentrated by high rates of evaporation. The main sources of potash are evaporites that after deposition have been buried by overlying sediments and are thus protected from solution by surface water. Major deposits of potash minerals have been found in Germany, France, USSR, Spain, United States and, more recently, in Saskatchewan.

Two potash bearing minerals, sylvite and carnallite, are found in huge deposits in Saskatchewan. Sylvite is the most important potash mineral because of its high potassium content.

Potash is recovered from brines at Searles Lake in California. It is also recovered in Israel from brines drawn from the Dead Sea. Similar recovery is planned by Jordan at the Dead Sea. Brine occurrences in the Sechura desert of Peru have been investigated as a source of potash.

WESTERN CANADA DEPOSITS

Potash is found in three or more fairly continuous and consistent layers in the upper part of the vast Prairie Evaporite Formation of Middle Devonian age. The formation has the shape of a huge platter underlying southern Saskatchewan and adjacent parts of Manitoba and Alberta. It is tilted slightly to the southwest, the shallow northern edge lying from 2,500 to 3,500 feet below the surface. Southward the depth increases to 5,000 feet at Regina and 7,000 feet at the International Boundary. The Blairmore Formation, a layer of interbedded shales and water-bearing fine sands, is probably the best known of the stratigraphic series because its high water pressures present difficult problems in sinking shafts. The Prairie Evaporites consist largely of salt concentrated by the evaporation of an ancient sea; the potash zones are the result of final precipitation of the most soluble materials. Thus, the potash occurs with salt and is overlain by various sedimentary rocks ranging from glacial drift to limestone.

CANADIAN POTASH ACTIVITIES

The aggressive development of the Canadian potash industry in Saskatchewan continued throughout 1966. Table 3 lists three producers and six additional projects under construction. The current construction will increase productive capacity from its present level of about 3.45 million tons of product (KCl concentrate) to about 12 million tons per year by 1970. This rapid and large-scale expansion of production is viewed with some uneasiness by the world-wide potash industry and forecasts of large surpluses of potash by 1970, with depressed prices and uneconomic operations, have been made. Although the amount of new capacity coming on stream over a short period makes some surpluses likely, there is no certainty that they will occur. The fact that highly competent major companies comprise a large part of the potash industry suggests that the long term demand for potash has been studied with care and production has been found to be economically attractive.

The scale of the new operations in Canada, and in several other countries, favours their economic success. Reserves of high quality potash in Canada are very large. Such resources assure operations over a long period of time, and this justifies major capital investments for large-scale facilities using the most modern equipment and techniques. Although potash has sold at very high prices during periods of restricted supply, it will be much easier to expand markets for potash if supplies are plentiful and prices remain stable and low. The large plants in production and under construction in Saskatchewan thus appear to be in a strong position to compete for potash markets. Low production costs should permit them to survive during any period of surplus supply and reduced prices may eliminate some competitors operating smaller facilities using lower quality ores. Over the longer period, additional producers, changes in mining and refining technology, and lower cost methods of transportation will undoubtedly contribute to the continued expansion of the Canadian industry.

TABLE 3

SASKATCHEWAN POTASH PRODUCERS AND PROSPECTIVE PRODUCERS

				Capacity Million tons/year		Production-Million tons K_2O per year				
Company	Location	Start of Production	Cost $ Millions	KCl	K_2O	1962	1963	1964	1965	1966
	PRODUCERS									
IMC	Esterhazy K-1	1962	65	2.00	1.20	x	x	x	x	x
Kalium	Belle Plaine	1964	50	0.75	0.45			x	x	x
PCA	Saskatoon	1965	50	0.70	0.42				x	x
	Totals to end of	1966	165	3.45	2.07	0.135	0.627	0.832	1.490	2.04
	PROSPECTIVE PRODUCERS									
IMC	Esterhazy K-2	1967	65	2.50	1.50 [1]					
Alwinsal	Lanigan	(1968)	60	1.00	0.60					
Allan	Allan	(1968)	80	1.50	0.90					
Cominco	Vanscoy	(1969)	65	1.20	0.72					
Noranda	Viscount	(1970)	81	1.20	0.72					
Duval	Saskatoon	(1969)	63	1.00	0.60					
Totals 1966 to 1970			406	8.40	5.04					
Totals in 1970			570	11.85	6.51					

[1] Initial capacity will be 1.50 million tons product or 0.90 million tons K_2O, the plant is designed for expansion to 2.50 million tons of product.

INTERNATIONAL MINERALS & CHEMICAL CORPORATION (CANADA) LIMITED

IMC, the major potash producer in Canada, operated its K-1 plant near Esterhazy at capacity during 1966 and at year-end had almost completed the shaft and refinery at K-2, some six miles away. The K-2 shaft was somewhat delayed by problems in the last water bearing strata in July 1966. Water under very high pressure entered the shaft at a point only a few hundred feet above the potash deposit. The break was sealed and the shaft completed early in 1967 and the refinery was operating in April 1967. The K-2 plant has a current capacity of 1.5 million tons of product per year but has been designed for later expansion to 2.5 million tons.

The company is active in research into many aspects of potash mining, beneficiation, transportation, marketing and fertilizer use. New mining equipment is being tested and farming operations are carried on adjacent to the plant to test various fertilizers and farming practices not normally used in western Canada.

POTASH COMPANY OF AMERICA

The first company to sink a shaft to the potash deposits and build a refinery for processing in Saskatchewan was Potash Company of America. Its plant is located just east of Saskatoon. The shaft and mill, completed in 1958, operated for about 9 months but were forced to close in 1959 because of leaks in the shaft wall. After a slow and careful repair program in the shaft, and replacement of some mill equipment production resumed in April 1965 and continued at full capacity through 1965 and 1966.

A second shaft will be sunk about 3,000 ft south of the present plant starting in January 1967. Additional storage capacity will be constructed in 1967.

KALIUM CHEMICALS LIMITED

Kalium operates the world's only potash solution mine at Belle Plaine, about 25 miles west of Regina. Production started in August 1964 and has been continuous since that time.

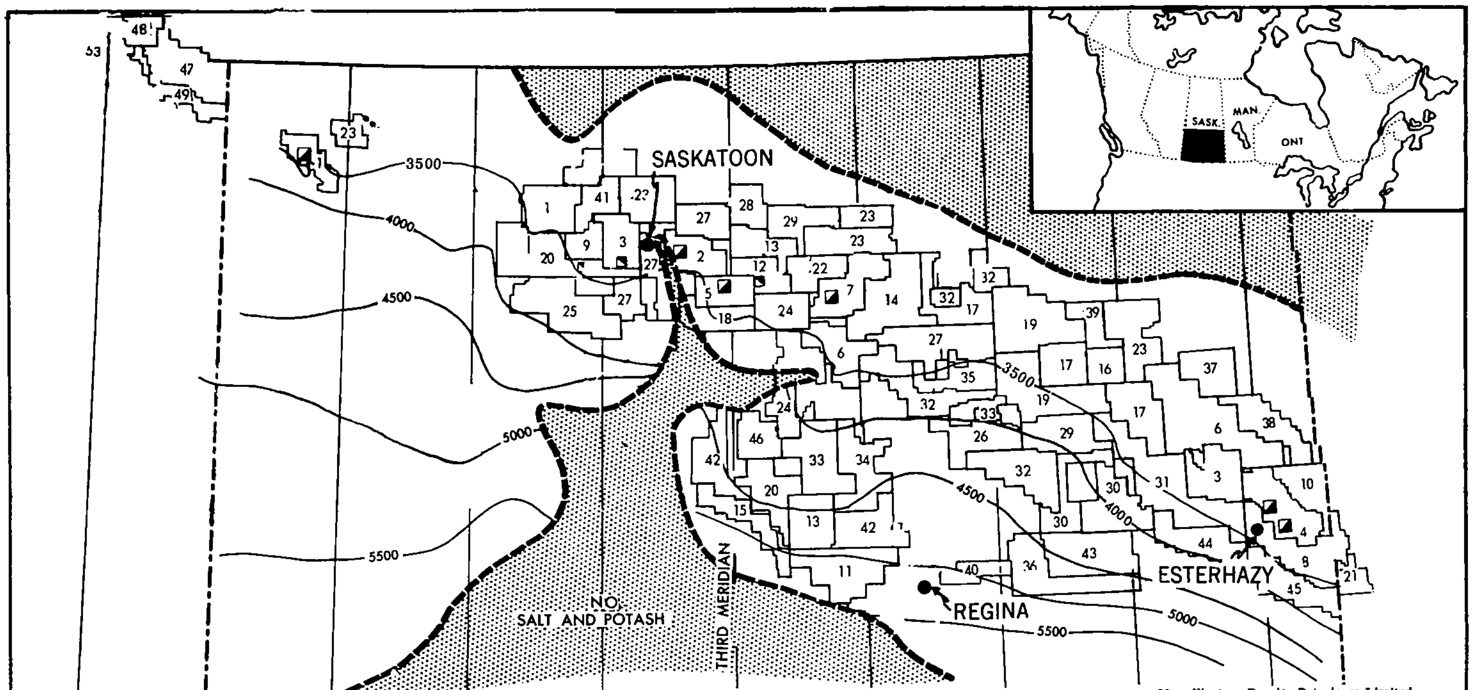
A hot weak brine is pumped into the potash formation some 5,200 feet below surface through drilled holes. The solution dissolves the potash (KCl) and salt (NaCl) and a rich brine is brought to the surface. The pregnant solution is further concentrated by evaporation, the salt is precipitated out and removed, and the KCl in the remaining solution is crystallized into solid particles of three sizes, dried, screened and moved to storage or shipping facilities. The creamy white potassium chloride crystals are somewhat higher in purity than the flotation product from shaft mining operations. Although this is not a significant advantage for fertilizer use, it may be a preferred material for some other markets.

The development of potash solution mining in Saskatchewan is a significant research achievement and is economically important because it has added vast amounts of potash reserves to the total recoverable by shaft mines. For economic and technical reasons shaft mining is not attractive below depths of 3,500 feet. Because half of the total potash tonnage in Saskatchewan may be found below 3,500 feet this method of recovering deep deposits will be very important in the future. The unusual thickness and high quality of the potash deposits in Saskatchewan was an important factor in the success of the solution method here after numerous attempts in other countries had failed.

For these reasons successful solution mining of potash may be restricted to Canada for several years at least. It has been estimated that production costs are higher than those at shaft mines; however, any such differential in cost does not appear to be sufficient to discourage operations at Kalium.

ALLAN POTASH MINES

Exploration for potash by United States Borax & Chemical Corporation in the mid-nineteen-fifties culminated in a joint project starting near Allan, Saskatchewan, about 40 miles east of Saskatoon, in May 1964. United States Borax and Homestake Mining Company each hold a 40 per cent interest and Swift Canadian Co., Limited holds the balance. United States Borax is the operator. Two shafts are being sunk. At the end of 1966 they had reached depths of about 2,000 and 2,300 feet. The No 1 shaft, flooded in February 1966, was completely rehabilitated at year-end. The Blairmore section of the 16 ft diameter shafts



1. Continental Potash Corporation Limited
2. Potash Company of America
3. Duval Corporation
4. International Minerals & Chemical Corporation (Canada) Limited
5. Allan Potash Mines
6. Southwest Potash Corporation
7. Alwinsal Potash of Canada Limited
8. Sylvite of Canada Ltd.
9. National Potash Company
10. Canberra Oil Company Ltd.
11. Kalium Chemicals Limited
12. Noranda Mines Limited
13. Imperial Oil Limited
14. Kerr-McGee Oil Industries, Inc.
15. Domtar Chemicals Limited, Sifto Salt Division
16. Shell Canada Limited
17. Mobil Oil Canada, Ltd.
18. Columbian Oil Limited
19. Scurry-Rainbow Oil Limited
20. Cominco Ltd.
21. Prairie Potash Mines Limited
22. Dafoe Minerals Limited
23. The British American Oil Company Limited
24. Bison Petroleum & Minerals Limited
25. William James
26. Mill City Petroleums Limited
27. Continental Minerals Incorporated
28. Kennco Explorations (Canada), Limited
29. Brinco Holdings Ltd.
30. Central-Del Rio Oils Limited
31. Texas Gulf Sulphur Company
32. King Resources Company
33. Great Canadian Potash Corporation Limited
34. Ruby Jessel
35. The Atlantic Refining Company
36. Banff Oil Ltd. and Aquitaine Company of Canada Ltd.
37. Mule Creek Oil Company, Inc.
38. Western Decalta Petroleum Limited
39. Apollo Minerals Ltd.
40. The Canadian Salt Company Limited
41. Canadian Exploration, Limited
42. C. M. Taylor
43. Canada Permanent Trust Company
44. Gulf Coast Western Oil Company & Nicona Minerals Ltd.
45. Montreal Trust Company
46. Potasse Premiere Corporation Limited
47. National Trust Company, Limited
48. Bayfield Oil & Gas Ltd.
49. City Saving & Trust Company

was lined with cast iron tubbing. The head frames at Allan Potash are unusual both to the prairies and to mining construction. It is a "space frame" a symmetrical structure with four sloped legs with a Koepe hoist on top. This arrangement allows more working space at the collar and is supported on foundations well outside the frozen column of the shaft.

Surface construction, including the mill and 400,000 tons of storage capacity, was on schedule. Late in 1966 it was announced that production would start in 1968 and that capacity would be increased to 1.5 million tons of product.

ALWINSAL POTASH OF CANADA LIMITED

Two West German and one French potash companies organized Alwinsal and after careful exploration are sinking a shaft and building a refinery near Lanigan, about 75 miles east of Saskatoon. Work started in mid-1964. By the end of 1966 the shaft was at a depth of nearly 2,800 feet and refinery construction was well advanced. Production at the rate of 1.0 million tons per year is expected to start in 1968. A second shaft will be sunk later.

The Alwinsal shaft has a double wall welded steel lining in the wet formations with concrete in the annular space and between the outer wall and the formation. This type of lining should assure a dry shaft, particularly in the deeper and higher pressure water zones which are difficult to seal off by other methods. A reinforced concrete shaft lining is constructed where water is not a problem.

COMINCO POTASH

In January 1965 Cominco Ltd. announced the start of a major potash development near Vanscoy, about 16 miles west of Saskatoon. Freeze-hole drilling was started in the fall of 1965 and at the end of 1966 the two shafts had reached depths of 1,900 feet and about 1,600 feet. Plant construction was on schedule and the progress being made with the project suggests an earlier completion than originally estimated, possibly by early 1969.

Cominco, a producer of phosphate and nitrogen fertilizer for many years, will be the first Canadian company to produce all three main fertilizer ingredients.

NORANDA MINES LIMITED

In October 1964 Noranda Mines purchased the property of Consolidated Morrison Explorations Limited adjoining the Potash Company of America property. In February 1965 the start of a major potash project at Viscount, about 45 miles east of Saskatoon, was announced. Work on the site started in October 1965 and at the end of 1966 the twin shafts were at depths of about 1,200 and 800 feet. Site preparation work for plant construction had started but no permanent structures had been erected. The Noranda plant has been designed to produce 1.2 million tons of product per year and is expected to be on stream by 1970.

The potash project is Noranda Mine's first activity as a major producer of fertilizer material and potash sales arrangements were an important element in the project. This problem was solved by a long-term contract to supply potash to Central Farmers Fertilizer Company of the United States. Central Farmers will take a large part of production and have the option of acquiring a substantial interest in the project – up to 49 per cent. The balance of production will be marketed by Noranda Sales Corporation Ltd.

DUVAL CORPORATION

Of the plants now under construction Duval was the last to announce a large project but has been competent and aggressive in development. This company has held property in Saskatchewan for many years and has tested several areas by drilling. Also, a two-year solution-mining test was conducted near Saskatoon from 1963 to 1965. In July 1965 the development of a twin shaft potash mine was announced and work was started before the end of the year.

The plant is located about six miles west of Saskatoon and is expected to produce 1.0 million tons of product per year starting in 1969. At the end of 1966 the two 16 ft diameter shafts had reached depths of about 1,800 and 1,600 feet and the contractor had established a shaft-sinking record in the No. 2 shaft. Surface construction was continued throughout the winter and at year-end the refinery building was being erected.

In addition to the projects now under construction several other companies are considering active development and two or more are expected to start work during 1967. In some cases marketing arrangements are not yet completed and in other cases the performance of other potash producing operations, or the estimated supply-demand balance at the date of the projects' completion (in 3 or 4 years), are deciding factors.

Among several companies expected to develop projects, Southwest Potash Corporation, with a property near Yorkton, has completed much of the preliminary work and is in a position to announce active development. Southwest operated a solution mine test plant for two years but present thinking is in terms of a twin shaft mine and refinery capable of producing about 1.0 million tons per year. Similarly, Sylvite of Canada Ltd., formed by Tombill Mines Limited and Francana Oil & Gas Ltd., holds a property adjoining IMC and has completed enough work to make a development decision. During 1966 Hudson Bay Mining and Smelting Co., Limited purchased Francana Oil & Gas Ltd. and gained a controlling interest in Sylvite.

Several other companies, including Scurry-Rainbow Oil Limited, National Potash Company and Kerr-McGee Oil Industries, Inc., are believed to hold attractive potash deposits.

Although overshadowed by the major developments in Saskatchewan, potash was of interest in two other provinces in 1966. Several permits for potash were recorded in Alberta and, in Nova Scotia, encouraging results were obtained from an investigation of potash occurrences by the Atlantic Development Board and the Nova Scotia Department of Mines. Geophysical and geological studies of the area between Pugwash and Oxford, and in the Malagash-Wallace area, together with a limited amount of shallow and deep drilling, served as a preliminary investigation. The possibility of recovering salt (NaCl) and potash (KCl) by solution mining methods from the4,000foot deep deposit has been suggested by this work.

Several companies specializing in various phases of exploration, shaft-sinking and construction have made noteworthy contributions to the solution of the problems peculiar to potash developments in Saskatchewan. Two companies employing different and highly specialized shaft-sinking techniques have been active in Saskatchewan for several years. Both have established records for sinking and lining Saskatchewan potash shafts. These companies are; The Cementation Company (Canada) Limited, and AMC-Harrison Ltd., a joint company formed by Associated Mining Construction of West German origin and the Harrison shaft-sinking group of Canada. Oil well drilling techniques have been adapted to potash problems. South African shaft equipment, Canadian mucking machines, British and German shaft lining techniques and Canadian shaft-sinking

TABLE 4

World Potash Production, Consumption and Trade by Continents
1964-65

	Production (%)	Consumption (%)	Exports	Imports
			Thousands metric tons	K_2O equivalent
Europe	53.9	48.7	3,220	3,015
USSR	16.0	12.8	314	—
North America	27.8	26.1	1,270	946
South America	0.3	1.6	14[e]	128
Asia	2.0	7.7	209	840
Africa	—	1.7	—	115[e]
Oceania	—	1.4	—	155
Totals	100.0	100.0	5,027	5,199

Sources: *Fertilizers, 1965 FAO of United Nations*, Tables 2 and 4.
— Nil; [e] Estimated by author.

experience have now developed into a new body of technical and practical experience which will be used even more effectively in Saskatchewan and undoubtedly will be in demand for difficult mining projects throughout the world.

Several companies, in particular, Stearns-Roger Canada Ltd., have been involved in the planning, construction and starting of the major plants to beneficiate potash ores. The schedules of these projects, and the high capacity operation of the plants in production, is convincing proof of the careful planning, technical skill and the work of a great many people, from foreign and Canadian engineers to Saskatchewan farmers turned miners.

WORLD REVIEW

The world-wide potash industry is now influenced by several factors which are difficult to assess accurately and which are vitally important to the individual companies involved, or about to become involved, as producers. Over the long term world requirements for fertilizer, as the most direct solution to the population-famine problems, are clearly apparent to all who have studied the approaching crisis. However, the immediate future is indistinct because there is as yet no assurance that world fertilizer requirements, which are very large, are within the practical and economic ability of the industrialized world.

The Saskatchewan potash deposits, because of their size, and quality, are certain to become one of the dominating factors in the world potash industry. Already their production, and potential production, is affecting operations and plans in other parts of the world as companies with less attractive raw materials and more costly operations reduce production and adjust their activities to changing conditions. Major potash developments are also in progress in USSR and these seem destined to become another major factor in world potash.

TABLE 5

Estimated World Potash Resources and Production in 1965 and 1966

Country	Reserves millions metric tons	Per cent K_2O	Production-thousand metric tons K_2O 1965	1966
United States			2,849	2,995
New Mexico	400	18		—
Utah-Colorado	400	25		—
West Germany	10,000	12	2,385	2,297
USSR	50,000	15	2,368	2,700
East Germany	10,000	20	1,825	1,900
France	300	17	1,808	1,736
Canada	50,000	25	1,297	1,855
Spain	340	16	0.364	0.395
Italy	155	12	0.169	0.190
Israel (including Jordan reserves)	1,200	3	0.289	0.305
Chile (KNO_3)	?	2	0.020	0.023
Ethiopia	50	25	—	—
Congo	40	20	—	—
Britain			—	—
England	150	16	—	—
Scotland (shales)	100	10	—	—
Peru (brines)	12	3	—	—
Morocco	300	12	—	—
Libya	9	?	—	—
Brazil	11	15	—	—
Poland	165	8	—	—
Totals	125,000	15	13,394	14,423

Sources: *Phosphorus and Potassium*, U.S. Bureau of Mines and others.
(Includes estimates based on limited data)
Note: 1 metric ton = 1.1023 short tons

However, the USSR and associated countries of the Communist Bloc have pressing domestic needs for additional fertilizer materials whereas Canadian production will be mainly directed to export.

The rising scale of world potash operations justifies increasing sophistication in all sections of the industry, from production and beneficiation to transportation and marketing, and, at the same time, tends to reduce the unit cost of potash to the consumer. This is probably the most important factor in the expansion of potash production because stable and relatively low prices would appear to offer a strong incentive in efforts to enlarge the world-wide potash market.

UNITED STATES

In the United States potash production increased about 5 per cent to a new high of almost 3.0 million metric tons. Reductions of output at Carlsbad, New Mexico, have been announced by two producers which have properties in Saskatchewan. At Moab, Utah, the Potash Division of Texas Gulf Sulphur Company reported improvements in operations and announced that a crystallization unit would be added to increase recovery. Projects to recover potash from brines were being considered in Arkansas, Utah and California.

USSR

New potash producing projects were under construction in the three producing areas of USSR. At Soligorsk, the first plant was completed in 1964 with a capacity of 2.0 million metric tons per year K_2O. Operations started in 1966 at the second plant, which has a capacity of 2.2 million tons per year, and a third complex is scheduled to start in 1969 with a capacity of 2.4 million tons per year. Equipment for expansion is being obtained from West Germany and Poland. Production in 1966 was about 2.7 million metric tons and is expected to increase substantially.

WEST GERMANY

Output in 1966 totalled 2.3 million metric tons, down slightly from the record production of 1965. Increasing competition for markets resulted in some build-up of stocks and a few producers reduced output. Efforts are being made to improve efficiency at some of the mines and developing countries have been given assistance in making potash purchases.

EAST GERMANY

Output in 1966, at 1.9 million metric tons was somewhat greater than in 1965 and work is in progress on two new mines. These are scheduled for production in 1970 and no significant change in output is expected until then.

FRANCE

Production at 1.74 million tons was somewhat lower than in 1965 due to competition for markets in Europe. There is doubt that output can be increased in France but the French company, Mines Domaniales de Potasse d'Alsace, holds a half interest in Alwinsal Potash of Canada Limited and is active in potash exploration in other areas.

SPAIN, ITALY AND ISRAEL

Production increased slightly in each country in 1966 and further expansion is planned, particularly in Spain and Israel. In Israel a pipeline project to transport potash from the plant at Sodom to the port of Ashdod was under study.

Potash projects are at various stages of development in several other countries. These range from fairly large mining and processing plants to relative small production from brine sources. Many, however, are significant because they are taking place in Africa or South America where supplies are needed.

Compagnie des Potasses du Congo has obtained funds from the World Bank to assist in the development of its $82 million potash project near Holle in the Congo. Production at the rate of 500,000 tons K_2O per year is expected in 1969. The ore is reported to be sylvinite grading 18-35 per cent K_2O.

The potash deposit in the Danakil Depression of Ethiopia, some 45 miles from the Red Sea, is under development by the Ralph M. Parsons Company of the United States. Production of 500,000 metric tons K_2O per year is expected to start in 1969.

Potash occurrences have also been found in Morocco, Libya and Tunisia and development work has been done to investigate their potential. Yugoslav and Polish interests are reported to be interested in exploitation of the Moroccan deposit near Khemisset.

In South America the potash brine occurrences in the Sechura desert of northern Peru are being developed for production at the rate of 130,000 tons per year. Potash has been found at two locations in Brazil.

In England a solution mining test is reported to be operating in Yorkshire.

OUTLOOK

In 1966 estimated world potash consumption increased almost 6 per cent over 1965 to a total of 12.7 million metric tons K_2O. Production totalled 14.7 million tons, an increase of some 9 per cent. In 1967 the addition of the IMC K-2 plant and expansions in Spain and elsewhere will add more than 1 million tons of production, suggesting that output in 1967 may reach nearly 16 million metric tons.

In terms of capacity, some 10.5 million tons were available in the western world in 1966, and almost 5 million tons existed in USSR and East Germany, for a world total of more than 15 million tons. Additions to capacity in the western world by 1970 total about 6 million tons K_2O (5 million in Canada, including the IMC K-2 plant, and 1 million in Africa). In USSR and East Germany additional capacity is planned and though information is meager it is estimated that expansion by 1970 may total 5 million tons K_2O. The outlook for potash production by 1970 thus indicates available capacity of about 25 million tons.

While there is no certainty that all this vast potential will materialize, or be used, the countries and individual companies involved have concluded that it is justified. These developments, by realistic and experienced groups, illustrate the trends in and the outlook for potash. The world is running short of food to supply its exploding population. Full use of fertilizer potential will help to resolve the difficult problem of providing enough food for the world's population.

The outlook for potash must therefore be considered highly promising for the world-wide industry in general, and in particular, for Canada.

USES AND SPECIFICATIONS

Potash is one of the three basic ingredients in mixed chemical fertilizers, the others being phosphorus and nitrogen. The familiar grade notations on packaged fertilizers, such as 5-10-15, indicate the percentage content of nitrogen, phosphate and potash in that order. As fertilizer, potash contributes to healthy plant growth and assures the maximum of balanced development by regulating the intake of other fertilizer ingredients.

About 95 per cent of the potash produced is used as fertilizer, five per cent is used in the form of various chemicals of which potassium hydroxide has the widest application. Most fertilizer potash is used as concentrates of muriate (KCl) in various strengths, mixed with other ingredients. Smaller amounts are used as potassium sulphate for particular soils and crops.

PRICES

E & MJ Metal and Mineral Markets of December 26, 1966 quoted the following United States prices: per short ton unit (20 lbs) K_2O contained bulk, f.o.b. Carlsbad, New Mexico

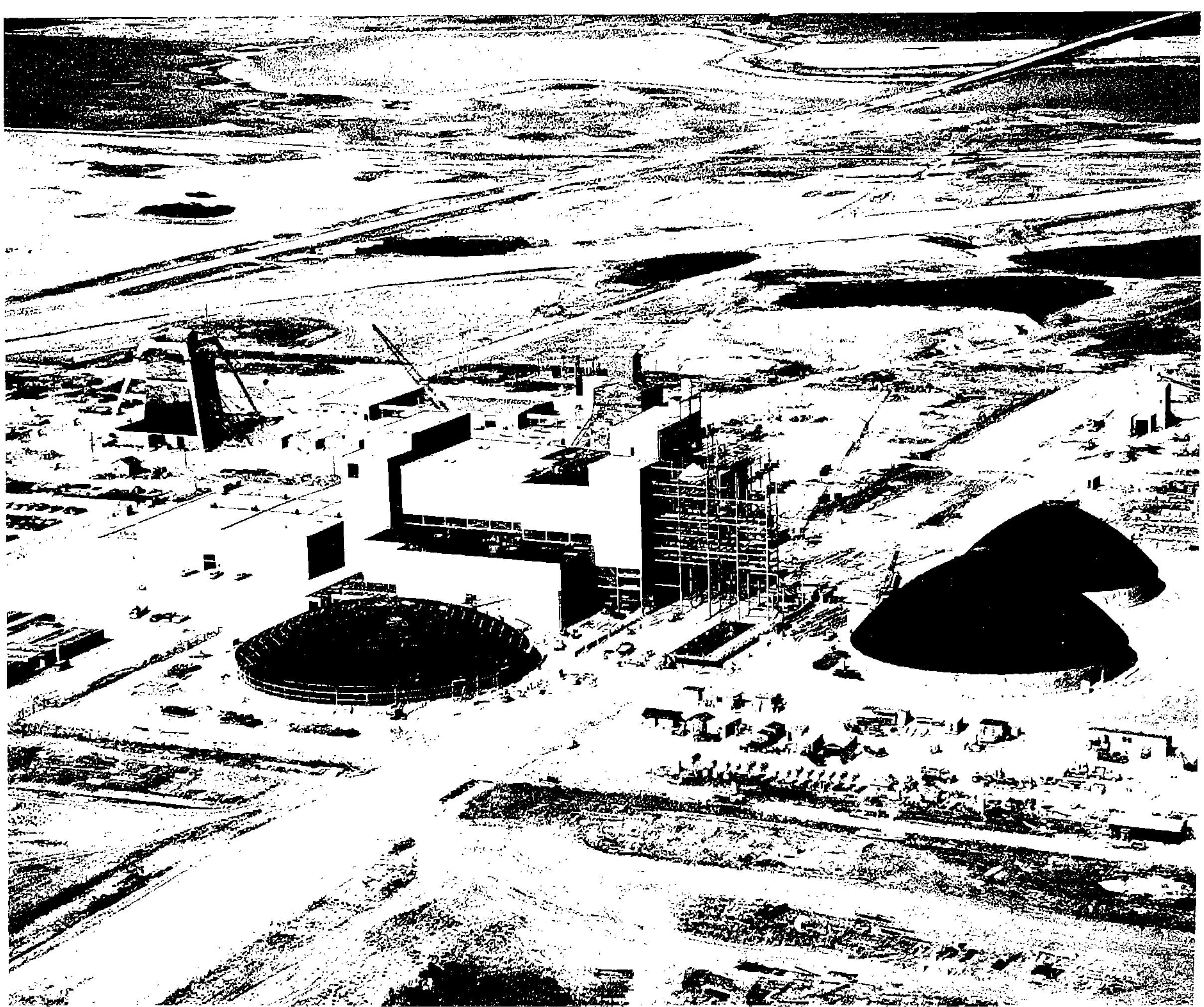
	June – Sept. 1966	Oct. 1966– Jan. 1967	Feb. – May 1967
Muriate 60% K_2O			
Standard	34¢	39¢	42¢
Coarse	38	43	46
Granular	41	47	50
Sulphate, 50% K_2O			
Standard	70¢	75¢	80¢
Granular	78	83	88

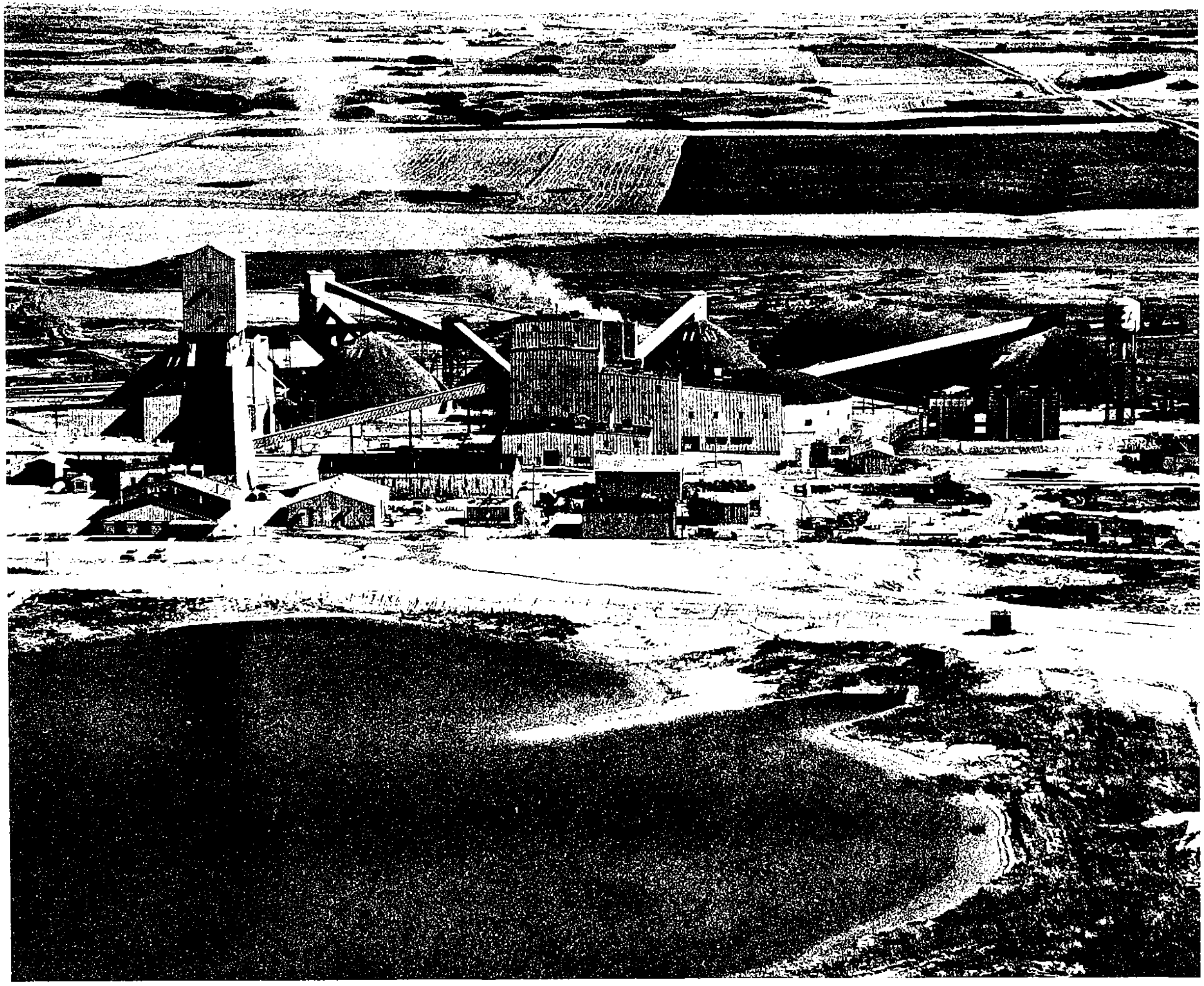
f.o.b. Saskatchewan, Canada
(same quotes as f.o.b. Carlsbad – will equalize to Carlsbad delivery if it is cheaper).

TARIFFS

	British Preferential	Most Favoured Nation	General
Canada			
Potash, muriate and sulphate of crude; saltpetre or nitrate of potash	free	free	free
German potash salts and German mineral potash	free	free	free
Potassium chloride	free	free	25%
Potash, chlorate of, not further processed than ground	free	15%	20%
United States			
Potassium chloride or muriate of potash		free	
Potassium sulphate		free	
Potassium nitrate or saltpetre, crude		free	

SOMETHING NEW IN MINE HEAD FRAMES: Surface buildings of Allan Potash Mines, under construction 40 miles east of Saskatoon, Saskatchewan, in September 1966. The four-legged head frame is new to mining construction.





FIRST PRODUCER IN SASKATCHEWAN'S THRIVING POTASH INDUSTRY: Potash Company of America's plant at Patience Lake, just east of Saskatoon. The plant began operations in 1958, but closed in 1959 for major shaft repairs. After reopening in 1965, it has continued operations at capacity.

Rare-Earth Elements

W.H. JACKSON*

The common classification of the rare earths includes elements 57 to 71 inclusive, namely: lanthanum, cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium and lutetium. The term rare-earth elements includes yttrium, element 39, as its chemistry is similar and from a geological viewpoint the occurrence is the same. Some workers also include scandium, element 21.

The relative abundance of the rare earths in the earth's crust in relation to one another is: cerium 28.6, yttrium 17.8, neodymium 15.9, lanthanum 11.4, gadolinium 6.4, praseodymium 4.45, dysprosium 2.9, erbium 2.5, ytterbium 1.9, terbium 1.0, europium 0.8, holmium 0.8, lutetium 0.6, thulium 0.5 and promethium is not detectable. Accordingly, the more abundant rare-earths will tend to predominate in mineral deposits.

The main minerals containing the rare-earth elements are euxenite, brannerite, priorite, pyrochlore, bastnasite, monazite, apatite and xenotime. Of the rare-earth elements only promethium is not recovered from naturally occurring minerals. It was detected in 1947 as a fission product of spent nuclear fuels and can be recovered from this source.

Low priced mixtures of rare earths comprise most of the tonnage sold by processors of rare-earth concentrates. The greatest revenue is obtained from a relatively small quantity of separated compounds containing yttrium and europium which are mainly used as phosphors. Accordingly, concentrates high in yttrium and europium are in demand, and other rare-earth elements in ores or in concentrates have no significant value. This situation will likely prevail until demand for other rare-earth elements progresses to the point where payment for processing costs is warranted. As quantities of most rare earths are recovered in processing those which can be profitably sold, there are now quantities of most of rare earths on hand and this has stimulated research on them.

WORLD SOURCES

Data on world sources of rare earths and quantities produced are lacking in any detail. The Finnish producer, Typpi Oy, is the only company that recovers high-grade concentrates of yttrium and europium from Russian apatite which is high in these elements and in gadolinium, thulium and erbium but is low in cerium. Yttrium concentrate is a coproduct of gravel-pump tin mining in Malaysia in the form of the mineral xenotime and 150 long tons were produced in 1966. Xenotime is mainly sold to European processors. Further investigation of this source by tin producers is expected. The

*Mineral Resources Division.

grade of concentrate is variable but may range from 25 to 50 per cent yttrium oxide. Monazite is still a source of mixed rare earths but this source lacks significant amounts of the elements in demand and, accordingly, has a low unit value. The yttrium oxide content is typically lower than 0.04 per cent. The main source of the few thousand tons produced is Australia; additional sources are Malaysia, Ceylon, Korea, Malagasy, Nigeria, and Brazil.

Demand for the rare-earth elements has not evolved in proportion to content of the elements in available ores. Monazite and bastnasite, the main sources of mixed rare-earth oxides, are in ample supply. The present pattern of the industry arose in response to the need to provide economic sources of yttrium and europium to avoid utilization of plant capacity in undue processing of unwanted elements. The development of solvent extraction methods permitted rejection early in the recovery process of the bulk of the elements and impurities. Sources high in yttrium were sought such as the byproduct production of the Canadian uranium mines or xenotime, both of which can be processed by ion-exchange methods.

United States is the main producer and main market for ores containing the rare-earths. Its ore production is in the order of 30,000 tons annually. United States annual production of mixed rare-earth oxides is about 4,000 tons and of high-purity rare-earths about 150 tons. The market in the United States and elsewhere is small but growing.

Molybdenum Corporation of America is the main producer of rare-earth ore. Bastnasite is recovered from a carbonatite-type of deposit located at Mountain Pass, California. In 1966, the annual mill capacity was expanded from 9 million pounds of rare-earth oxides to 30 million pounds and a new mill is to be constructed with 50 million pounds capacity. The ore grades about 10 per cent rare-earth oxides and flotation concentrates grade 70 per cent. In this particular ore, the light rare earths, lanthanum through gadolinium, predominate and although the europium content is only 0.11 per cent this element is of particular value. The yttrium content is only 0.05 per cent. Capacity to recover europium oxide from this complex ore has been increased from 6,000 pounds annually in 1965 to 20,000 pounds at the end of 1966.

The general process is illustrative of the problems in treating the admixture of rare earths in bastnasite. For europium recovery, the concentrate is roasted, digested in concentrated hydrochloric acid, and then insoluble cerium products are removed by filtration. Details of the subsequent two-step solvent extraction have not been published. By keeping the pH selective to europium a 98-per-cent recovery is made, using di-2, ethylhexylphosphoric acid as the extractant, from solutions containing 0.002 pound of europium oxide per gallon. Products of this bulk separation include lanthanum, neodymium and praseodymium. In another step, europium is separated from samarium, gadolinium and yttrium oxides. The final purified solution flows through zinc amalgam to reduce europium to its divalent state, which is then precipitated with sulphuric acid. Phosphor-grade (99.9 per cent) europium oxide production began in July 1965. A related plant at Louviers, Colorado, can produce 180,000 pounds of 99.9 per cent yttrium oxide and neodymium oxide capacity of 200 tons annually is to be constructed.

A combined solvent extraction — ion exchange process will be utilized by American Potash and Chemical Corporation in 1967 for europium and yttrium recovery. In 1966, one company recovered euxenite residues which provided some 200,000 pounds of yttrium oxide to relieve a potential shortage. As Canadian production of yttrium concentrate is being expanded, supplies for 1967 are adequate. Michigan Chemical Corporation, which processes part of the Canadian concentrate and whose sources probably average 10 to 15 per cent yttrium oxide, has optioned an euxenite property in Idaho. In addition to the yttrium content, the heavy rare earths tend to predominate in the ore. The company announced that production of yttrium oxide would be increased from 60,000 pounds annually to 140,000 pounds in 1967.

Processors of rare earths include: in the United States, American Potash and Chemical Corporation, W.R. Grace and Co., Molybdenum Corporation of America, Michigan Chemical Corporation, and Nuclear Corporation of America; in Austria, Treibacher Chemische Werke Aktiengesellschaft; in France, Pechiney, Compagnie de Produits Chimiques et Electrometallurgiques; in Britain, New Metals and Chemicals Limited, London and Scandinavian Metallurgical Company, Johnson, Matthey and Co., Limited, and Thorium Limited; in Finland, Typpi Oy; in West Germany, Th. Goldschmidt A.G.; and in Japan, Santoku Metal Industry Company. Production from the USSR is sold through Techsnabexport. India and Brazil also have plants that produce chemicals. "Compilation of Rare-Earth Products Available from Commercial Suppliers" issued by the Rare-Earth Information Center, Ames, Iowa, provides additional information.

CANADIAN INDUSTRY

Rare-earth recovery in the Elliot Lake district of Ontario, has resulted in a stable and continuing source of yttrium-bearing concentrate for processors. There are no facilities in Canada for the separation of the individual rare earths and all output is exported.

The uranium ores at Elliot Lake contain, in per cent, about 0.11 uranium oxide (U_3O_8), 0.028 thorium oxide (ThO_2) and 0.057 rare-earth oxides. The distribution of rare earths is variable but approximates in per cent 20 to 40 yttrium oxide, 20 cerium oxide, and 10 to 20 neodymium oxide; other light rare-earths individually seldom exceed 5 per cent but only promethium has not been detected. Thorium and the rare earths can be recovered as chemical precipitates from mine waters or from effluent solutions, formerly wasted, following uranium recovery. Quantities, values, and grade of rare-earth concentrates produced have not been published but value would likely vary with the yttrium oxide content and with impurities.

Rio Algom Mines Limited was the first to achieve commercial rare-earth production when in 1965 Rio Tinto Nuclear Products Limited installed an organic solvent extraction recovery plant at Rio Algom's Nordic Mine. Thorium is stripped first, followed by rare-earth recovery. The initial rate of output was 100,000 pounds annually. Shipments were made to Yttrium Corporation of America and Thorium Limited. Since early 1966, Stanrock Uranium Mines Limited has recovered rare earths in addition to uranium by bacterial leaching of underground workings. Sales contracts with Michigan Chemical Corporation called for a minimum rate of 1,500 pounds monthly. In 1966, Denison Mines Limited added a recovery circuit and production of rare earths commenced in January 1967. Contracts for up to 300,000 pounds annually were negotiated with Michigan Chemical and Yttrium Corporation of America but the actual production rate was not announced.

Percentage recovery of rare-earth elements recovered from processing ores of the Elliot Lake area is not precisely known but it is certain that production will increase in proportion to increased output of uranium at the mines in the coming years. Similar conglomerate-type uranium deposits are known to the east at Agnew Lake where Agnew Lake Mines Limited formed by Kerr Addison Mines Limited and Quebec Mattagami Minerals Limited in 1967, is carrying out development work. Rare earths are also associated with uranium deposits in the Bancroft area of Ontario and at one deposit in British Columbia; the distribution of rare-earth elements in these deposits is not known. Phosphorite formations in western Canada contain small quantities of rare earths and so does Florida phosphate imported into Canada for the production of phosphoric acid. Other potential sources include the rare-earth content of apatite or pyrochlore associated with carbonatite rocks. Again, the distribution of rare-earth elements is not known and there remains the problem of working out recovery methods.

Few laboratories are equipped to analyze samples containing the rare-earth elements. Assay results can be misleading as a guide to further work on a prospect or on the examination of possible byproduct sources unless the laboratory is provided with information on the mineralogy or chemistry of the test material.

USES

Rare-earth oxides, products of chemical extraction, are mainly used as mixtures in about the same proportions as they occur in concentrate. Major outlets include glass-polishing compounds and the use of both oxides and fluorides of mixed rare earths in carbon-arc lights. Mixed rare-earth metal (mischmetal), a product available for many years, is made by fused salt electrolysis of mixed rare-earth chloride, purified of phosphate and sulphate. Mischmetal is used for lighter flints, in nodular cast iron, and in magnesium alloys. Master alloys for nodular cast iron can also be made from rare-earth minerals. A more refined product that is a mixture of rare-earth chlorides of cerium, lanthanum, praseodymium, neodymium and samarium, the members of lower atomic weight, is used in petroleum-cracking catalysts. Didymium and cerium salts colour glass.

Of the higher-purity compounds, yttrium and europium oxides are currently in demand for the electronics industry. They are used in the approximate ratio of 14 to 1 as the red phosphor, europium-doped yttrium vanadate in colour television tubes and in mercury vapour lamps. Yttrium, neodymium and gadolinium have potential as components of glasses or artificial garnets for microwave applications and for lasers. Dysprosium is a component of phosphors in fluorescent lighting tubes and neodymium in television tube filters. Lanthanum oxide is used in camera lens glass, praseodymium oxide in colouring ceramics yellow, and yttrium oxide in ceramics for high temperature applications. Other pure separated rare earths are mainly used for research purposes. These are costly but prices bear no relation whatever to the value of the elements in the raw materials from which they are derived. Promethium 147 is being investigated as a thermal power source, as among the heat-producing radioisotopes, it does not emit intense gamma radiation and consequently requires less shielding.

PRICES

E & MJ Metal and Mineral Markets in December 1966 quoted a nominal value for monazite, on a per pound total rare-earth content basis, of 14 cents for massive material grading 55 per cent rare-earth oxides. For monazite sands containing 55 per cent rare earths, the price quoted was 8 cents a pound, for 60 per cent material it was 10 cents, and for 66 per cent material 12 cents. The thorium and phosphate content are presently considered to be impurities and no payment is made for them.

Mixed rare earths in the form of bastnasite concentrates assaying 55 to 60 per cent rare-earth oxide sell for 30 cents a pound, f.o.b. Nipton, California, and 68 to 72 per cent for 35 cents a pound. Mixed rare-earth oxide assaying 88 to 92 per cent rare-earth oxide is worth 45 cents a pound.

In general, a mixed concentrate commands a relatively low price and prices are subject to negotiation between buyer and seller. Concentrates high in rare-earth elements in demand, mainly europium and yttrium, command higher prices, but are still subject to negotiation. There is no information on the basis of payment for these elements.

Mischmetal sells for about $3.00 a pound; rare-earth oxides suitable for glass polishes for $0.75 to $1.50 a pound. Representative prices per pound for some oxides of 99.9 per cent purity include: $7.50 for cerium, $37.50 for neodymium, $55 for yttrium, $550 to $850 for europium. Metal prices, per pound, are quoted at $70 for cerium, $115 for neodymium, $160 for yttrium and $1,200 to $5,000 for europium.

Roofing Granules

H.S. WILSON*

Consumption of roofing granules in Canada during 1966 amounted to 133,857 short tons, valued at $3.57 million. This is an increase of 5.3 per cent in volume and 4.7 per cent in value over the 1965 figures of 127,066 short tons and $3.41 million.

Consumption of artificially-coloured granules increased 7.0 per cent in volume and 6.6 per cent in value from 1965 to 1966. Naturally-coloured granules including slag, showed an increase in consumption of 3.1 per cent in volume and 0.7 per cent in value. Consumption of slag granules alone, decreased 1.4 per cent in volume and 2.1 per cent in value.

The consumption of the three types of granules produced in Canada increased during 1966, whereas the consumption of the three types of granules imported from the United States decreased. The Canadian share of the total granule market increased from 76.9 per cent in 1965 to 79.7 per cent in 1966. The Canadian portion of the naturally-coloured granules consumed amounted to 82.6 per cent in 1966, increased from 79.5 in 1965. Of the artificially-coloured granules consumed, 77.7 per cent was produced in Canada, in 1966, compared with 74.9 per cent, in 1965. The percentage of slag granules consumed that were produced in Canada increased from 76.6 in 1965 to 80.7 in 1966.

Table 1 shows the consumption in 1965 and 1966 by type and colour, and the consumption of domestic and imported granules. Table 2 shows granule consumption for the period 1954 to 1966, the total annual values, the average price per ton for each year and the percentage of granules consumed that were produced in Canada. Table 3 shows the average prices of naturally- and artificially-coloured granules, both domestic and imported, for 1965 and 1966. In all tables, the prices are f.o.b. consumer plants.

*Mineral Processing Division, Mines Branch.

TABLE 1

Consumption*

	1965		1966	
	Short tons	$	Short tons	$
Consumption				
By kind				
Artificially coloured	73,039	2,359,855	78,159	2,516,535
Naturally coloured	54,027	1,049,566	55,698	1,057,404
Total	127,066	3,409,421	133,857	3,573,939
By colour				
Black and grey-black	51,263	1,096,432	55,159	1,164,592
Grey	21,081	384,885	21,951	402,170
White	20,701	814,747	21,948	860,139
Green	16,972	567,120	17,799	607,636
Red	6,321	182,773	6,503	187,919
Brown and tan	6,153	179,592	6,468	194,105
Blue	2,778	114,399	2,289	96,945
Buff	688	25,577	801	28,214
Turquoise	542	23,932	342	14,786
Coral, cream and yellow	567	19,964	325	9,844
Not differentiated	–	–	272	7,589
Total	127,066	3,409,421	133,857	3,573,939
Canadian produced				
Artificially coloured	54,734	1,646,159	60,697	1,851,128
Naturally coloured	42,935	794,729	46,034	843,586
Total	97,669	2,440,888	106,731	2,694,714
Imported, United States:				
Artificially coloured	18,305	713,696	17,462	665,407
Naturally coloured	11,092	254,837	9,664	213,818
Total	29,397	968,533	27,126	879,225

* Values calculated from figures supplied by the consumers

– Nil

TABLE 2

Consumption 1954 - 66

	Total Tons	Total Dollars	Average Price/Ton	Canadian Percentage
1966	133,857	3,573,857	26.70	79.7
1965	127,066	3,409,421	26.83	76.9
1964	140,890	3,852,704	27.35	73.9
1963	125,909	3,392,354	26.94	68.8
1962	125,463	3,476,875	27.71	59.5
1961	123,486	3,286,670	26.62	35.8
1960	113,826	2,962,363	26.03	44.7
1959	138,758	4,182,615	30.14	37.1
1958	134,565	4,509,638	31.82	29.8
1957	110,543	3,405,655	30.90	29.8
1956	133,691	3,884,961	29.20	25.0
1955	147,877	4,087,668	27.70	18.3
1954	133,917	3,563,578	26.61	19.0

CANADIAN PRODUCERS

Manufacturers of granules in Canada are located at Havelock, Ont., Montreal, Que., and Vancouver, B.C.

Minnesota Minerals Limited at Havelock crushes a trap rock (basalt) for granules and operates a colouring plant, which produces a wide range of artificially-coloured granules. This basalt is also crushed in sizes suitable for other uses, principally for road building and concrete aggregate applications.

Industrial Granules Ltd. of Montreal, the producer of the black-slag granule, obtains its raw material, a waste slag, from a steam-generating plant in Halifax, N.S. Other sources

TABLE 3

Average Granule Prices
($ per short ton)

	Canadian		Imported	
	1965	1966	1965	1966
Naturally coloured				
Rock	15.13	17.80	20.78	18.61
Slag	20.76	20.66	24.49	24.95
Slate	21.49	19.89	–	–
Artificially coloured				
Black and grey-black	21.13	22.05	34.65	32.99
Grey	28.89	26.02	30.22	29.39
White	38.38	39.00	41.25	39.58
Green	31.16	32.43	40.71	40.10
Red	26.00	27.30	35.28	34.62
Brown and tan	27.34	28.59	35.74	36.42
Blue	38.82	40.12	46.33	46.50
Buff	37.14	33.79	37.27	39.53
Turquoise	42.35	38.04	48.75	48.31
Coral, cream and yellow	28.71	28.97	44.73	41.62
Not differentiated	–	–	–	29.70
Average	31.99	30.50	39.49	38.11

of waste slag are constantly being investigated for their ability to granulate with a minimum of acicular-shaped fragments when quenched. The slag must be free from deleterious materials; its composition has much to do with the success of the granule product. A low iron content is necessary to assure freedom from staining of the granule surface when exposed to the weather.

G.W. Richmond of Vancouver, B.C., produces slate granules.

ROOFING PLANTS

There were six companies manufacturing roofing shingles in 15 plants in Canada at the end of 1966. The three plants operated by Allied Chemical Canada, Ltd., at Montreal, St. Boniface and Vancouver were purchased by Canadian Gypsum Company, Limited, during the year. Two roofing plants were closed during the year: Building Products of Canada Limited, at Hamilton, Ont., and Domtar Construction Materials Ltd., at St. John, N.B.

The companies and plants manufacturing roofing at the end of 1966 are:

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
- Abestos, Que.

Domtar Construction Materials Ltd.
- Brantford, Ont.
- Burnaby, B.C.
- Lachine, Que.
- Lloydminster, Alta.

Iko Asphalt Roofing Products Limited
- Brampton, Ont.
- Calgary, Alta.

The Philip Carey Company Ltd.
- Lennoxville, Que.

Salt

D.H. STONEHOUSE*

During 1966, salt production in Canada maintained the record level reached the previous year despite the fact that one major producer of rock salt was idle because of a strike during part of the winter season. Preliminary statistics indicate total production to be 4.3 million tons of which a little over 50 per cent was mined rock salt, about 35 per cent was recorded as salt content of brine, 12 per cent was fine vacuum pan salt, and the remainder was salt recovered from chemical operations. Production from Ontario accounted for slightly more than 84 per cent of the total; Nova Scotia produced about 10 per cent.

Imports increased by 15.4 per cent to 510,000 tons, with notable increases from the Bahamas and from Mexico. This is a record for salt imports, which have been increasing steadily since 1960.

Since 1959, figures on the amount of exported salt have not been available for publication. Total value of exports dropped by 28 per cent from close to $5.0 million to $3.6 million. This was caused in part by a loss of some United States business as a result of a strike at one major salt operation in Ontario during the late winter of 1966. Quantities exported to Jamaica, British Guiana, and those listed as other countries in Table 1, were also less than in 1965. United States continues to be the main foreign market for Canadian salt, accounting for 94 per cent of the total value of exports during 1966. About 55 per cent of the salt imported into the United States comes from Canada.

Increased use of salt by the manufacturers of industrial chemicals is evident in recent years and the amount so used in 1964 rose 500,000 tons over that used the previous year. The second-largest market for salt is in the removal and control of ice and snow, mainly on highways.

PRODUCERS

ONTARIO

Thick salt beds underlie the southwestern section of Ontario between Kincardine and Amherstburg at depths varying from 800 feet to 1,800 feet. Exploitation of this resource has kept Ontario the leading salt-producing province.

*Mineral Processing Division, Mines Branch.

Rock salt is produced from two mines in Ontario, one at Ojibway, operated by The Canadian Rock Salt Company Limited, the other at Goderich, operated by Sifto Salt Division of Domtar Chemicals Limited. Room and pillar mining methods and trackless conveying equipment are used in both mines. Ojibway works on the 980-foot horizon, taking an 18-foot section; Goderich works at a depth of 1,760 feet, removing a 45-foot vertical section.

TABLE 1

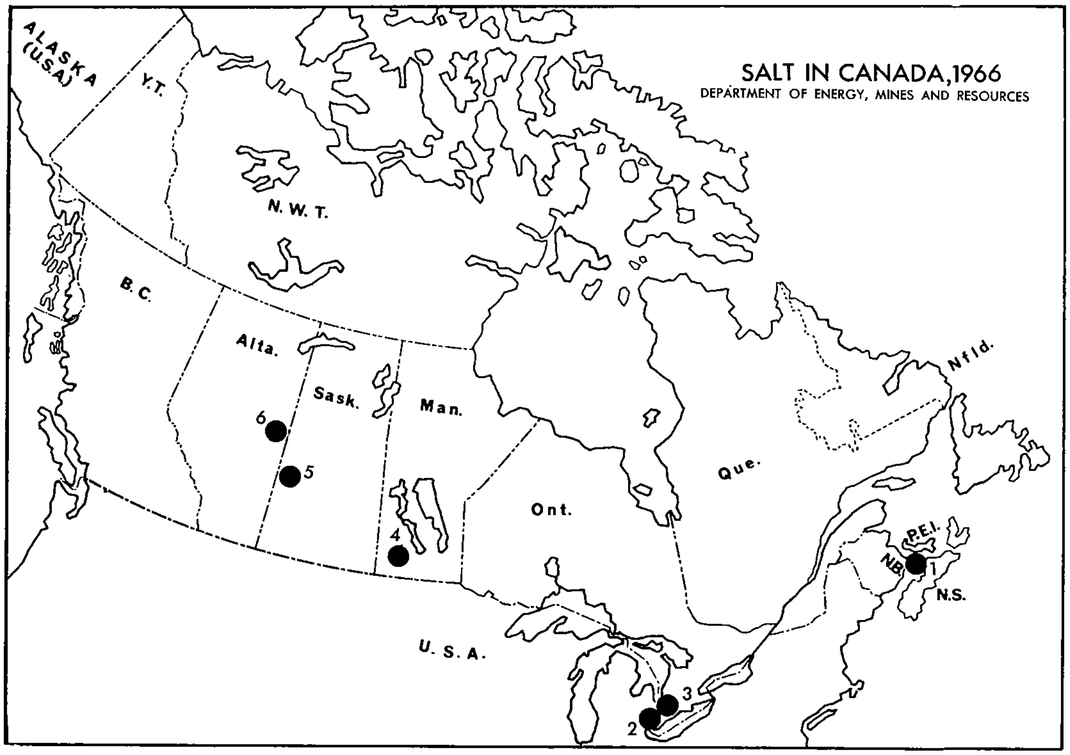
Salt—Production and Trade, 1965-66

	1965		1966P	
	Short tons	$	Short Tons	$
Production (shipments)				
By type				
Fine vacuum salt	558,346	10,164,034		
Mine rock salt	2,399,919	11,726,289		
Salt recovered in chemical operations	10,000	45,130		
Salt content of brines used or shipped	1,615,831	2,050,391		
Total	4,584,096	23,985,844	4,328,245	23,162,763
By provinces				
Ontario	3,900,484	15,499,274	3,647,632	14,340,218
Nova Scotia	459,114	4,607,548	447,805	4,847,188
Alberta	115,706	1,815,828	116,000	1,591,700
Saskatchewan	78,958	1,413,001	89,808	1,721,057
Manitoba	29,834	650,193	27,000	662,600
Total	4,584,096	23,985,844	4,328,245	23,162,763
Imports				
Total, salt and brine				
Mexico	190,066	251,923	220,841	302,000
United States	184,022	1,411,970	174,634	1,330,000
Bahamas	20,106	80,044	76,405	304,000
Spain	44,949	188,999	35,133	134,000
Jamaica	2,079	8,947	2,496	45,000
Britain	69	1,930	39	3,000
Netherlands	310	6,039	—	—
Total	441,601	1,949,852	509,548	2,118,000
Exports*				
United States		4,740,135		3,371,000
Jamaica		100,290		98,000
British Guiana		41,260		26,000
New Zealand		16,176		24,000
Leeward and Windward Islands		18,245		23,000
Bermuda		9,604		10,000
Other countries		70,799		36,000
Total		4,996,509		3,588,000

Source: Dominion Bureau of Statistics.

*Quantities not available.

P Preliminary; — Nil.



EVAPORATOR PLANTS

(numbers refer to numbers on map)

1. Domtar Chemicals Limited, Sifto Salt Division, Nappan, N.S.
   The Canadian Rock Salt Company Limited, Pugwash, N.S.
2. The Canadian Salt Company Limited, Sandwich, Ont.
   Allied Chemical Canada, Ltd. Amherstburg, Ont.
3. Domtar Chemicals Limited, Sifto Salt Division, Goderich, Ont.
4. The Canadian Salt Company Limited, Neepawa, Man.
5. Domtar Chemicals Limited, Sifto Salt Division, Unity, Sask.
6. The Canadian Salt Company Limited, Lindbergh, Alta.

FUSION PLANTS

2. The Canadian Salt Company Limited, Sandwich, Ont.
5. Domtar Chemicals Limited, Sifto Salt Division, Unity, Sask.
6. The Canadian Salt Company Limited, Lindbergh, Alta.

MINES

1. The Canadian Rock Salt Company Limited, Pugwash, N.S.
2. The Canadian Rock Salt Company Limited, Ojibway, Ont.
3. Domtar Chemicals Limited, Sifto Salt Division, Goderich, Ont.

TABLE 2

Salt - Production and Trade, 1957-66
(short tons)

	Production[1]	Imports	Exports[3] Tons	Exports[3] $
1957	1,771,559	367,483	457,888	
1958	2,375,192	340,887	906,707[2]	
1959	3,289,976	369,967	1,274,077	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
1966p	4,328,245	509,548		3,588,000

Source: Dominion Bureau of Statistics.
[1]Producers' shipments. [2]Adjusted to include salt content of brine, estimated at 500,000 tons, exported to the United States during 1958. [3] Tonnages not available after 1959.
p Preliminary.

Salt is recovered from brining operations in four centres — Sandwich, a suburb of Windsor, Amherstburg, Sarnia and Goderich. The Canadian Salt Company Limited produces fine evaporated salt from brine at Sandwich and a subsidiary, Canadian Brine Limited, also at Sandwich, exports its production of brine via pipelines to a chemical plant in Detroit. Allied Chemical Canada, Ltd., produces industrial salt, soda-ash, calcium chloride and other chemicals at Amherstburg. Caustic soda and chlorine are produced by Dow Chemical of Canada, Limited, at Sarnia from company-owned wells. At Goderich, Domtar Chemicals Limited operates brine wells from which fine evaporated salt is produced. Fused salt is made at the Sandwich plant of The Canadian Salt Company Limited.

NOVA SCOTIA

The Canadian Rock Salt Company Limited operates a rock salt mine at Pugwash where room and pillar mining methods are used. The dome-like body of salt is worked from the 630-foot horizon by rooms 20 to 25 feet in height. Some benching has been done. Brine, made on surface from mined rock salt, is used to produce fine evaporated salt through multiple stage, vacuum pan evaporation at the same plant site.

Fine evaporated salt is produced at Nappan by Sifto Salt Division of Domtar Chemicals Limited from brine which is recovered from depths of 1,100 to 1,800 feet.

PRAIRIE PROVINCES

The Canadian Salt Company Limited operates fine evaporated salt plants at Neepawa, Man., and at Lindbergh, Alta. Natural brine occurs at a 3,600-foot depth at Lindbergh. The plant of Domtar Chemicals Limited at Unity, Sask., uses natural brine from a 3,000-foot depth to produce fine salt. High-purity fused coarse salt is produced at both Unity and Lindbergh. Western Chemicals Ltd. of Calgary produces caustic soda, chlorine and hydrochloric acid at Duvernay, Alta., using brine from company wells.

TABLE 3

World Production
('000 short tons)

	1965
United States	34,687
China	14,300
USSR	10,500
Britain	7,716
West Germany	6,883
India (including Goa)	5,184
Canada	4,584
France	4,255
Other countries	30,481
Total	118,590

Source: US Bureau of Mines, Preprint, *Salt, 1965*.

OTHER OCCURRENCES

In addition to the deposits that underlie the Nappan-Malagash area of Nova Scotia, the western part of southern Ontario and the Unity-Lindbergh area of Saskatchewan-Alberta, rock salt occurs at depth in the Mabou-Port Hood area of Cape Breton Island; near Antigonish in Antigonish County, N.S.; under Hillsborough Bay, P.E.I.; in the area south of Moncton, N.B.; under large sections of southwestern Manitoba, central Saskatchewan and the northeastern part of Alberta; in the area to the north of Great Slave Lake and in the vicinity of Norman Wells in the District of Mackenzie.

Although no definite evidence of rock salt deposits has yet been uncovered, brine springs, indicative of salt, are plentiful in the southwestern section of Newfoundland, north-central Nova Scotia, the Sussex area of New Brunswick, in southwestern Manitoba and northeastern Alberta, on Vancouver and Saltspring Islands in southwestern British Columbia and at Kwinitsa, east of Prince Rupert, B.C.

USES

Salt is the most common and the least expensive source of sodium and chlorine for the manufacture of chemicals containing these elements. There are 11 primary chemicals made directly from salt and most of these are used to make large numbers of other chemicals for direct use or for use in manufacturing processes. Approximately 90 per cent of the salt used for production of chemicals is used to make chlorine and caustic soda. Much of the salt used for the manufacture of chemicals is used as brine.

TABLE 4

Available Data on Consumption of Salt in Specified Canadian Industries, 1963 and 1964
(short tons)

	1963	1964
Manufacturers of industrial chemicals		
Dry salt	405,476	498,340
Brine (salt content)	939,100	1,396,767
Snow and ice control	750,000e	750,000e
Food preparation	50,098	55,582
Slaughtering and meat packing	55,622	58,756
Pulp and paper mills	61,025	67,812
Artificial ice	389	212
Leather tanneries	15,389	7,059
Soap and cleaning preparations	2,471	2,375
Dyeing and finishing textiles	1,570	1,547
Breweries	538	580
Fishing industry and fish processing	75,000e	75,000e
Sausages and sausage casings	1,905	1,932

Source: Dominion Bureau of Statistics except for estimates which are made by the Mineral Processing Division.
e Estimated

The use of salt to achieve soil stabilization for highway construction has received much attention in sections of the United States and this use combined with use for removal of ice and snow from highways comprises a transportation use which is second in importance to chemical uses.

In addition, considerable quantities of salt are used in food processing operations such as bakeries, canneries and dairies. Meat packers, tanners and manufacturers of casings use significant amounts in their products. Other major outlets include the pulp-and-paper industry and the textile industry (for fixing dyes). Considerable quantities are used in the mixing of animal feeds, in refrigeration, in water softener regeneration and as stock salt.

TECHNOLOGY

Salt occurs either in solid form as rock salt, or in solution as a brine. Under favourable conditions affording evaporation, soluble salts are crystallized and deposited from saturated solutions. Sodium chloride deposits several thousand feet thick have been formed from sea waters under lagoonal conditions. Calcium carbonate and sulphates are often associated with the sodium chloride, and where the evaporation was carried to completion, magnesium and potassium salts were formed.

Some deposits have been formed by evaporation of waters containing salts leached from surrounding material. These playa deposits can contain a considerable quantity of carbonate, sulphate and boron.

Salt has plastic qualities and under conditions of great pressure can be made to flow. Dome structures are the result of such deformation of deep deposits of salt.

In Canada, salt production is realized from mining underground deposits, from brining such deposits and from processing natural brine. Mining operations involve room and pillar development and the use of heavy equipment to enable removal and processing of large amounts of salt at low cost. The depth at which a mine is operated, and conditions peculiar to specific mines, determine room and pillar sizes. Rooms vary from 30 to 60 feet in width and from 18 to 50 feet in height. Brining operations consist of circulating water through an underground cavity in a salt deposit and recovering the brine for evaporation on surface, usually in a vacuum-pan installation. One Canadian producer uses the waste fines and scalped material from its rock-salt operation to produce a brine under controlled conditions. The brine is then put through a vacuum-pan evaporation cycle and fine evaporated salt is recovered.

Market requirements dictate whether rock salt or evaporated salt can be used and what quality and screen size would be acceptable. Rock salt is normally crushed, screened and shipped in bulk or in sacks. Rock-salt fines can be compacted to yield a greater recovery of coarser sizes. Some fine evaporated salt is compressed into blocks, licks or briquettes, the last being crushed and sized for specific applications. Various additives are included during processing as required, to provide iodine, cobalt and antiset material.

The association of gypsum, anhydrite and limestone with rock salt in varying degree in some deposits makes necessary some process of beneficiation. Taking advantage of the lesser friability of the impurities, it is common to scalp off coarser fractions after secondary crushing of coarse mine feed. Recent advances in the fields of electronic scanning and thermo-adhesive separation have made the application of such devices practical for use in upgrading coarse rock-salt output for certain markets requiring high purity.

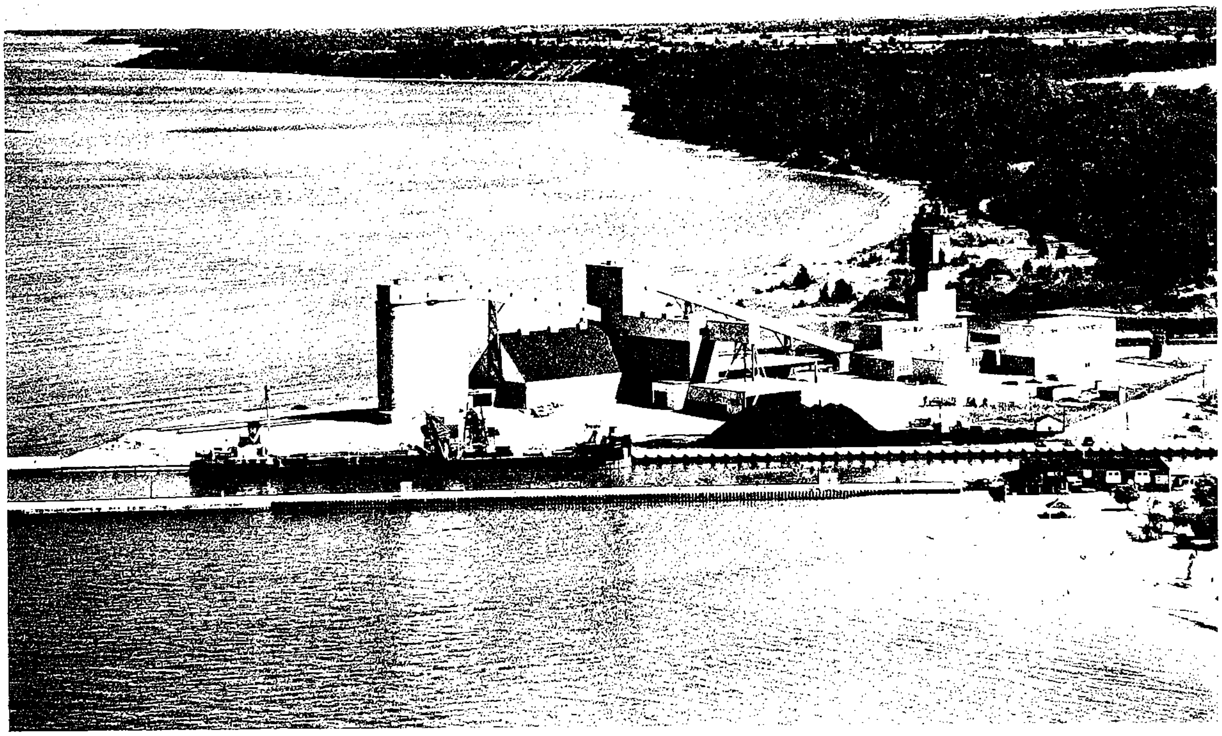
Work continues by major United States salt companies towards producing additives to rock salt used for highway ice control, for inhibiting rusting of automobiles.

Recent patents have been issued for processes for the production of sodium chloride of relatively low bulk density and high surface area. This quality would be considered an asset in the chemical industry and soap and dye stuffs manufacture. Patents for an apparatus and method for dissolving rock salt and separating the gypsum and other impurities from the brine have been issued recently as well.

TARIFFS

	British Preferential	Most Favoured Nation	General
Canada			
Fishery salt	free	free	free
Bulk salt	free	3¢ per 100 lb	5¢ per 100 lb
Salt in bags, barrels, etc.......	free	3.5¢ per 100 lb	7.5¢ per 100 lb
Table salt	5%	10%	15%

United States	
Bulk salt	1.7¢ per 100 lb
Salt in bags, barrels, etc.	3.5¢ per 100 lb
Salt in brine	10% ad val.



ONE OF CANADA'S THREE ROCK SALT MINES: Mine buildings and shipping facilities at Goderich, Ontario, operated by Sifto Salt Division of Domtar Chemicals Limited.

Sand, Gravel and Crushed Stone †

F.E. HANES*

The estimated** production of sand, gravel and crushed stone in 1965 was 245.5 million short tons valued at $193.1 million which is a 1.7 per cent increase in volume and 4.2 per cent increase in value compared with the 1964 revised statistics.

The estimated sand and gravel production for 1965 is 179.4 million short tons for an estimated value of $121.6 million, a slight gain in volume and a 3.6 per cent increase of value. The estimated production of crushed stone in 1965 amounted to 66.1 million short tons for a value of $71.5 million, increases of 5.1 and 5.2 per cent, respectively.

SAND AND GRAVEL

Following the procedure used in estimating the sand and gravel products in the 1964 review, volume production for 1965 will be calculated on 93 per cent of the total sand and gravel volume as shown by the Dominion Bureau of Statistics while the value of this product will be estimated at 94 per cent of the total 1965 value. This per cent share was sufficiently close in 1964 calculations to be acceptable as a method for estimating the principal 1965 construction materials included in the sand and gravel review. Materials used in the construction of roads and buildings in the form of concrete and fill materials, asphalt mixes, railroad ballast and mortar mixes, constitute this major category. Not included are such commodities as engine sand, molding sand, and other uses in non-construction applications. The estimated figures representing this commodity include both fine and coarse aggregates obtained from crushing natural gravels which for statistical purposes is not to be confused with crushed stone described below.

CRUSHED STONE

Estimates of total crushed stone figures shown in the 1964 review were obtained by adjusting the 1963 revised figures by a percentage amount equal to the increase reported for total structural materials in 1964 compared with 1963. The estimated figures involved in 1964 amounted to 60,150,000 short tons valued at $65,000,000 which proved to be quite conservative as shown by the adjusted 1964 figures in Table 1. In each case the values were roughly 4 per cent below the final adjusted figures.

Values for the 1965 production of crushed stone will probably be conservatively estimated, similarly, by increasing the 1964 values an amount equal to the increase of the 1965 total construction materials product over the 1964 product.

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* Mineral Processing Division, Mines Branch.

** Values estimated by the author based on values for construction supplied by the Dominion Bureau of Statistics.

† This is a reprint of the 1965 review, subsequent information is not available.

TABLE 1

Production of Sand, Gravel and Crushed Stone

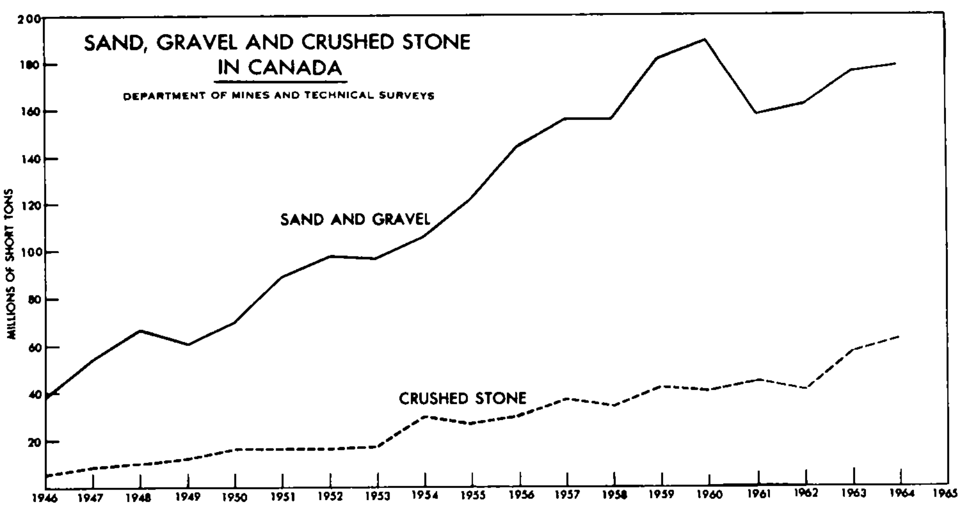
	1964		1965P	
	Short Tons	$	Short Tons	$
Production				
By Province				
Sand and gravel				
Newfoundland	4,431,349	3,370,310		
Prince Edward Island	608,923	481,283		
Nova Scotia	6,471,709	4,186,112		
New Brunswick	4,630,700	2,598,603		
Quebec	39,542,804	19,981,840		
Ontario	69,747,691	50,584,294		
Manitoba	9,453,260	6,793,687		
Saskatchewan	9,071,905	5,707,387		
Alberta	16,048,992	12,898,083		
British Columbia	18,457,949	10,795,465		
Total	178,465,282	117,397,064	179,378,400	121,570,200
Crushed stone				
Newfoundland	102,655	274,546		
Prince Edward Island	350,000	350,000		
Nova Scotia	318,250	477,425		
New Brunswick	2,954,130	2,538,614		
Quebec	35,582,483	37,587,412		
Ontario	21,475,168	24,617,291		
Manitoba	617,014	536,193		
Saskatchewan	–	–		
Alberta	112	520		
British Columbia	1,522,692	1,647,091		
Total	62,922,504	68,029,092	66,100,000	71,500,000
By Type				
Sand and gravel				
In roads (roadbed surface)	98,252,618	52,313,693		
Concrete aggregate	20,466,247	19,023,517		
Asphalt aggregate	5,576,891	5,291,028		
Railroad ballast	5,893,168	2,527,492		
Mortar sand	1,596,487	1,287,984		
Total	131,785,411	80,443,714		
Crushed gravel				
For roads (roadbed surface)	33,611,515	24,092,967		
Concrete aggregate	6,277,569	7,587,276		
Asphalt aggregate	2,947,496	2,378,125		
Railroad ballast	1,790,249	1,239,869		
Other uses	2,053,042	1,655,113		
Total	46,679,871	36,953,350		
Total sand, gravel and crushed gravel	178,465,282	117,397,064	179,378,400	121,570,200

Table 1 (cont.)

	1964		1965P	
	Short Tons	$	Short Tons	$
Crushed stone				
Concrete aggregate	19,300,500	21,869,957		
Railway ballast	2,612,650	2,398,781		
Road metal	34,300,682	35,993,846		
Rubble and riprap	1,359,265	1,484,109		
Terrazzo, stucco and artificial stone	87,749	1,068,354		
Other uses	5,261,658	5,214,045		
Total	62,922,504	68,029,092	66,100,000	71,500,000
Total sand, gravel, crushed gravel and crushed stone	241,387,786	185,426,156	245,478,400	193,070,200

Source: Dominion Bureau of Statistics.

PPreliminary estimates projected from available information by the author. Further information unavailable.



On the basis of 1965 preliminary figures, the per cent increase value for structural materials used for calculating the 1964 figures was 5.7 per cent. With the revised 1964 total construction material value of $403,058,324 the per cent increase in this category is actually 6.35.

The total preliminary value of all structural materials produced in 1965 amounted to $423.2 million, a 5 per cent increase over the revised 1964 value amounting to $403,058,324. Using this 5 per cent to estimate the 1965 crushed stone production, a conservative, but reasonably accurate, indication of the trend in this industry was obtained. As was true in 1964, only unreliable values would result by attempting to estimate the production for each province or for each type of material.

UTILIZATION BY TYPE

The magnitude of the aggregate industry is often overlooked and considered only as a low value per ton product. The average value per ton for sand and gravel based on revised 1964 statistics was 66 cents, and for crushed stone, $1.08 per ton. The average value for the total sand, gravel and crushed stone product was approximately 77 cents per ton. The total aggregate industry can be ranked, on the basis of its utilization as a construction material, high in the table of leading minerals exceeded only by two fuel minerals, natural gas and crude oil, and by four metallic minerals, nickel, iron ore, copper and zinc.

Natural and crushed aggregates are used in many ways and make up, in one form or another, the principal ingredient and often the secondary material in a varied number of applications. For example, its use in road building alone can be classified under numerous subheadings. In some cases, very specialized uses for certain aggregates such as top dressing mixes, antiskid uses and others, require selective quarrying, careful processing, and quality controls that call for specialized equipment and increased handling. The volume of this material, in size alone, requires a tremendous fleet of transportation equipment to move it first from the quarry, then to storage and finally to the job site where it often requires additional handling and moving. Because of the increasing importance for safety and durability as well as an occasional need to reach an aesthetic level, stiff specifications obtain for exploitation and processing for many aggregates.

Seventy-five per cent of the total sand and gravel product amounting to almost 100 million tons is used in road building and earth dam construction, 15.5 per cent, or 20.5 million tons, is used in concrete aggregate and most of the remainder is evenly distributed for use between railroad ballast and asphalt mixes.

Seventy-two per cent of the crushed gravel product is used for road metal, 13.4 per cent for concrete and about 13 per cent for asphalt and railroad ballast.

One twelfth of the crushed stone product is classified as 'other uses'; its value, approximately 99 cents per ton, does not identify its ultimate use. Almost 55 per cent of total crushed stone is used for road construction while 31 per cent is used in concrete. Railway ballast and rubble and riprap make up 4.2 and 2.2 per cent of the total products, respectively.

Aggregates for terrazzo, stucco and artificial stone use amounting to 87,749 short tons were produced in 1964. These various materials were valued at $1,068,354. An average value per ton calculated from these figures is misleading as it overvalues the artificial stone materials and undervalues the terrazzo chip and stucco dash products. The average price from this table gives a calculated value for these materials at $12.20 per ton; terrazzo chips often command $30 and more per ton. The Dominion Bureau of Statistics reports the production of terrazzo chips, stucco dash and artificial stone products separately amounting to 22,806, 23,563 and 41,380 short tons, respectively, for values of $376,966, $469,925 and $221,463. The average prices from these values are $16.53, $19.94 and $5.35 per ton.

UTILIZATION BY PROVINCE

Ontario is the largest producer of sand and gravel with 39 per cent of the total production. Quebec is second with 22 per cent. However, Quebec only values its sand aggregate at 51 cents per ton (average) while Ontario values its products at 73 cents per ton. Ontario therefore has a larger share of the total value of sand and gravel, 43 per cent, while Quebec has only 17 per cent. The product is either in readily available amounts or of a quality where less processing is required. Another possibility may be a difference in marketing and economics between the two provinces.

A similar relationship exists between British Columbia and Alberta. The former has 18.5 million short tons of sand and gravel production, or 10.3 per cent of the total, while the latter has 16.05 million short tons or 9.3 per cent of the product. Alberta, however, values this product at an average price of 80 cents per ton while British Columbia's value is 58.5 cents per ton. The higher average price for this commodity in Alberta may be due to a different economic structure between the two provinces or it might be a difference based on the availability of suitable deposits.

In the crushed stone field, Quebec accounts for more than half of the total product, by volume 56.5 per cent, and by value, 55 per cent. Ontario shares only 34 per cent of the total product by volume and 36 per cent of the total value. Quebec's average price at $1.06 per ton is about 10 cents lower than Ontario's $1.15 per ton value.

New Brunswick with 2.95 million short tons and British Columbia with 1.52 million short tons make up 7 per cent of the remaining 9.5 per cent.

IMPORTS AND EXPORTS

A 25.4 per cent increase in volume and 13.6 per cent increase in value was reported for the total imported sand, gravel and crushed stone products in 1965 compared with 1964. About 4 per cent less sand and gravel was imported this year compared with 1964 and, based on average prices per ton, only $1.20 was paid per ton in 1965 compared with $1.25 per ton for the 1964 product. There was 42 per cent more crushed stone imported in 1965 compared with 1964. Less was paid per ton for the product which was valued at an average price of $2.34 per ton for the 1965 material compared with $2.78 paid the previous year.

Thirty per cent more stone materials were exported in 1965 compared with 1964 for an increased value amounting to 29.4 per cent. A greater volume of sand (almost 50 per cent) was exported at an increase of 48 per cent in value compared with 1964. The selling price of sand was $1.48 per ton. Seventy per cent more gravel was exported but at a decreased value (12 per cent) in 1965 compared with 1964.

TABLE 2

Imports and Exports – Sand, Gravel and Crushed Stone

	1964		1965P	
	Short Tons	$	Short Tons	$
Imports				
Sand and gravel	593,455	741,466	570,977	682,701
Crushed stone, incl. stone refuse	1,052,468	2,934,275	1,493,439	3,493,404
Total	1,645,923	3,675,741	2,064,416	4,176,105
Exports				
Sand	432,564	574,029	637,058	849,045
Gravel	28,900	30,051	50,883	26,448
Crushed limestone and refuse	910,869	1,290,911	1,098,073	1,576,949
Total	1,372,333	1,894,991	1,786,014	2,452,442

PPreliminary

Selenium and Tellurium

A.F. KILLIN*

Selenium

Selenium, a greyish semimetal with electrical properties characteristic of the semiconductor group of metalloid elements, is widely distributed in the earth's crust but there are no known deposits that can be mined profitably for the element alone. Selenium's recovery as a byproduct of the electrolytic refining of copper is a hampering factor in developing industrial uses because this byproduct source is too inflexible to permit adjustment of production to meet shifting demands. Selenium recovery plants were in operation at each of Canada's two copper refineries and production in 1966 totalled 521,163 pounds valued at $2,872,484. This was 9,086 pounds and $388,911 more than in 1965.

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, Quebec, smelter of Noranda Mines Limited and the Murdochville, Quebec, smelter of Gaspé Copper Mines, Limited, 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 metals and salts. The copper refinery will be enlarged early in 1967 to treat a further 50,000 tons of copper a year; selenium production will increase in proportion to copper production.

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 produced is a minus 200-mesh, 99.7 per cent selenium powder.

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 the demand for selenium, and its price, 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 a steady growth in demand is forecast.

Canadian consumption of selenium in 1966 was 15,670 pounds. Approximately half the domestic use was in the manufacture of glass; the rest was consumed by the rubber, electronics, steel and pharmaceutical industries.

Selenium is used in glassmaking both as a decolourizer and as a colouring agent. Small

*Mineral Resources Division.

TABLE 1

Selenium — Production, Exports and Consumption, 1965-66

	1965		1966P	
	Pounds	$	Pounds	$
Production				
All forms [1]				
Quebec	314,780	1,526,683	297,800	1,828,500
Ontario	123,175	597,399	111,000	538,350
Saskatchewan	36,100	175,085	56,415	253,868
Manitoba	38,022	184,406	55,948	251,766
Total	512,077	2,483,573	521,163	2,872,484
Refined [2]	514,595		546,085	
Exports (metal)				
Britain	218,600	1,151,521	272,300	1,577,000
United States	196,500	1,137,675	266,400	1,872,000
Argentina	9,300	42,928	11,700	53,000
Brazil	400	2,090	11,300	50,000
Spain	4,000	19,204	6,500	29,000
Australia	7,400	29,480	4,900	19,000
Other countries	15,000	71,811	15,000	76,000
Total	451,200	2,454,709	588,100	3,676,000
Consumption (selenium content)	15,888 [3]		15,670 [4]	

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] As reported by consumers. [4] Producers' domestic shipments, refined selenium.

P Preliminary.

TABLE 2

Selenium — Production, Exports and Consumption, 1957-66
(pounds)

	Production		Exports [4] Metals and Salts	Consumption[3]
	All Forms [1]	Refined [2]		
1957	321,392	332,011	228,051	15,572
1958	306,990	342,141	250,351	16,600
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	466,654r	325,600	12,587
1963	468,772	462,385r	445,700	12,424
1964	465,746	462,795	401,300	13,968
1965	512,077	514,595	451,200	15,888
1966P	521,163	546,085	588,100	15,670 [5]

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] To 1958 inclusive, producers' domestic shipments of selenium produced at domestic refineries, for 1959 and years following consumption (selenium content) as reported by consumers. [4] From 1956 to 1960 exports of selenium metal and compounds; from 1961, exports of metal, metal powder, shot, etc. [5] Producers' domestic shipments, refined selenium.

Symbols: P Preliminary; r Revised.

TABLE 3

Free World Production of Selenium, 1964-66
(pounds)

	1964	1965	1966e
United States....	928,145	540,132	600,000
Canada.........	465,746	512,077	521,163
Japan...........	325,924	325,924	360,000
Sweden	180,779	141,096	170,000
Belgium and Luxembourg ...	87,082	93,033	100,000
Zambia	57,631	59,525	..
Other countries ..	53,693	53,213	..
Total.......	2,099,000	1,725,000	..

Source: U.S. Bureau of Mines Mineral Trade Notes, December, 1966 and U.S. Bureau of Mines Commodity Data Summaries, January, 1967.

Symbols: eEstimate; .. Not available.

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.

TABLE 4

Canadian Industrial Use of Selenium, 1964-65
(pounds of contained selenium)

	1964	1965
By end-use		
Glass	6,498	8,370
Other*..................	7,470	7,518
Total.................	13,968	15,888

Source: Consumers' reports to Dominion Bureau of Statistics.

* Electronics, rubber, steel, pharmaceuticals.

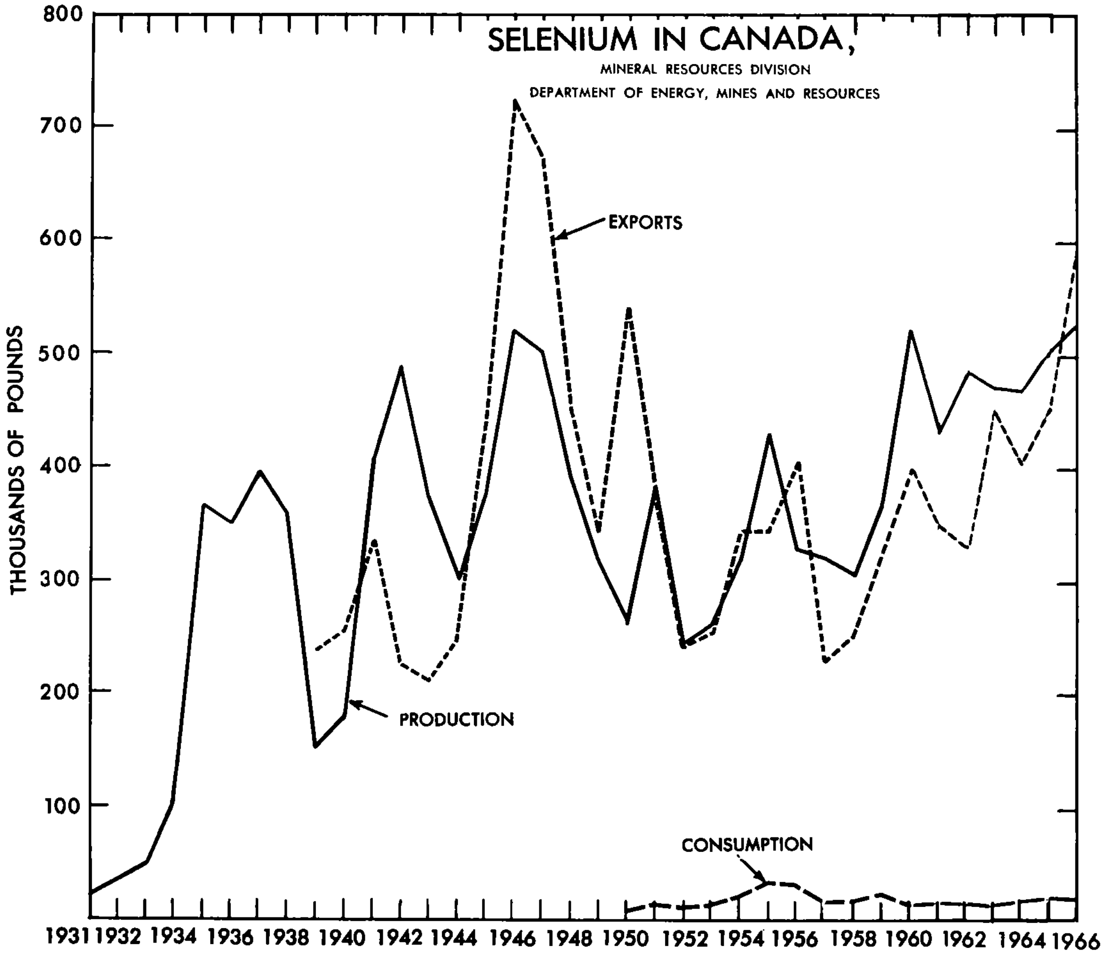
Finely ground metallic selenium and selenium diethyldithiocarbamate (selenac) are used in natural and synthetic rubber to increase the rate of vulcanization and to improve the ageing and mechanical properties of sulphurless and low-sulphur rubber stocks. Selenac acts as an accelerator in butyl rubber.

Selenium, in proportions from 0.20 to 0.35 per cent, 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 1966 selenium prices per pound of selenium were quoted in the United States by E & MJ Metal and Mineral Markets as follows:

Commercial grade powder – $4.50
High purity selenium – $6.00



TARIFFS

	British Preferential %	Most Favoured Nation %	General %
Canada			
In pure form as lumps, powder, ingot, blocks, if of a class not produced in Canada........	Free	15	25
Above forms if produced in Canada...........	15	20	25
Alloys, rod, sheet, or processed form.........	15	20	25
United States			
Selenium metal, selenium dioxide, selenium salts.........................		Free	
Other selenium compounds		8% ad val.	

Tellurium

Like selenium, tellurium is also 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. Total production in 1966 as reported by The International Nickel Company of Canada, Limited and Canadian Copper Refiners Limited was 78,900 pounds valued at $504,100, an increase of 9,106 pounds and $50,439 from 1965. Refined production in 1966 was 72,745 pounds. The excess over refined production was stockpiled as telluriferous refinery sludge.

TABLE 5

Tellurium – Production and Consumption, 1965-66

	1965		1966p	
	Pounds	$	Pounds	$
Production				
All forms [1]				
Quebec	54,364	353,366	56,900	372,100
Ontario	9,315	60,548	8,600	51,600
Saskatchewan	2,978	19,357	6,728	40,368
Manitoba	3,137	20,390	6,672	40,032
Total	69,794	453,661	78,900	504,100
Refined [2]	69,930		72,745	
Consumption (refined) [3]	1,870		862	

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] Reported by consumers.

p Preliminary

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.

TABLE 6

Production of Tellurium, 1957-66
(pounds)

	All Forms*	Refined**
1957	31,524	34,895
1958	38,250	42,337
1959	13,023	8,900
1960	44,682	41,756
1961	77,609	81,050
1962	58,725	57,630
1963	76,842	79,640r
1964	77,782	80,255
1965	69,794	69,930
1966p	78,900	72,745

Source: Dominion Bureau of Statistics.

* Includes recoverable tellurium content of blister copper, not necessarily recovered in year designated, plus refined tellurium from domestic primary material. ** Refinery production from all sources.

Symbols: p Preliminary; r Revised.

TABLE 7

Free World Production of Tellurium
(pounds)

	1964	1965	1966e
United States	145,505	194,006	225,000
Canada...........	77,782	69,794	78,900
Peru	46,758	36,045	40,000
Japan	7,573	20,126	25,000
Other countries....	164	869	..
Total.........	277,782	320,840	..

Source: U.S. Bureau of Mines Minerals Yearbook and U.S. Bureau of Mines Commodity Data Summaries, January 1967.

Symbols: eEstimated; .. Not available.

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.

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 8

Refined Tellurium Used in Canada, 1964-65
(pounds of contained tellurium)

	1964	1965
By end-use		
Metal alloys	576	1,870
Other*	897	—
Total...............	1,473	1,870

Source: Consumers' reports to Dominion Bureau of Statistics.

* Rubber, electronics.

PRICES

The price for 100 pound lots of tellurium in the United States as quoted by E & MJ Metal and Mineral Markets, was $6 a pound for both powder and slab.

TARIFFS

	British Preferential %	Most Favoured Nation %	General %
Canada			
In lumps, powder, ingots, etc.*	free	15	25
In alloys, rod, sheet, or processed form	15	20	25
United States			
Tellurium metal...........................		8% ad val.	
Tellurium salts and compounds		10% ad val.	

*This tariff applies if material is determined to be of a class or kind not produced in Canada, otherwise tariff quoted immediately below applies.

Silica

R.K. COLLINGS*

Silica (silicon dioxide) commonly occurs as the mineral quartz in sand, sandstone, quartzite and vein quartz deposits. Although silica is widespread in occurrence, only those deposits that are of high purity are of commercial interest.

Domestic production of silica is confined to Ontario, Quebec, Manitoba, Saskatchewan and British Columbia, and mainly consists of crushed quartzite and sandstone, and sand for use as metallurgical flux. Flux accounts for 70 per cent of the total production of silica; the remainder consists of lump silica for use in silicon and ferrosilicon manufacture and in the production of elemental phosphorus (15 per cent), and silica sand for glass manufacture, silicon carbide production, foundry use and for other purposes (15 per cent).

Production of silica in 1966 was 2.3 million tons, 7 per cent less than 1965. This decline is largely attributable to reduced production of smelter flux by The International Nickel Company of Canada Limited, as a result of a prolonged strike at Sudbury, Ontario. The value of production, on the other hand, increased 7 per cent, to $5.5 million as a result of increased output of higher-priced silica sand.

Imports of silica – consisting of silica sand, quartzite pebble and mill liner block, quartz crystal, and firebrick – showed an overall increase in value of almost 50 per cent. This mostly resulted from a marked increase in silica brick imports in 1966. Despite increased domestic production of silica sand, statistical data somewhat surprisingly indicates a 20 per cent increase in the tonnage of sand imported.

Silica exports, mostly lump silica for ferrosilicon manufacture, amounted to 156,038 tons valued at $530,000. The bulk of this silica originated in Ontario, with smaller quantities from British Columbia. All was shipped to the United States.

Although the annual production of silica sand in Canada has gradually increased over the last decade, the two current domestic producers today supply only 25 to 30 per cent of the Canadian market. Industrial Minerals of Canada Limited, the chief producer, operates two silica quarries in southern Quebec and supplies perhaps 60 per cent of the Quebec silica sand and flour market. The balance of the Quebec market is supplied by a United States producer. Industrial Minerals of Canada, early in 1967 acquired control of Simsil Mines Inc. (formerly Dominion Industrial Mineral Corporation) and now, in addition to supplying finer grades of silica sand from its quarry at St. Canut, Quebec, will also supply a coarser grade of silica sand, such as that preferred for silicon carbide production, from the newly acquired quarry at St. Donat, Quebec. This company is unable to compete with imported sand in Ontario because of higher processing costs and freight

*Mineral Processing Division, Mines Branch.

TABLE 1

Silica — Production and Trade, 1965-66

	1965		1966[p]	
	Short Tons	$	Short Tons	$
Production, quartz and silica sand*				
By province				
Ontario	1,301,583	790,245	1,101,000	854,000
Quebec	522,474	3,246,032	540,000	3,400,000
Manitoba	392,320	739,216	407,831	845,881
Saskatchewan	182,349	177,337	160,000	108,000
British Columbia	34,959	171,112	52,740	264,033
Total	2,433,685	5,123,942	2,261,571	5,471,914
By use				
Flux	1,790,420	1,332,005		
Ferrosilicon	247,244	983,320		
Silicon carbide	79,269	641,616		
Glass	130,353	823,865		
Foundry	30,193	254,551		
Other uses	156,206	1,088,585		
Total	2,433,685	5,123,942	2,261,571	5,471,914
Imports				
Silica sand				
United States	826,139	3,221,479	1,003,421	3,522,000
Norway	4,542	45,560	4,619	41,000
Australia	3,522	154,447	4,339	297,000
Britain	21	1,710	906	3,000
Belgium and Luxembourg	556	29,232	—	—
Total	834,780	3,452,428	1,013,285	3,863,000
Silex and crystallized quartz				
United States	5,014	330,930	280	116,000
Other countries	90	64,179	8	279,000
Total	5,104	395,109	288	395,000
Firebrick and similar shapes, silica	(Thousands)		(Thousands)	
United States	2,062	1,533,554	3,245	2,292,000
Japan	—	—	1,280	473,000
West Germany	23	4,950	782	1,008,000
Britain	1	1,386	—	—
Total	2,086	1,539,890	5,307	3,773,000
	Short Tons	$	Short Tons	$
Exports				
Quartzite				
United States	111,533	369,310	156,038	530,000

Source: Dominion Bureau of Statistics.

* Producers' shipments, including crude and crushed quartz, crushed sandstone and quartzite, and natural silica sands.

[p] Preliminary; — nil.

TABLE 2

Silica – Production and Trade, 1957-66

(short tons)

	Production		Imports				Exports of Quartzite
	Quartz and silica sand	Silica Brick[1] (000's brick)	Silica sand	Silex or crystallized quartz	Flint and ground flint stones	Ganister[2]	
1957	2,139,246	4,308	744,867	13,718	528	667	232,299
1958	1,453,656	2,815	603,343	12,024	542	..	17,074
1959	2,163,546	1,926	792,129	13,815	786	..	147,412
1960	2,260,766	..	720,826	10,521	1,232	..	13,057
1961	2,194,054	..	693,210	10,327	1,339	..	26,774
1962	2,085,620	..	765,431	8,960	1,193	..	156,205
1963	1,836,612	..	787,157	11,887	1,812	..	47,437
1964	2,117,273	..	771,900	5,176	..	..	146,206
1965	2,433,685	..	834,780	5,104	..	..	111,533
1966[p]	2,261,571	..	1,013,285	288	..	..	156,038

Source: Dominion Bureau of Statistics.

[1] Not available after 1959. Beginning 1960, silica to make silica brick included in production of quartz and silica. [2] Included with miscellaneous stone imports from January 1, 1958.

[p]Preliminary; .. Not available.

TABLE 3

Available Statistics on Consumption of Silica by Specified Industries, 1965

Industry	Short Tons
Smelter flux*	1,790,420
Glass manufacturing (including glass fibre)	386,004
Foundry sand	377,728
Artificial abrasives	143,473
Ferrosilicon	134,598
Fertilizer, stock and poultry feed	16,449
Chemicals	22,152
Ceramic	9,835
Asbestos products	37,008
Paints	2,053
Soaps, cleansers and detergents	8,197
Other	228,549
Total	3,156,466

Source: Dominion Bureau of Statistics.

*Producers' shipments of quartz and silica for flux purposes.

rates. This market is entirely supplied by producers in northeastern United States. Canada's other producer, The Winnipeg Supply and Fuel Company, Limited, Winnipeg, now supplies a large portion of the silica sand market in western Canada but is unable to compete with imported sand in the southern Ontario market or in British Columbia. The British Columbia sand market is largely supplied by a producer at Valley, Washington.

Interest in silica deposits, particularly for silica sand production, continued at a high level throughout the year. Several companies, including Ottawa Silica Company of Ottawa, Illinois, the largest producer of silica sand in the United States, are actively engaged in the search for high-purity silica deposits in Canada.

Consumption of silica sand is expected to increase substantially during the next year or two. Pilkington Brothers (Canada) Limited's float glass plant, near Toronto, is expected to come on stream early in 1967 and two other glass plants are planned – one, for sheet glass manufacture, will be built at Owen Sound, Ontario, by Canadian Pittsburgh Industries Limited; the other, for the manufacture of glass for television tubes, will be constructed near Bracebridge, Ontario, by Corning Glass Works of Canada Ltd.

In Newfoundland, quartzite deposits in the Burin and Avalon Peninsulas are being drilled and evaluated by the Department of Mines, Agriculture and Resources, St. John's, as possible raw material for use by Electric Reduction Company of Canada, Ltd's $40 million phosphorus plant which is planned for Long Harbour, Placentia Bay. This plant is expected to require up to 200,000 tons of quartzite per year.

PRINCIPAL PRODUCERS

QUEBEC

Union Carbide Exploration 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 metallurgical flux.

E. Montpetit et Fils Ltée also quarries sandstone in the Melocheville area. This sandstone is used by Chromium Mining & Smelting Corporation, Limited, for ferrosilicon production at Beauharnois.

Industrial Minerals of Canada Limited, Toronto, produces silica sand and flour at St. Canut, Two Mountains County, from Potsdam sandstone. The sand is used for glass and silicon carbide manufacture, and for foundry purposes. The flour is used by steel foundries, as a filler in asbestos-cement products, and in various cleaners. This company, having acquired the silica mine at St. Donat de Montcalm from Simsil Mines Inc. (formerly Dominion Industrial Mineral Corporation) early in 1967, is now capable of supplying a wide range of sizes of silica sand and flour to the Quebec market. The St. Donat deposit, a friable quartzite, is about 50 miles from St. Canut. Industrial Minerals also holds a sandstone property near Ste. Scholastique, 10 miles from St. Canut, which will serve as a future source of silica for the St. Canut plant.

Baskatong Quartz Products, with head office in Montreal, produces lump and crushed quartz from a deposit on the southwestern shore of Lake Baskatong. This material is used, in lump form, in silicon metal manufacture and, to a limited extent, as grinding pebble. The crushed quartz is sold for use as exposed aggregate in decorative concrete.

ONTARIO

Union Carbide Canada Limited operates a quarry at Killarney in the Lorraine quartzite formation that extends along the northern end of Georgian Bay. Most of the production is exported to company-owned plants in the United States for ferrosilicon production. The balance is used in Canada for the same purpose.

MANITOBA

The Winnipeg Supply and Fuel Company, Limited, operates a sand deposit on Black Island, Lake Winnipeg. Sand from this deposit is shipped to Selkirk where it is washed, sized, and sold for glass manufacture, foundry purposes and for other uses.

BRITISH COLUMBIA

Pacific Silica Limited quarries quartz near Oliver. This 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 the manufacture of silicon carbide and ferrosilicon.

OTHER AREAS

Metallurgical silica is quarried near Howick, Quebec, for use in elemental phosphorus production at Varennes; near Sudbury, Ontario, and Thompson, Manitoba, for use in smelting nickel-copper ores; and west of Flin Flon, in Saskatchewan, for use in smelting copper-zinc ore.

SPECIFICATIONS AND USES

LUMP SILICA

Silica Flux

Quartz, quartzite, sandstone and sand are used as fluxes in smelting low-silica, base-metal ores. A high silica content is required. Impurities such as iron and alumina are not objectionable in small amounts. Lump silica used as flux is usually minus one, plus 5/16 inch in size.

Silicon Alloys

Lump quartz, quartzite and well-cemented sandstone are used in the manufacture of silicon, ferrosilicon and other alloys of silicon. The silica content should be 98 per cent, the iron, expressed as Fe_2O_3, and alumina should be less than 1 per cent each, and the total iron and alumina less that 1½ per cent. Lime and magnesia should each be less than 0.2 per cent. Phosphorus and arsenic are objectionable. Size is usually minus 6, plus 1 inch.

Silica Brick

Quartz and quartzite, crushed to minus 8 mesh, are used in the manufacture of silica brick for high-temperature refractory furnaces. The iron and alumina should be less than 1 per cent each and other impurities, such as lime and magnesia, should be low.

Aggregate

Crushed and sized quartz and quartzite are finding new markets as exposed aggregate in precast concrete building panels, slabs, sidewalks and decorative landscape units, in addition to their traditional use in stucco applications. Colour and texture are important. Some architects prefer a white, opaque quartz, while others prefer the shiny, translucent variety.

Other Uses

Lump quartz and quartzite are used as lining in ball and tube mills and as lining and packing for acid towers. Naturally occurring flint pebbles and rounded pebbles produced from lump quartz or quartzite are used as grinding media for the reduction of various nonmetallic ores.

SILICA SAND

Glass Manufacture

Naturally occurring sand and sand produced by crushing quartzite or sandstone are used in the manufacture of glass and fused silicaware. The silica content should be 99 per cent and that of iron (Fe_2O_3) less than 0.02 per cent. Other impurities such as alumina, lime and magnesia should be low. All sand preferably should be between 20 and 100 mesh.

Silicon Carbide

Sand used for silicon-carbide manufacture should have a silica content of 99 per cent. Iron (Fe_2O_3) and alumina should be less than 0.1 per cent each. Lime, magnesia and phosphorus are objectionable. A coarse-grained sand is preferred. All sand should be plus 100 mesh, with the bulk of it plus 35 mesh.

Hydraulic Fracturing

Sand used in the hydraulic fracturing of oil-bearing formations must be clean and dry and have a high compressive strength, a high silica content, and be free of acid-consuming constituents. The grain size should be between 20 and 35 mesh. Grains should be well rounded to facilitate placement and to provide maximum permeability.

Foundry Use

Naturally occurring sand and sand produced by the reduction of sandstone are used by the foundry industry for moulding. Sands for this purpose vary greatly in screen size and chemical composition. Grain size varies between 20 and 200 mesh in closely sized ranges. A rounded grain is preferred.

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 as Fe_2O_3. All sand should be between 20 and 100 mesh.

Other Uses

Coarsely ground, closely sized quartz, quartzite, sandstone and sand are used as abrasive grit in sandblasting operations and for the manufacture of sandpaper. Various grades of sand are used in water-treatment plants as filtering media. Silica is also used in portland cement manufacture.

SILICA FLOUR

Silica flour, formed by grinding quartz, quartzite, sandstone or sand, is used in the ceramic industry for enamel frits and pottery flint. It is also used as an inert filler in rubber and asbestos-cement products, as an extender in paint and as an abrasive ingredient

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in soaps and scouring powders. Silica flour is finding increasing application in concrete used in the fabrication of autoclave-cured products such as building blocks and panels.

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, in part, by excellent quality synthetic crystal grown in the laboratory from quartz 'seed'.

There is only a small demand for quartz crystal in Canada and virtually no production, domestic requirements being met by imports chiefly from Brazil and the United States. Quartz Crystals Mines Limited, Toronto, occasionally produces minor tonnages from its mine near Lyndhurst, Ontario, for sale to museums, rock collectors, etc.

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

Sand and ganister...................... free
Silex, or crystallized quartz,
  ground or unground.................. free

United States

Sand containing by weight 95% or more
  silica and not more than 0.6% oxide
  of iron, per long ton .... 50¢
Quartzite, whether or not manufactured... free
Silica, not specially provided for........ free

Silver

J.G. GEORGE*

Canadian mine production of silver in 1966 was 33,341,751 troy ounces, about 1 million ounces greater than in 1965. Declines in the Yukon Territory, Manitoba, Saskatchewan and Ontario were more than offset by increases in other provinces. Quebec had the largest increase, because of increased byproduct output at several base-metal mines and output in the Northwest Territories reached a new high because of increased production by Echo Bay Mines Ltd. at its silver-copper property near Port Radium. Although Ontario was again the leading silver-producing province, its output dropped almost 5 per cent from that of 1965 largely because of lower output in the Cobalt-Gowganda area.

The principal source of silver was again base-metal ores, which accounted for almost 83 per cent of output. Approximately 16 per cent came from silver-cobalt ores mined in the Cobalt-Gowganda area of northern Ontario, and the remainder was byproduct recovery from lode and placer gold ores.

The 4 largest mine producers in declining order of output were United Keno Hill Mines Limited in the Yukon Territory, Cominco Ltd. (Sullivan mine) in southeastern B.C., Noranda Mines Limited (Geco Division) in Ontario, and Brunswick Mining and Smelting Corporation Limited (No. 12 mine) near Bathurst, N.B. Ores mined by these 4 producers were the source of about 35 per cent of Canada's total silver production. Largest producer in the Cobalt-Gowganda area was again Silverfields Mining Corporation Limited with output of 1,520,984 ounces.

Canadian Copper Refiners Limited at Montreal East, Que., remained Canada's largest producer of refined silver. It recovered 10,051,000 ounces from the treatment of anode and blister copper. The silver refinery of Cominco Ltd. at Trail, B.C. was the second largest producer, recovering 6,609,110 ounces in the processing of lead and zinc ores and concentrates. Other producers of refined silver were Kam-Kotia Mines Limited, Refinery Division (formerly Cobalt Refinery Limited) at Cobalt, Ontario (from silver-cobalt ores and concentrates); The International Nickel Company of Canada, Limited (Inco) at Copper Cliff, Ontario (from nickel-copper concentrates); Royal Canadian Mint at Ottawa, Ontario (from gold bullion); and Hollinger Consolidated Gold Mines, Limited at Timmins, Ontario (from gold precipitates).

*Mineral Resources Division.

TABLE 1

Canada, Silver Production, Trade and Consumption, 1965–66

	1965		1966p	
	Troy Ounces	$	Troy Ounces	$
Production*				
By provinces and territories				
Ontario	10,822,213	15,151,098	10,318,325	14,435,337
Quebec	5,154,403	7,216,164	5,780,130	8,086,402
British Columbia	4,991,109	6,987,553	5,411,590	7,570,814
Yukon	4,615,995	6,462,393	4,078,223	5,705,434
New Brunswick	2,745,274	3,843,384	3,025,094	4,232,107
Northwest Territories	1,064,824	1,490,754	1,952,634	2,731,735
Newfoundland	1,086,978	1,521,769	1,070,943	1,498,249
Manitoba and Saskatchewan	1,348,019	1,887,227	1,130,293	1,581,279
Nova Scotia	443,630	621,082	574,505	803,732
Alberta	19	26	14	20
Total	32,272,464	45,181,450	33,341,751	46,645,109
By sources				
Base-metal ores	25,965,430		27,603,812	
Gold ores	497,371		423,566	
Silver-cobalt and silver ores	5,800,234		5,305,214	
Placer gold ores	9,429		9,159	
Total	32,272,464	45,181,450	33,341,751	46,645,109
Refined silver	20,630,190		21,567,473	
Exports				
In ores and concentrates				
United States	6,834,846	7,842,965	8,147,203	9,753,000
Belgium and Luxembourg	2,950,666	3,766,196	2,098,182	2,294,000
Japan	525,959	669,146	773,351	984,000
Sweden	205,501	285,658	333,294	464,000
West Germany	746,827	806,809	201,981	174,000
Britain	337,787	352,149	187,999	162,000
Norway	53,316	73,863	74,483	64,000
Other countries	590,975	666,054	33,976	32,000
Total	12,245,877	14,462,840	11,850,469	13,927,000
Refined metal				
United States	11,239,541	15,637,397	12,093,535	16,850,000
West Germany	—	—	105,454	145,000
Venezuela	16,845	25,762	14,535	23,000
Ecuador	—	—	3,215	5,000
Other countries	11,724	19,359	4,403	5,000
Total	11,268,110	15,682,518	12,221,142	17,028,000
Imports, refined metal				
United States	13,412,838	18,738,707	14,452,372	20,174,000
Britain	596	1,133	25,415	39,000
Total	13,413,434	18,739,840	14,477,787	20,213,000

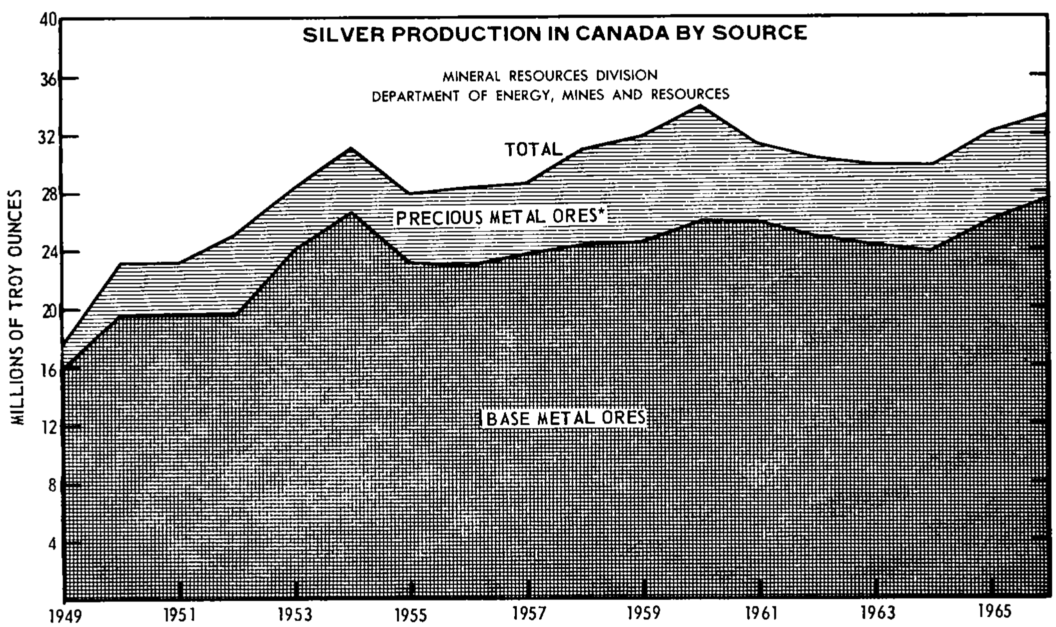
TABLE 1 (Concl.)

Consumption, by use		
Coinage	24,427,576	15,481,651
Silver salts	1,811,124	1,716,868
Silver alloys	447,298	470,410
Sterling	1,552,115	1,653,118
Wire and rod	16,753	11,674
Other**	1,915,231	1,969,983
Total	30,170,097	21,303,704

Source: Dominion Bureau of Statistics.

*Comprised of recoverable silver in ores, concentrates and matte exported; silver in crude gold bullion produced; silver in blister and anode copper produced in Canadian smelters; silver in base bullion produced from domestic ores by Cominco Ltd.; silver bullion produced from treatment of domestic silver-cobalt ores at Cobalt, Ontario.
**Includes electroplating, sheet and other miscellaneous uses.

pPreliminary; —Nil.



STATISTICAL SOURCE: Dominion Bureau of Statistics
*Mostly from Silver-Cobalt Ores; Some from Gold Ores.

Canada's exports of silver in ores and concentrates and as refined metal totalled 24,071,611 ounces, 557,624 ounces more than in 1965. The United States, Belgium and Japan were the principal markets. Virtually all of the imports, which totalled 14,477,787 ounces, came from the United States.

Reported consumption of silver in Canada at 21,303,704 ounces was almost 9 million ounces less than in 1965. Substantially reduced requirements for coinage accounted for most of the decrease. There was no change in the composition of the coins minted.

TABLE 2

Canada, Silver Production, Trade and Consumption, 1957--66
(troy ounces)

	Production		Exports			Imports	Consumption**
	All Forms*	Refined Silver	In ores and Concentrates	Refined Silver	Total	Refined Silver	Refined Silver
1957	28,823,298	20,533,053	5,979,459	12,799,990	18,779,449	1,859,131	10,730,255
1958	31,163,470	25,430,204	5,098,788	16,026,550	21,125,338	2,701	9,299,809
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
1966p	33,341,751	21,567,473	11,850,469	12,221,142	24,071,611	14,477,787	21,303,704

Source: Dominion Bureau of Statistics.
*Recoverable silver in ores, concentrates and matte shipped for export; in crude and gold bullion produced; in blister and anode copper made at Canadian smelters; in base bullion made by Cominco Ltd. at Trail, B.C.; and bullion produced from the treatment of silver-cobalt ores. **Includes consumption for coinage.
pPreliminary.

WORLD PRODUCTION AND CONSUMPTION

Silver production in the non-communist world in 1966, according to an estimate of Handy and Harman*, amounted to 231 million ounces, about 3.5 per cent higher than the previous year. In 1966, non-communist world consumption for both industrial and coinage uses, excluding requirements for United States coinage which are supplied from Treasury stocks, was 410.3 million ounces. The gap between production and consumption was more than 179 million ounces, about the same as in 1965.

Consumption of silver for coinage in the non-communist world, excluding the United States, was 53.8 million ounces, 1.5 million ounces less than the previous year. A sharp drop in Canada's consumption was the main reason for the decline with the reduction more than offsetting increases in France and Japan. The recent trend toward using non-silver coins, or ones of lower silver content, has brought about reduced demand for this purpose. In October, Japan discontinued the minting of its 100-yen silver coin. In December the Canadian government announced that, beginning in 1968, the 10-cent, 25-cent and 50-cent silver coins would be minted from pure nickel in place of silver; the silver dollar would remain unchanged.

TABLE 3

World Production of Silver 1965–66
(troy ounces)

	1965p	1966e
United States	39,806,033	42,200,000
Mexico	40,332,077	42,000,000
Peru	35,255,411	36,000,000
Canada	32,272,464	33,300,000
Russia	27,000,000e	
Australia	16,713,000	
Japan	9,984,879	
Sweden	4,955,201	
East Germany	4,800,000e	
Yugoslavia	4,148,057	
Bolivia (exports)	4,115,295	
Honduras	3,670,659	
Chile	3,272,946	
Republic of South Africa	3,131,580	
Other Countries	21,542,398	105,700,000
Total	251,000,000	259,200,000

Source: 1965 statistics from U.S. Bureau of Mines Minerals Yearbook, 1965. 1966 statistics from U.S. Bureau of Mines, Commodity Data Summaries, January 1967.
pPreliminary; eEstimate.

*The Silver Market in 1966, compiled by Handy and Harman.

Based on preliminary figures covering mine production of silver in 1966, Mexico was for the first time in almost half a century surpassed, by the United States, as the world's leading producer. Canada continued to be the world's fourth largest silver producer.

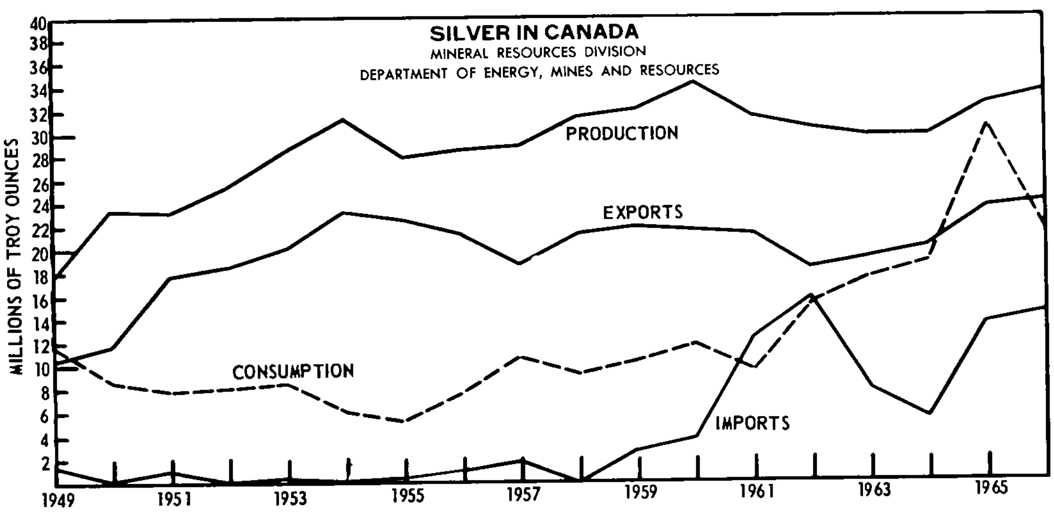
New production of silver in the United States, the world's largest consumer, increased from 35.0 million ounces in 1963 to 42.2 million ounces in 1966 when consumption for industrial uses and coinage, as estimated by Handy and Harman, was 150.0 and 53.6 million ounces, respectively. The large deficit in requirements was again met by withdrawals from United States Treasury stocks, which also continued to provide all United States coinage requirements. Silver for nonmonetary or industrial uses continued to be made available from the Treasury at the statutory price of $1.2929 a troy ounce, under the terms of legislation enacted on June 4, 1963. Treasury bullion reserves during 1966 were reduced from 794 to 592 million ounces. The United States Mint used only 53.6 million ounces of silver for coinage in 1966 compared with the record quantity of 320.3 million ounces the previous year. Its coinage requirements are expected to taper off to 25 or 30 million ounces in 1967 and during the next few years are expected to range between 15 and 20 million ounces annually.

DEVELOPMENTS

YUKON TERRITORY

Output of United Keno Hill Mines Limited was almost one-half million ounces less than in 1965. Late in the year the company suspended underground development and curtailed production operations.

Late in 1966, Anvil Mining Corporation Limited completed a diamond drilling program on the Faro No. 1 orebody at its lead-zinc-silver deposit in the Vangorda Creek area in central Yukon Territory about 140 miles northeast of Whitehorse. Drilling results indicated reserves of about 40 million tons grading in excess of 10 per cent combined lead and zinc and about one ounce of silver a ton. An underground diamond drilling and exploration program commenced in October at the Arctic Caribou gold-silver property of Arctic Mining and Exploration Limited about 9 miles southeast of Carcross. Promising copper-lead-zinc-silver showings were discovered by Atlas Explorations Limited in the Sheldon area, about 180 miles northeast of Whitehorse.



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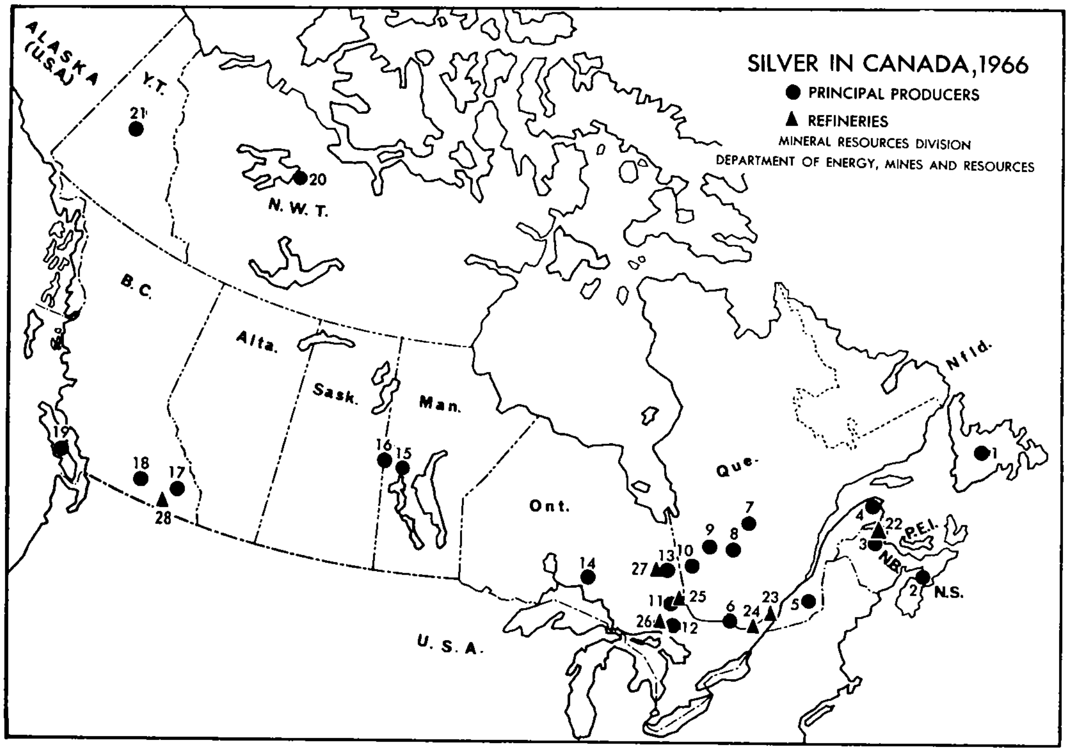


PRINCIPAL PRODUCERS

(numbers refer to numbers on the map)

1. American Smelting and Refining Company (Buchans Unit)
2. Magnet Cove Barium Corporation
3. Brunswick Mining and Smelting Corporation Limited (Nos. 12 and 6 mines)
   Heath Steele 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. The Coniagas Mines, Limited
9. Mattagami Lake Mines Limited
10. Lake Dufault Mines, Limited
    Manitou-Barvue Mines Limited
    Noranda Mines Limited (Horne mine)
    Normetal Mining Corporation, Limited
    Quemont Mining Corporation, Limited
11. 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
    Siscoe Metals of Ontario Limited
12. The International Nickel Company of Canada, Limited
13. Texas Gulf Sulphur Company
14. Noranda Mines Limited (Geco Division)
    Willecho Mines Limited
    Willroy Mines Limited
15. Hudson Bay Mining and Smelting Co., Limited (Chisel Lake mine, Stall Lake mine)
16. Hudson Bay Mining and Smelting Co., Limited (Flin Flon mine, Schist Lake Mine)
17. Cominco Ltd. (Bluebell mine, Sullivan mine)
18. Mastodon-Highland Bell Mines Limited
19. Western Mines Limited
20. Echo Bay Mines Ltd.
21. United Keno Hill Mines Limited

REFINERIES

22. East Coast Smelting and Chemical Company Limited
23. Canadian Copper Refiners Limited
24. Royal Canadian Mint
25. Kam-Kotia Mines Limited (Refinery Division)
26. The International Nickel Company of Canada, Limited
27. Hollinger Consolidated Gold Mines, Limited
28. Cominco Ltd.

TABLE 4

Principal Silver Producers in Canada, 1965–66

Company and Location	Mill Capacity (short tons/ day)	Type of Ore Milled	Silver Grade 1966 (1965) (oz/ton)	Ore Produced 1966 (1965) (short tons)	Contained Silver Produced 1966 (1965) (troy ounces)	Remarks
British Columbia						
Cominco Ltd., Sullivan mine, Kimberley	10,000	Pb,Zn,Ag	.. (..)	2,135,660 (2,301,071)	3,190,431[1] (2,839,161)	Major revision to underground ventilation system completed.
Bluebell mine, Riondel	700	Pb,Zn,Ag	.. (..)	246,390 (256,332)	347,369 (351,378)	Exploration and development to the north end of the mine will be continued.
Mastodon-Highland Bell Mines Limited, Beaverdell	100	Ag,Pb,Zn	30.88 (27.92)	24,138 (23,213)	745,278 (656,571)	Mill capacity increased 20 per cent.
Western Mines Limited, Myra Falls, Vancouver	750	Zn,Cu,Pb, Ag	.. (–)	.. (–)	.. (–)	Mine brought into production in December 1966.
Yukon Territory – Northwest Territories						
Echo Bay Mines Ltd., Port Radium, N.W.T.	100	Ag,Cu	39.35 (52.6)	46,353 (30,730)	1,615,763 (1,455,522)	
United Keno Hill Mines Limited, Hector-Calumet, Elsa and Keno mines, Mayo District, Y.T.	500	Ag,Pb,Zn	36.56 (33.25)	120,374 (146,850)	4,235,678 (4,701,820)	Underground development and production to be further curtailed.
Manitoba and Saskatchewan						
Hudson Bay Mining and Smelting Co., Limited	6,000 (treated at central mill at Flin Flon)	Cu,Zn,Pb, Ag	0.66 (0.86)	1,685,635 (1,643,048)	1,055,565 (1,288,624)	Automation of concentrator ball mill feed system on two ball mills completed.
Flin Flon mine, Flin Flon		Cu,Zn,Ag	0.65 (0.90)	1,044,206 (873,934)		
Chisel Lake mine, Snow Lake		Zn,Cu,Pb, Ag	0.95 (1.27)	250,524 (293,221)		

TABLE 4 (Cont.)

Company and Location	Mill Capacity (short tons/ day)	Type of Ore Milled	Silver Grade 1966 (1965) (oz/ton)	Ore Produced 1966 (1965) (short tons)	Contained Silver Produced 1966 (1965) (troy ounces)	Remarks
Coronation mine, Flin Flon		Cu,Zn,Ag	— (0.24)	— (82,491)		Coronation mine ceased operations in August 1965 following depletion of ore reserves
Schist Lake mine, Flin Flon		Cu,Zn,Ag	1.13 (1.22)	99,079 (109,010)		
Stall Lake mine, Snow Lake		Cu,Zn,Ag	0.29 (0.34)	291,826 (284,392)		
Ontario						
Noranda Mines Limited (Geco Division), Manitouwadge	3,700	Cu,Zn,Ag, Pb	2.03 (2.17)	1,459,586 (1,326,400)	2,203,443 (2,214,600)	Preparations made to instal underground crusher immediately above 3,850' level.
Texas Gulf Sulphur Company, Kidd Creek mine, Timmins	9,000	Zn,Cu,Ag, Pb	.. (–)	.. (–)	.. (–)	In November, tune-up operations began at first of three similar 3,000-ton-a-day concentrator units. The other two units were expected to commence operations in the first quarter of 1967.
Willecho Mines Limited, Lun-Echo mine, Manitouwadge	ore custom-milled	Zn,Cu,Ag, Pb	1.79 (1.73)	325,738 (283,259)	391,567 (318,890)	
Willroy Mines Limited, Manitouwadge	1,700	Zn,Cu,Ag, Pb	2.03 (1.84)	219,400 (293,989)	311,003 (365,575)	Put in addition to crushing plant to handle Willecho and Big Nama Creek ores.
The International Nickel Company of Canada, Limited, Sudbury, Ont., and Thompson, Man.	2	Ni,Cu	.. (..)	17,550,000[3] (19,750,000)[3]	1,513,000[4] (1,581,000)[4]	

TABLE 4 (Cont.)

Agnico Mines Limited, Nipissing 407, Christopher and O'Brien mines, Cobalt district	400	Ag,Co	17.80 (16.40)	47,550 (70,975)	802,151 (1,101,932)	1,000-ton-a-day mill under construction to retreat old tailings in the bed of Cobalt Lake.
Canadian Keeley Mines Limited, Keeley-Frontier mine, Cobalt district	200	Ag,Co	– (..)	– (..)	– (128,000)[e]	The mine and mill ceased operations in 1965.
Deer Horn Mines Limited, Cross Lake O'Brien mine, Cobalt district	100	Ag,Co	13.0 (12.7)	13,695 (25,092)	177,739 (319,533)	Milling operations suspended August 1966, and company concentrating on underground exploration and development of additional ore reserves.
Glen Lake Silver Mines Limited, Bailey mine, Cobalt district	130	Ag,Co	65.14 (39.72)	5,572 (7,641)	352,479 (292,053)	Diamond drilling exploration work continuing.
Hiho Silver Mines Limited, Hiho mine, Cobalt district	ore custom-milled	Ag,Co	29.85 (36.54)	31,508 (23,562)	941,354 (860,876)	Plans to sink winze from bottom level at Giroux Lake to an additional 100' in depth.
Langis Silver & Cobalt Mining Company Limited, Langis mine, Cobalt district	175	Ag,Co	10.81 (12.98)	35,258 (34,992)	341,966 (437,190)	Continuing development at Murray mine which is now under lease.
Silverfields Mining Corporation Limited, Cobalt district	250	Ag,Co	20.8 (29.44)	74,648 (68,795)	1,520,984 (1,114,853)	Considering sinking shaft to open one more level (the 6th).
Siscoe Metals of Ontario Limited, Miller-Lake O'Brien mine, Gowganda district	275	Ag,Co	17.15 (18.77)	52,398 (58,049)	1,206,149 (1,103,785)	

TABLE 4 (Cont.)

Company and Location	Mill Capacity (short tons/ day)	Type of Ore Milled	Silver Grade 1966 (1965) (oz/ ton)	Ore Produced 1966 (1965) (short tons)	Contained Silver Produced 1966 (1965) (troy-ounces)	Remarks
Quebec						
Campbell Chibougamau Mines Ltd., Main, Kokko Creek, Cedar Bay and Henderson mines, Doré Lake, Chibougamau district	3,500	Cu,Au,Ag	0.2741 (0.2752)	966,027 (941,198)	205,258 (201,830)	Shaft sinking programs continued at the Henderson and Cedar Bay mines.
The Coniagas Mines, Limited, Coniagas mine, Bachelor Lake	500	Zn,Ag,Pb	3.14 (3.14)	140,093 (123,059)	340,608 (330,189)	Company expected to suspend milling operations about the end of May 1967.
Cupra Mines Ltd., Cupra mine, Stratford Place	ore custom-milled	Cu,Zn,Pb Ag	1.395 (1.34)	158,130 (82,427)	167,476 (85,437)	In 1966 did considerable underground drilling, development, and stope preparation.
Gaspé Copper Mines, Limited, Gaspé mine, Murdochville	7,500	Cu	0.19 (..)	2,731,700 (2,602,900)	528,100[5] (524,500)[5]	Stripping of new Copper Mountain mine orebody was on schedule. Mill expansion to 11,000 tons of ore daily will be completed in 1967.
Lake Dufault Mines, Limited, Noranda	1,300	Cu,Zn,Ag	.. (..)	489,387 (475,007)	1,024,666 (921,663)	The 6th level was extended to allow further exploration of the lower C zone, and the 3rd level drive under the D zone was completed.
Manitou-Barvue Mines Limited, Golden Manitou mine, Val d'Or	1,300	Zn,Cu,Ag, Pb	2.75 (2.85)	173,130[6] (168,895)[6]	392,187 (393,221)	

TABLE 4 (Cont.)

Mattagami Lake Mines Limited, Mattagami Lake mine, Matagami	3,850	Zn,Cu,Ag	1.02 (1.07)	1,411,100 (1,406,154)	392,490 (350,674)	At the end of 1966 ore reserves were 18,726,000 tons grading 10.4 per cent zinc, 0.69 per cent copper, and 1.13 oz silver a ton.
New Calumet Mines Limited, Grand Calumet	800	Zn,Pb,Ag	4.03 (3.58)	95,761[7] (97,586)[7]	318,491[7] (283,674)[7]	
Noranda Mines Limited, Horne mine, Noranda	3,200	Cu,Au	.. (..)	774,719 (771,400)	159,413 (..)	
Normetal Mining Corporation, Limited, Normetal mine, Normetal	1,000	Zn,Cu,Ag	1.38 (1.59)	335,666 (350,693)	326,891 (429,818)	Completed sinking No. 5 shaft to 7,994 feet below surface.
Opemiska Copper Mines (Quebec) Limited, Chapais	2,000	Cu,Au,Ag	0.43 (0.45)	766,128 (745,976)	275,959 (281,088)	Deepening Perry shaft 1,300' and sinking new Robitaille shaft 1,400'.
Quemont Mining Corporation, Limited, Noranda	2,300	Cu,Zn,Au, Ag	0.70 (0.86)	578,171 (657,307)	275,112 (343,754)	
Solbec Copper Mines, Ltd., Stratford Place	1,500	Zn,Cu,Pb, Ag	1.926 (1.23)	154,795 (403,869)	183,898 (295,078)	Operations suspended September 9 by labour strike which was still not settled at year-end.
New Brunswick						
Brunswick Mining and Smelting Corporation Limited, No. 12 mine, Bathurst	4,500	Zn,Pb,Cu, Ag	.. (2.76)	.. (1,657,519)	.. (..)	
No. 6 mine, Bathurst	2,250	Zn,Pb,Cu, Ag	.. (–)	.. (–)	.. (–)	Operations commenced in second half of 1966.

TABLE 4 (Concl.)

Company and Location	Mill Capacity (short tons/ day)	Type of Ore Milled	Silver Grade 1966 (1965) (oz/ton)	Ore Produced 1966 (1965) (short tons)	Contained Silver Produced 1966 (1965) (troy ounces)	Remarks
Heath Steele Mines Limited, Newcastle	1,500[8]	Zn,Cu,Pb, Ag	2.11 (2.61)	287,515 (..)	345,405 (433,621)	Commenced sinking of new production shaft, which is expected to be completed in 1967 to depth of 1,750'.
Nova Scotia						
Magnet Cove Barium Corporation, Walton	125	Ag,Pb,Cu,. Zn	12.0 (12.5)	50,213 (48,594)	489,338 (548,800)	Exploration program under way.
Newfoundland and Labrador						
American Smelting and Refining Company, (Buchans unit), Buchans	1,250	Zn,Pb,Cu, Ag	4.19 (4.24)	355,000 (366,000)	1,307,579 (1,401,721)	

Source: Company reports.
1 Cominco Ltd.'s total silver production, including that from purchased ores and concentrates, was 6,609,110 ounces.
2 Inco operated ten nickel-copper mines in Sudbury district and Thompson nickel-copper mine in northern Manitoba. Ores from Sudbury district mines were treated in three mills having combined daily capacity of 48,000 tons. Thompson mill has daily capacity of 6,000 tons.
3 Ore production includes output of Thompson mine in Manitoba.
4 Silver delivered to markets.
5 Includes some silver derived from treatment of custom ores and concentrates.
6 Production does not include copper ore milled in separate circuit. In 1966, 295,875 short tons of copper ore were milled.
7 Production for fiscal years ending September 30.
8 Part of Heath Steele's mill capacity used to treat copper ore from nearby Wedge mine operated by Cominco Ltd.
e Estimated; —Nil; ..Not available.

BRITISH COLUMBIA

Tune-up operations commenced in December at the 750-ton-a-day concentrator at the copper-zinc-lead-silver-gold property of Western Mines Limited near Myra Falls in central Vancouver Island. In the third quarter of 1966 Giant Soo Mines Limited brought into production the Estella zinc-lead-silver mine and mill near Wasa at a rated capacity of 120 tons of ore daily; millheads were expected to average 3 ounces of silver a ton. Giant Soo, the operating company, is jointly owned by Giant Mascot Mines, Limited and Copper Soo Mining Company Limited.

Development work continued at the silver-lead-zinc property of Columbia River Mines Ltd. in the East Kootenay district about 20 miles south of Golden. Proven and probable ore reserves totalled over 600,000 tons grading almost 7 per cent combined lead and zinc and about 5 ounces of silver a ton. Several smaller operators continued exploration and development at their properties in the Slocan district. In the same area, Johnsby Mines Limited and London Pride Silver Mines Ltd. suspended operations.

MANITOBA-SASKATCHEWAN

In Manitoba and Saskatchewan most of the silver output came from the 4 base-metal mines near Flin Flon and Snow Lake, Man., operated by Hudson Bay Mining and Smelting Co., Limited. The company continued development of 3 new mines, the Osborne Lake and Anderson Lake mines near Snow Lake and the Flexar mine of Flexar Mines Limited (80 per cent owned by Hudson Bay), 8½ miles southwest of Flin Flon. Mine preparation and mill construction continued at the base-precious metals property (Par group of claims) of Share Mines & Oils Ltd. in the Hanson Lake area of Saskatchewan about 45 miles west of Flin Flon, Man. The 350-ton-a-day concentrator was expected to commence operations about the end of April 1967. Ore reserves were estimated at 253,000 tons grading 4.74 ounces of silver a ton.

ONTARIO

Although Ontario was again the leading silver-producing province, its output was about one-half million ounces lower than that of 1965. More than half of the provincial output was derived from silver-cobalt mines in the Cobalt-Gowganda area of northern Ontario, with the largest individual producer again being Silverfields Mining Corporation Limited with output of over 1.5 million ounces. 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.

McIntyre Porcupine Mines Limited (Castle Division) suspended operations at Gowganda. In the Cobalt area Agnico Mines Limited closed down its Christopher and O'Brien mines while Silver Town Mines Limited resumed underground operations and purchased the 250-ton-a-day La Rose mill from Silver-Miller Mines Limited. In addition to milling ore from its Coleman township properties, Silver Town planned to treat mill tailings from former operations.

In November, tune-up operations commenced at the first of three similar 3,000-ton-a-day units making up the 9,000-ton-a-day concentrator of Texas Gulf Sulphur Company near Timmins. The entire plant was expected to be operating at capacity early in 1967. Ore reserves at the company's Kidd Creek mine were estimated at 55 million tons grading 7.08 per cent zinc, 1.33 per cent copper and 4.85 ounces silver per ton.

QUEBEC

Silver output in the province, derived almost entirely from gold and base-metal ores, was slightly higher in 1966 than the previous year. A large portion of the increase resulted from considerably higher byproduct production by Cupra Mines Ltd. at Stratford Place, and by Mines de Poirier inc., a wholly-owned subsidiary of Rio Algom Mines Limited in Poirier township, both of which completed their first full year's operation.

NEW BRUNSWICK

The main producers continued to be Brunswick Mining and Smelting Corporation Limited and Heath Steele Mines Limited, each operating base-metal properties near Bathurst and Newcastle, respectively. Late in 1966, Brunswick brought into production its No. 6 mine where 14.8 million tons of base-metal ore, containing 1.91 ounces of silver a ton, are available for open pit mining. Ore from the No. 6 orebody is milled at the newly-constructed No. 12 minesite's 2,250-ton-a-day concentrator, which began tune-up operations late in the same year. Nigadoo River Mines Limited, one of the Sullivan group of companies, continued development of its silver-base-metals property 15 miles northwest of Bathurst. A 1,000-ton-a-day concentrator is under construction at the minesite and production was anticipated in the second half of 1967. Heath Steele Mines Limited started sinking a new shaft on B orebody at its property about 40 miles northwest of Newcastle. It is part of an expansion program designed to double ore production by 1968.

USES

Because of silver's intrinsic value, attractive colour and appearance, corrosion resistance and good alloying properties, its greatest single use continues to be in the manufacture of coinage. The quantity required for coinage is, however, declining as a result of the recent trend toward using silverless coins, or ones of reduced silver content. Silver is used extensively in jewelry, sterling and plated silverware, and as a decorative material, for the same properties that make it popular as a coinage metal as well as for its high malleability, ductility and ability to take a fine finish. On account of the sensitivity to light and the ease of reduction of certain silver salts (which are made from silver nitrate), increasing amounts of silver are required by the manufacturers of photographic films and sensitized paper. The photographic industry remains the largest industrial outlet for the metal.

Greater quantities are being used in the electrical and electronics industries because of the increased demand for silver contacts, conductors, and other silver-bearing components. Silver is an important constituent of 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 Canadian price of silver fluctuated throughout the year between a low of \$1.3940 per troy ounce, which obtained during the second week of January, and a high of \$1.4070 which was the price at the end of the year. At the beginning of the year the price was \$1.3950. The New York price for silver remained unchanged for the third full calendar year at \$1.293 a troy ounce.

TARIFFS

	British Preferential (%)	Most Favoured Nation (%)	General (%)
Canada			
Silver ores and concentrates	free	free	free
Silver anodes	5	7½	10
Silver in ingots, blocks, bars, drops, sheets or plates, unmanufactured; silver sweepings, silver scrap	free	free	free
Silver leaf	12½	25	30
Manufactures of silver, not otherwise provided for	17½	27½	45
Wire or strip, silver, silver-filled, nickel-silver for manufacture of jewelry	free	12½	25

TARIFFS (Concl.)

United States

Silver ores and concentrates	free
Silver bullion and silver dore	free
Silver unwrought	
Platinum-plated	32.5%
Gold-plated	50%
Other	21%
Rolled silver	21%
Silver scrap, waste, sweepings	free

Sodium Sulphate

C.M. BARTLEY*

Production of sodium sulphate (salt cake) in Canada increased more than 50,000 tons in 1966 to establish a new high of 401,940 tons. Production gains have been recorded in eight of the past ten years. Imports increased slightly and exports decreased about 10 per cent to 101,417 tons. Consumption of sodium sulphate has increased consistently over the past ten years to 275,620 tons in 1965, the most recent year for which consumption data is available.

Steadily rising demands for kraft pulp have been the major incentive for the increase in salt cake production. Current construction and long-term trends in the pulp and paper industry indicate continuing and increasing needs for paper and, since kraft pulp processing is the major consumer of sodium sulphate, the requirements for this mineral are expanding. The new demands will be met by expansions at some of the five currently operating plants, by two new plants under construction in 1966 (for operation in 1967), and by a third new plant planned for 1967.

PRODUCTION AND TRADE

Four companies in Saskatchewan operated five plants in 1966 to produce natural sodium sulphate from alkali lake deposits in the southern part of the province. In addition, a small amount has been produced as a byproduct of a manufacturing process at Cornwall, Ontario. Saskatchewan salt cake serves western and central Canadian markets and part of the market in eastern Canada. Imports, mainly from the United States but also from Britain, serve some eastern Canadian markets and some in British Columbia. Canadian exports of sodium sulphate are almost entirely to the United States and comprise amounts ranging from one quarter to one third of production.

Canadian producers have adequate reserves and efficient plants and have for many years produced high quality salt cake for the kraft pulp and other industries at relatively low prices. Marketing however is somewhat restricted by the high cost of rail transport. For this reason Saskatchewan producers have difficulty competing for markets in eastern Canada and, up to the present, have not been able to compete in overseas markets.

The rising demand for sodium sulphate has resulted in the construction of two new plants in Saskatchewan which will increase production capacity from about 500,000 tons to 700,000 tons yearly by late 1967.

*Mineral Processing Division, Mines Branch.

TABLE 1

Sodium Sulphate — Production, Trade and Consumption, 1965–66

	1965		1966P	
	Short Tons	$	Short Tons	$
Production (shipments)	345,469	5,527,281	401,940	6,448,400
Imports				
Total crude salt cake and Glauber's salt				
United States	16,312	313,423	22,871	445,000
Britain	12,535	209,777	7,824	123,000
West Germany	478	13,211	566	15,000
Netherlands	22	598	–	–
Total	29,347	537,009	31,261	583,000
Exports				
Crude sodium sulphate				
United States	116,340	1,927,048	101,417	1,687,000
Other countries	5	203	–	–
Total	116,345	1,927,251	101,417	1,687,000

	1964 Short Tons	1965 Short Tons
Consumption (available data)		
Pulp and paper	236,432	261,610
Glass, including glasswool	3,224	3,895
Soaps	4,088	5,444
Other products[1]	848	4,671
Total	244,592	275,620

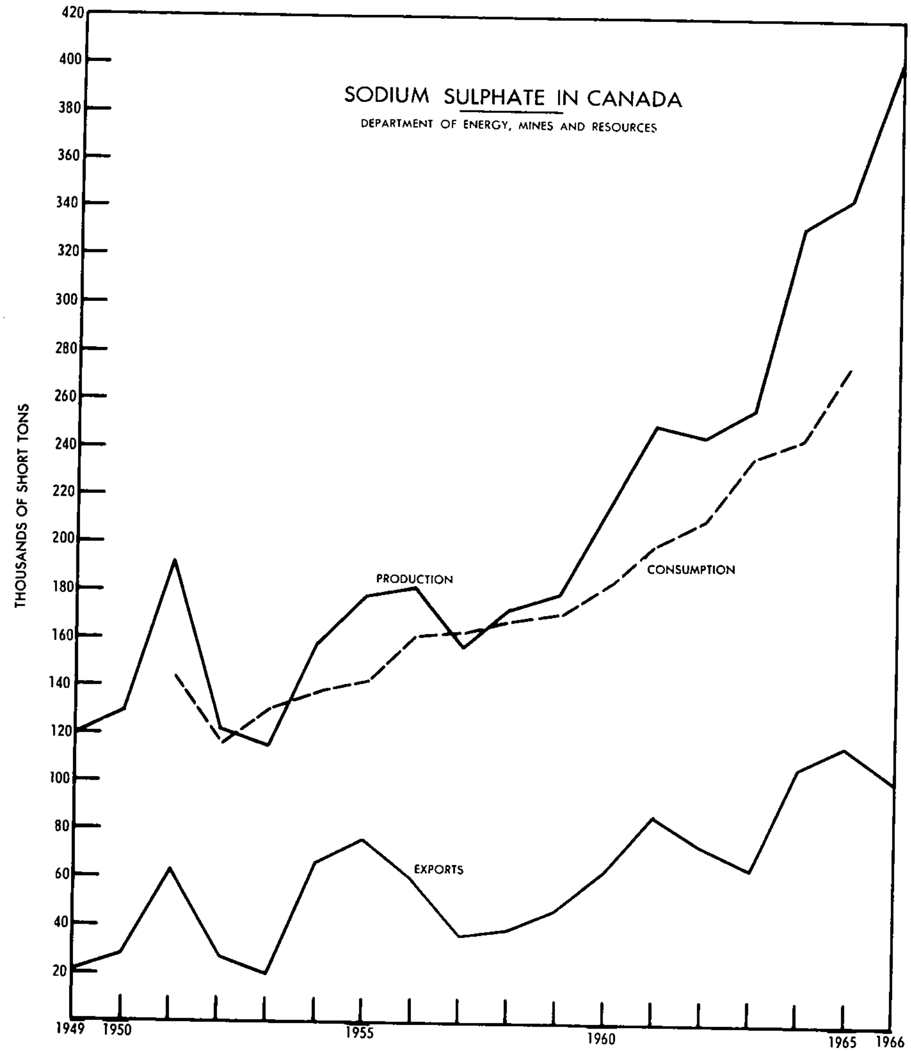
Source: Dominion Bureau of Statistics.
[1]Colours, pigments, gypsum products, textiles, medicinals and miscellaneous other uses; P Preliminary.

TABLE 2

Sodium Sulphate — Production, Trade and Consumption, 1957–66
(short tons)

		Imports				
	Production*	Salt Cake	Glauber's Salt	Total	Exports	Consumption
1957	157,800	28,088	1,512	29,600	37,023	163,743
1958	173,217	25,813	1,217	27,030	39,763	168,067
1959	179,535	27,157	966	28,123	47,922	171,634
1960	214,208	24,706	1,151	25,857	63,831	183,062
1961	250,996	32,310	899	33,209	87,048	200,096
1962	246,672	31,347	426	31,773	74,049	210,691
1963	256,914	19,002	495	19,497	65,348	238,321
1964	333,263	. .	. .	30,833	107,318	244,592
1965	345,469	. .	. .	29,347	116,345	275,620
1966P	401,940	. .	. .	31,261	101,417	. .

Source: Dominion Bureau of Statistics.
*Producers' shipments of crude sodium sulphate.
PPreliminary; . . Not available.



PRODUCING AND DEVELOPING COMPANIES

Table 3 lists four producing companies that operated five plants in Saskatchewan with a combined annual capacity of nearly 500,000 tons; two companies bringing plants into production in 1967 with a total capacity of 200,000 tons; and a third company planning construction of a 100,000 ton capacity plant in 1967.

The new plants are located in the southwest part of the province, at Alsask on the Saskatchewan–Alberta boundary and at Ingebrigt and Cabri between Alsask and Swift Current.

Courtaulds (Canada) Limited, at Cornwall, Ontario, produces a few thousand tons of byproduct salt cake annually.

TABLE 3

Sodium Sulphate — Producers and Prospective Producers

Company	Plant Location	Source Lake	Approx. Annual Capacity	Remarks
Midwest Chemicals Limited............	Palo	Whiteshore	120,000	Operating
Ormiston Mining and Smelting Co. Ltd. ..	Ormiston	Horseshoe	100,000	Operating
Sybouts Sodium Sulphate Co., Ltd.......	Gladmar	East Coteau	50,000	Operating
Saskatchewan Minerals				
Sodium Sulphate Division............	Chaplin	Chaplin	150,000	Operating
,, ,, ,,	Bishopric	Frederick	70,000	Operating
,, ,, ,,	Fox Valley	Ingebrigt	150,000	Producing 1967
Sodium Sulphate (Saskatchewan) Ltd.....	Alsask	Alsask	50,000	Producing 1967
Tombill Mines Limited................	Cabri	Snakehole	100,000	Construction planned 1967

DEPOSITS

Sodium sulphate is found in many of the lakes and ponds of southern Saskatchewan in the form of permanent or intermittent crystal beds and in the brines which cover them. Sulphates in the soil are dissolved by the water from rain and snow and the solutions accumulate in closed drainage basins. Summer evaporation reduces the water content of the brine and the solution becomes more concentrated. In the fall and winter the brine chills to the point of crystallization, and a bed of crystals is deposited at the bottom of the lake. The seasonal repetition of this cycle over a long period of time has accumulated thick beds of sodium sulphate crystals in numerous lakes.

Sodium sulphate occurs in nature as Glauber's salt or mirabilite (Na_2SO_4, $10H_2O$) and occasionally as thenardite (Na_2SO_4) or anhydrous sodium sulphate. Both minerals are soluble in water and solubility increases as the temperature rises. The fact that solubility varies with temperatures is used advantageously in Saskatchewan to recover a relatively pure product from the natural occurrences.

Reserves in Saskatchewan lakes have been estimated at more than 200 million tons. Fifteen deposits have been estimated to contain at least 1 million tons each. Similar though smaller deposits occur in Alberta and British Columbia.

RECOVERY AND PROCESSING

The first recovery of sodium sulphate from Saskatchewan lakes, some 15 tons in 1919, was obtained by harvesting raw crystal from dried and frozen lake beds in the winter. Refinements of this method are still used but most of the production is now obtained by pumping concentrated lake brine to prepared reservoirs in the late summer and recovering the crystal which is deposited when cold weather chills the brine in the fall. These operations are carefully timed and controlled so that brine is pumped from the lake at its highest estimated concentration for that particular season. Just before precipitation is complete the remaining liquid, which now contains a small amount of sodium sulphate and a concentration of some undesirable elements, is pumped back to the lake. This procedure concentrates the sodium sulphate in a clean-floored enclosure and removes much of the unwanted elements present in the natural brine, to provide a relatively high-grade product. The crystal bed is later removed to the plant by scrapers, shovels and draglines. One company, Ormiston Mining and Smelting Co. Ltd., uses a floating dredge to excavate crystal from the lake bottom and to pump it in brine through a 10-inch pipeline directly to the plant.

Processing consists essentially of removing water and dehydrating the natural crystal to an anhydrous powder using equipment such as submerged combustion units, evaporators and rotary kilns. In recent years rotary kilns have been used mostly for final drying of the product rather than for bulk dehydration. The end product is usually marketed as a bulk product grading about 97 per cent Na_2SO_4.

The availability of natural gas in Saskatchewan has had a favourable effect on efficiency and economics at several plants, mainly as savings on storage, maintenance and corrosion costs, which were appreciable when fuels such as low-grade coal or heavy oils were used.

INDUSTRY ACTIVITIES AND OUTLOOK

A comprehensive investigation of Saskatchewan sodium sulphate occurrences by L.H. Cole of the Federal Mines Branch, Ottawa, from 1921 to 1924 provided the basic information for present operations. This general exploration and technical study was followed by detailed exploration and process development at various locations. The industry has been aware of the increasing use of kraft pulp and recently, various industry and government organizations have conducted exploration on unworked deposits and sponsored research directed to the more efficient operation of present processes and the development of new ones to suit particular occurrences.

Expansion of production from its present levels will require consideration of some new factors in arriving at economic feasibility. Current producers operate where large sodium sulphate deposits of satisfactory quality were found in the most favourable geographical locations. New producers must find the best remaining deposits. To obtain a deposit with large reserves it may be necessary to accept one that contains more insoluble material than that contained in presently operating deposits. Some variations in processing would be required but once the process has been decided, and a suitable plant built, these resources can be utilized to produce a standard commercial product. Various companies and the Saskatchewan Research Council have been active in this development research in recent years and processes are now available for deposits which formerly were difficult to treat.

Production of sodium sulphate in 1966 appears to be close to the nominal capacity of present plants. The effect that unfavourable weather might have on the harvest of crystals in any one year has been considered and all companies maintain considerable stockpiles of raw crystals to insure some supply. However, any extended period of unfavourable weather when demand is increasing might restrict output from some plants. For these reasons exploration and process development have been carried out in preparation for industry expansion. At some lakes, reserves and brine conditions are such that additional processing capacity at present plants would assure increased production. At other deposits, one or more dry years might reduce the brine volume and seriously restrict the ouput of the plant. To maintain and expand production under such circumstances it has been necessary to develop some of the untapped deposits and construct new processing plants.

The decision to expand sodium sulphate production capacity has been complicated by the announcement of a pulping process which eliminates the need for sodium sulphate. The Rapson process, developed by Dr. Howard Rapson of the University of Toronto and Electric Reduction Company of Canada, Ltd., uses sulphur, salt and limestone to produce the chemicals, including sodium sulphate, required for the process. The process reportedly permits significant cost savings and closer control of processing efficiency but it is too early to judge its acceptance by the pulp industry.

In Alberta, Western Minerals Ltd. has investigated the potential of the Metiskow sodium sulphate deposit but no decision regarding development has been announced.

In general the outlook for the Canadian sodium sulphate industry is favourable. Demands for kraft paper are increasing in Canada and the United States and production of sodium sulphate will have to be increased to satisfy requirements. Other consumer markets, though presently minor, show some increase.

The possibility has been considered of combining sodium sulphate in the form of brine or solid with potassium chloride, which is now in large-scale production in Saskatchewan, to produce potassium sulphate fertilizer. Several methods have been investigated and production of this type of fertilizer based on a process developed by the Saskatchewan Research Council, is reported to be under consideration by Tombill Mines Limited.

USES AND SPECIFICATIONS

About 95 per cent of sodium sulphate consumed goes into kraft paper, to which it adds strength and toughness. Some is used in the manufacture of newsprint, where an increase in wet strength permits the operation of production machinery at higher speed. Sodium sulphate is also consumed in the manufacture of glass, detergents, mineral-feed supplements, in base-metal smelting, in chemical and medicinal products and as a soil conditioner.

The physical and chemical specifications for sodium sulphate vary. Material of 95 per cent Na_2SO_4 content has been used for kraft paper but higher grades are desirable. Glass, detergent and chemicals require grades of about 98 per cent. Fine chemicals and medicinal products call for grades above 99 per cent. For detergents a high degree of whiteness is desired.

Uniform grain size, consistent quality and free-flowing characteristics are important in handling and use.

PRICES

The Canadian price of sodium sulphate (salt cake) bulk, carload, f.o.b. works as reported by Canadian Chemical Processing in October 1966 was $16.50 a ton.

According to the Oil, Paint and Drug Reporter of December 26, 1966, United States prices of sodium sulphate were:

	(per short ton)
Detergent, rayon-grade, car lots: bags	$ 38
f.o.b. works, bulk	34
Crude (salt cake), 100% Na_2SO_4, domestic, bulk, f.o.b. works	28

TARIFFS

Canada	
Crude (salt cake), per lb	
British Preferential	1/5¢
Most Favoured Nation	1/5
General	3/5
United States	
Crude, or crude salt cake	free
Anhydrous, per long ton	$0.50
Crystallized, or Glauber's salt, per long ton	1.00

CRYSTALS FOR THE KRAFT PAPER INDUSTRY: Saskatchewan Minerals, Sodium Sulphate Division, at Chaplin Lake produces natural sodium sulphate, or Glauber's salt, by the chill-precipitation technique in open ponds. Most of the product is used to strengthen and toughen kraft paper.

Stone, Building and Ornamental †

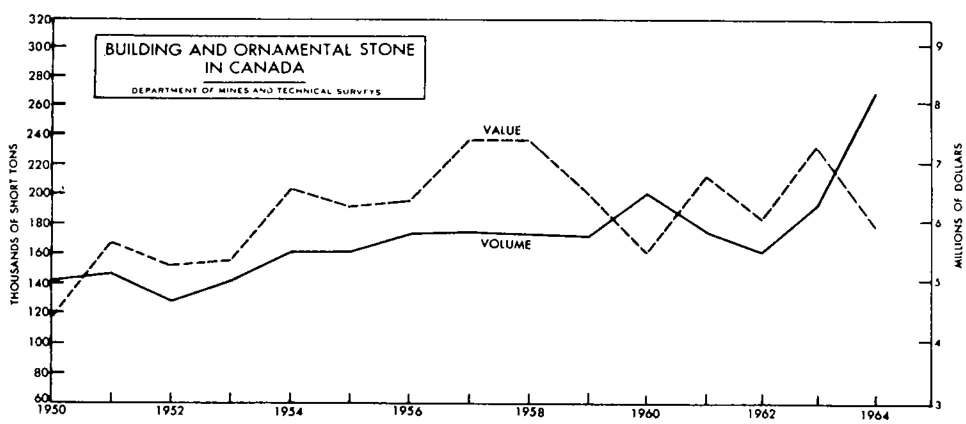
F.E. HANES*

There is no estimate for the 1965 production of building and ornamental stone due to the lack of specific statistical information.

To estimate a value for building and ornamental stone production in Canada for any year is extremely difficult due to the complexity of the statistical reports of the commodities. Statistics for individual rock types are not immediately available. Also, a comparison between 1964 and 1963 figures shows, by their extreme fluctuations in both volume and value for the commodities, the danger of direct interpolation. Since average values for stone materials are widely variable for different types, difficulty is encountered when comparing estimated annual values.

Statistics in reports from some of the provinces, where detail has been given, show increases in production for 1965 for some of the stone commodities. Also the trend shown in building materials, structural materials and the total mineral production in Canada all indicate marked increases in 1965 compared with the 1964 values. These trends should be considered, coupled with firsthand knowledge of the industry's growth, when attempting to evaluate the potential wealth of the industry.

British Columbia, for example, showed increased value in building stone production of $118,975 for 1965 compared with $25,522 in 1964. Cement, lime and limestone, rubble, riprap and crushed stone, and sand and gravel production all show increases in value of from 12 to 50 per cent for the same period. Note the increased value in production of building stone amounting to 366 per cent; an anomalous situation such as this makes estimating very difficult. Total structural materials in British



*Mineral Processing Division, Mines Branch.

† This is a reprint of the 1965 review subsequent information is not available.

Columbia increased from $26.4 to $32.3 million from 1964 to 1965 according to preliminary figures by the province. The value for total structural materials after recent adjustments by the Dominion Bureau of Statistics is $37.4 million for this figure.

The Province of Nova Scotia, using a different tabulation, shows total production for granite, building and ornamental stone to be 517 net tons in 1963, 460 in 1964 and 525 in 1965. This is an increase in granite production for 1965 of 14 per cent. Sandstone production in 1965 of ornamental and building stone remained at the 10,000 ton volume it had attained in 1964. Only 9,000 tons were produced in 1963. The production of a quartzite building material in Nova Scotia decreased from 3,458 tons to 2,050 tons (1964 to 1965) but was still almost double the 1963 volume of 1,216 tons. Total structural materials produced in 1965 amounting to $8.7 million was an increase over 1964 of greater than 24 per cent.

Both Quebec and Ontario show increases in production of total structural materials and total mineral production. Total structural gains are slight, being less than 1 per cent for Quebec and 3 to 4 per cent for Ontario. The total mineral production for Quebec is less than a 2.5 per cent increase, while Ontario has a 9.4 per cent increase in the same category.

Increased production in 1965 over 1964 for Manitoba building stones is reported, while production of stone during 1966 continues to increase.

Statistics of New Brunswick's total structural materials and total mineral production show that the former dropped in value from $9.36 million to $9 million while the latter increased by about 73 per cent from $48.7 to $83.9 million from 1964 to 1965.

The total value of construction in Canada increased almost 15 per cent from its 1964 value of $8.63 billion to $9.91 billion in 1965. Building construction makes up almost 60 per cent of this total, or $5.88 billion, which showed an increase of 13.5 per cent over the 1964 value of $5.18 billion.

The total value (preliminary) for all structural materials produced in 1965 amounted to $423.2 million, a 5 per cent increase over the 1964 value (revised statistic) of $403,058,324. When compared with the $379,011,116 value for 1963 (6.3 per cent increase in 1964) the period from prior to 1963 to the present shows a definite trend of increased production of structural materials.

The total mineral production for Canada, amounting to $3.05, $3.39 and $3.74 billion for the years 1963, 1964 and 1965, respectively, shows consistent increases of 11.2 and 11.5 per cent for 1964 and 1965, respectively.

Building and ornamental stones share this increased productivity of structural material, and the more the architect, consumer and public are made aware of the aesthetic and durable qualities of our natural stone resources, the greater will be this share.

TABLE 1
Canadian Production of Building and Ornamental Stone, 1964[r]

	1964	
	Short Tons	$
By type		
Granite	158,733	3,632,507
Limestone	67,635	1,357,844
Marble	1,797	78,209
Sandstone	41,017	813,819
Total	269,182	5,882,379
By areas		
Atlantic provinces	4,943	395,949
Quebec	168,149	3,662,799
Ontario	82,647	1,438,091
Western provinces	13,443	385,540
Total	269,182	5,882,379

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

The total volume of stone for all types of rock produced in 1964 amounted to 269,182 short tons which is a 38 per cent increase over the 1963 production of 195,098 short tons. However, this represents a decrease in value of almost 17 per cent, dropping from $6,866,689 in 1963 to $5,882,379 in 1964.

TABLE 2

Production of Building and Ornamental Stone, 1964[r]

	Granite		Limestone		Marble		Sandstone		Total	
	Short Tons	$	Short Tons	$	Short Tons	$	Short Tons	$	Short Tons	$
By type										
Building										
Rough	123,107	716,388	29,725	295,714	1,453	64,609	31,209	456,816	185,494	1,533,527
Dressed	15,213	1,617,827	32,212	1,027,391	–	–	4,540	282,600	51,965	2,927,818
Total	138,320	2,334,215	61,937	1,323,105	1,453	64,609	35,749	739,416	237,459	4,461,345
Monumental										
Rough	8,311	316,875	–	–	–	–	–	–	8,311	316,875
Dressed	6,364	807,168	–	–	300	12,500	–	–	6,664	819,668
Total	14,675	1,124,043	–	–	300	12,500	–	–	14,975	1,136,543
Flagstone	625	9,063	5,698	34,739	44	1,100	4,448	62,563	10,815	107,465
Curbstone	5,113	165,186	–	–	–	–	–	–	5,113	165,816
Paving	–	–	–	–	–	–	820	11,840	820	11,840
Total	5,738	174,249	5,698	34,739	44	1,100	5,268	74,403	16,748	284,491
Grand Total	158,733	3,632,507	67,635	1,357,844	1,797	78,209	41,017	813,819	269,182	5,882,379
By areas										
Atlantic provinces	3,383	309,974	–	–	–	–	1,560	85,975	4,943	395,949
Quebec	148,350	3,206,035	12,126	385,784	405	4,710	7,268	66,270	168,149	3,662,799
Ontario	3,153	43,885	46,286	670,373	1,392	73,499	31,816	650,334	82,647	1,438,091
Western provinces	3,847	72,613	9,223	301,687	–	–	373	11,240	13,443	385,540
Total, Canada	158,733	3,632,507	67,635	1,357,844	1,797	78,209	41,017	813,819	269,182	5,882,379

[r]Revised

There is an increased production of rough granite building stone in 1964 amounting to 123,107 short tons compared with the same commodity in 1963 which amounted only to 28,429 short tons. This rough granite was valued at an average price of $20.80 per ton in 1963, while its counterpart was valued at an average price of $5.80 in 1964. The situation is also true (to a lesser degree) for limestone rough blocks which were sold at $15.70 a ton in 1963 and dropped to $9.95 per ton in 1964. Marble however exhibited a reversal of the granite and limestone trends. Rough marble building stone in 1963 averaged $12.30 per ton while the average value for the 1964 product increased to $44.50 per ton. The average price per ton for sandstone as rough building blocks in 1964 remains virtually unchanged from 1963.

Possibly this increased use of rough stone materials from the quarries and dressing plants is an effort to compete with the ceramic, plastics, and artificial stone and concrete producers, resulting in lower valued products.

IMPORTS AND EXPORTS

The value of building and ornamental stone imported into Canada in 1965 was $3,183,217, a decrease of 7.3 per cent from the 1964 value of $3,436,560. The greater part of this decrease is accounted for in the value of imported marble. Both rough and dressed blocks are involved in the decrease which amounted to 13.1 per cent.

Exports from Canada amounting to a value of $1,137,722 are slightly lower in 1965 compared with the 1964 value of $1,184,030, a decrease of 3.9 per cent.

TABLE 3

Building and Ornamental Stone,
Imports and Exports

	1964		1965	
	Short Tons	$	Short Tons	$
Imports				
Granite				
Rough	13,148	565,543	13,753	565,555
Dressed	..	218,704	..	232,793
Total		784,247		798,348
Marble				
Rough	2,429	176,313	1,515	121,830
Dressed		1,627,299	..	1,445,021
Total		1,803,612		1,566,851
Building stone, rough, n.e.s.	17,610	476,094	11,778	399,015
Natural stone basic products, n.e.s.[1]	..	372,607	..	419,003
Total imports		3,436,560		3,183,217
Exports				
Building stone, rough	22,254	499,786	20,611	605,374
Natural stone basic products[2]	..	684,244	..	532,348
Total exports		1,184,030		1,137,722

[1]Natural stone basic products including flagstones, floor tiles, roofing slate, slate mantels, etc. [2]Shaped and dressed stone, granite, marble, slate.
.. Not available; n.e.s. Not elsewhere specified.

CANADIAN DEPOSITS OF BUILDING AND ORNAMENTAL STONE

Not all deposits of rock are amenable for the production of sound, unfractured, massive and suitably coloured dimension stone. Quebec and Ontario are the two provinces which are producing, or have the potential to produce granite, limestone, marble and sandstone materials. Nova Scotia produces granite and sandstone rocks for building stones. New Brunswick has granite and sandstone production with potential deposits of marble in the St. John area. Manitoba has production of granite and limestone while British Columbia's production of building stone is principally restricted to granite. Alberta produces a silty quartzite from the Rocky Mountain area for use as a building block. Prince Edward Island has very limited production (if any) from weakly consolidated deposits of sandstone near Charlottetown. Newfoundland has outcrops of igneous and sedimentary rocks which are quarried for local use; the province is inconveniently located for more distant markets.

The following types of stone are being produced or are potentially available for production.

GRANITE

Nova Scotia. Grey granite is produced near Halifax, Middleton-Nictaux and Shelburne and black diorite is quarried in the Shelburne area. A hard, siliceous type of stone referred to as 'iron stone' is produced near Halifax, and quartzitic rocks referred to as 'blue stone' are produced in the Ostrea Lake and Echo Lake areas northeast of Dartmouth.

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.

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, Stanhope, St -Samuel-St -Sebastien and St -Gerard. Fine- and medium-grained, dark grey-blue essexite is quarried on Mont-St -Gregoire. A coarse-grained, dark green nordmarkite is available from the Lake Megantic mountain area. A fine-grained, apple-green granite is also produced near St -Gerard.

North of the St. Lawrence River, red, brown and black granites are quarried in the Lake St. John-Roberval-Chicoutimi area; anorthositic black rocks are quarried north of Alma on the banks of the Peribonka River and from the St -Ludger-de-Milot area. Blue-grey, rose-grey, deeper pink-grey, dark green, black and grey gneissic granites come from the Rivière-à-Pierre district; pink, fine-grained granite is quarried at Guenette, near Mt -Laurier. St -Alban supplies a pink-red granite and St -Raymond a banded gneiss. Brown-red to green-brown granites are quarried in the Grenville district. An augen-type, coarse-grained, rose-pink granite is located south of Mont-Tremblant. A mauve-red granite is produced in the Ville-Marie area on Lake Timiskaming. A dark-coloured anorthositic-type rock is found in the Rouyn area.

Ontario. A salmon-pink, medium-grained granite is available near Kenora at Vermilion Bay. A black anorthosite is produced in the River Valley area near North Bay. Rough building blocks are quarried near Parry Sound from a multicoloured gneissic rock. Potential red granites are available in the Lynhurst and Gananoque areas. Deposits of black and red granite along the north shore of Lake Superior are potential producers of dimension stone. A pink granite deposit located near Belmont Lake shows good potential.

Manitoba. A durable, red granite of good quality is being quarried in the Lac du Bonnet area, 70 miles northeast of Winnipeg.

British Columbia. A light grey and blue-grey, even-grained granite is available from both Nelson Island and from Granite Island.

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 produced in the vicinity of St -Marc-des-Carrières. The stone, besides being used in rough and sawn finishes, takes a good polish and is suitable for decorative use. Rough building stones are produced in small quantities from quarries near Montreal particularly on Ile-Jésus, north of the city. Small 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.

Manitoba. A mottled, buff-brown to grey-brown dolomitic limestone is obtained from quarries in the Garson area. It is effectively used in rough and sawn finishes and can take a polish for use as a decorative stone.

SANDSTONE

Nova Scotia. A massive-textured, fine- to medium-grained, olive-buff stone is quarried in the Wallace area.

New Brunswick. A red, fine- to medium-grained sandstone is available from an old quarry in Sackville. Numerous local-use deposits are situated about the province.

Quebec. A deposit of buff and red sandstone is being quarried in the Trois-Pistoles area.

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 available. A highly coloured, medium-grained, banded and mottled sandstone is produced from deposits 20 miles north of Kingston.

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.

MARBLE

Quebec. A small quantity of light and dark grey, green-white mottled marble is quarried in the Philipsburgh area, near the United States border south of Montreal. Sporadic quarrying of a white-grey marble is carried on in the western part of the Stukely area. A grey, mottled marble is potentially available from near Marbleton.

Ontario. Production of blue, blue-white, buff, white and grey, recrystallized limestone marbles is 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.

Sulphur

C.M. BARTLEY*

In 1966 world production of sulphur increased some 6 per cent but for the fourth consecutive year production was lower than consumption. Demand was met in part by further withdrawals from stocks which were reduced to dangerously low levels. Sulphur requirements, mainly to manufacture sulphuric acid for the production of phosphate fertilizer, continue to grow and in spite of strenuous efforts, no new major supply of sulphur has been found. Additions to elemental sulphur supply are coming on stream from present producing areas in the United States, Canada and Mexico, and new sources of supply are under development in the Middle East and elsewhere. Additions have been made to sulphur supply from non-elemental sources, such as pyrites, smelter gas, and others, (about 3 per cent) mainly in Europe. The increased supply of sulphuric acid from these sources tended to reduce the pressure on elemental sulphur stocks and suggests that a balance in sulphur supply and demand may be achieved before 1970. The balance is not yet assured because it depends on developments which cannot be accurately predicted. Sulphur consumption will continue to increase, mainly to supply many large new phosphate fertilizer facilities. Sulphur supply will increase but any gain in total output depends on maintaining full production from current sources and the prompt and successful opening of new production facilities. For various reasons the reliability of some current sources is uncertain and the production and schedules of some current developments are not predictable.

Production of elemental sulphur in Canada in 1966 increased only slightly and shipments were lower because long term commitments and reduced inventories made it impossible to accept all offers to purchase. Pyrites shipments were lower than in 1965 but consumption of sulphur in smelter gas increased appreciably.

The plateau in output indicated by these figures does not indicate a limiting of production because development now underway will increase Canadian sulphur from several sources in 1967 and following years. The world sulphur situation encouraged aggressive development of the Canadian industry on several fronts. Substantial additions are being made to sulphur capacity from sour gas. The production of sulphuric acid from smelter gas and pyrites sources is increasing rapidly, although there is little to indicate this in the 1966 figures. Sulphur production at Canadian oil refineries increased in 1966 as new facilities came on stream and additional amounts from this source and from Athabasca oil sands are expected in 1967.

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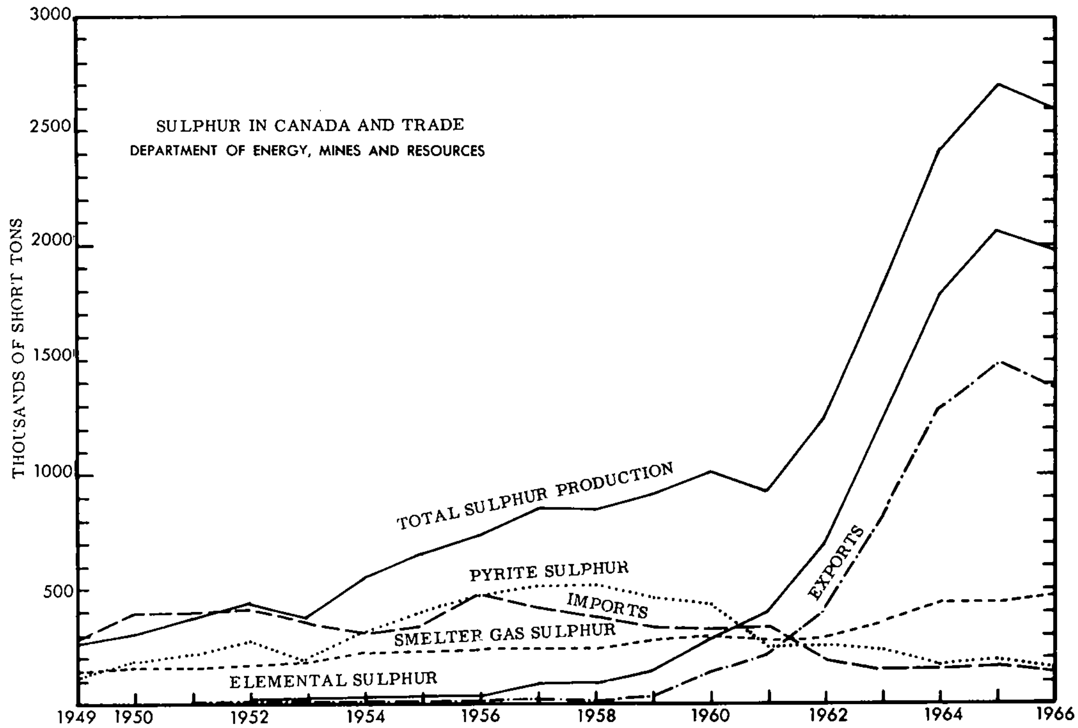


TABLE 1

Sulphur – Production and Trade, 1965-66

	1965		1966P	
	Short Tons	$	Short Tons	$
Production				
Pyrite and pyrrhotite[1]				
Gross weight	382,177		324,228	
Sulphur content	186,960	1,285,252	158,547	1,102,205
Sulphur in smelter gases[2]	444,758	4,317,362	470,467	4,644,062
Elemental sulphur[3]	2,068,394	26,394,595	1,980,716	35,875,487
Total sulphur content	2,700,112	31,997,209	2,609,730	41,621,754
Imports				
Sulphur, crude or refined				
United States	162,051	3,821,092	145,415	4,153,000
France	50	5,627	50	7,000
Mexico	100	2,160	–	–
Total	162,201	3,828,879	145,465	4,160,000

Table 1 (cont.)

	1965		1966^p	
	Short Tons	$	Short Tons	$
Exports				
Sulphur in ores (pyrite)				
United States	..	903,358	..	880,000
Japan	..	53,460	..	101,000
Finland	..	22,010	..	–
Total		978,828		981,000
Sulphur, crude and refined				
United States	741,723	9,311,259	785,691	12,786,000
Australia	202,408	4,117,033	196,350	6,035,000
Republic of South Africa	77,786	1,760,945	98,439	3,361,000
India	45,359	1,389,045	66,705	2,623,000
New Zealand	34,071	738,163	48,954	1,421,000
Hungary	74,978	1,512,993	44,477	1,177,000
Taiwan	73,117	1,789,725	37,822	2,035,000
Kuwait	–	–	19,880	736,000
Czechoslovakia	–	–	16,856	488,000
Russia	5,427	107,743	16,708	586,000
Other countries	243,078	5,764,186	67,214	2,342,000
Total	1,497,947	26,491,092	1,399,096	33,590,000

Source: Dominion Bureau of Statistics.

[1]Producers' shipments of by-product pyrite and pyrrhotite from the processing of metallic-sulphide ores. [2]Includes also sulphur in acid made from roasting zinc-sulphide concentrate. [3]Producers' shipments of elemental sulphur produced from natural gas. Includes a small quantity of elemental sulphur derived from treatment of nickel-sulphide matte at Port Colborne Ontario.

p Preliminary; – Nil; .. Not available.

Sulphur imports and exports were lower in 1966 than in 1965 and exports of pyrites had a slightly higher value but probably involved a lower tonnage. Sulphur consumption in Canada is estimated to be considerably higher than in 1965 but complete data are not available.

The continuing world shortage of sulphur has been caused by rapidly increasing demands, mainly for sulphuric acid for phosphate fertilizer manufacture. Producers have been unable to expand output quickly enough to supply the amounts needed and, over the past four years, heavy withdrawals have been made from the accumulated stockpiles in past years. At the end of 1966, world stocks were at a dangerously low level and could not be reduced further.

Efforts to increase production and to develop new sources of sulphur are in progress throughout the world. Sulphur prices have increased substantially over the past four years. Sulphur production is rising rapidly but the continuing strong demand makes a balance difficult to achieve.

PRODUCTION, TRADE AND CONSUMPTION

Canadian production of sulphur from all sources increased 16 per cent in 1967 to a new high of 2.66 million tons. Slightly more than 2 million tons was in the form of elemental sulphur, mainly from sour gases in Alberta, but including sour gas sources in British Columbia and Saskatchewan, oil refinery gases in Manitoba, Ontario, Quebec, New Brunswick and Nova Scotia, and base metal refineries in Manitoba and Ontario. The balance comprised some 470,467 tons in the form of smelter gas and 158,547 tons contained in pyrites.

Sulphur imports have decreased steadily over the past ten years, from 416,930 tons in 1957 to 145,465 tons in 1966. Exports of sulphur increased remarkably during this period, from 12,364 tons in 1957 to 1,497,947 tons in 1965. However, in 1966 exports, at 1,399,096 tons, were lower than in 1965 due to the depletion of stock piles and the resulting inability to supply all demands. Although tonnage decreased, the rising price of sulphur resulted in an increase of 25 per cent in value to nearly $33.6 million. Exports of pyrites, mainly to the United States were similar to those of 1965.

Consumption of elemental sulphur in Canada has almost doubled in the past ten years, from about 481,000 tons in 1957 to an estimated 824,000 tons in 1966. In addition, sulphur in smelter gases used in Canada brought total consumption of sulphur to more than 1.2 million tons in 1966. The strong growth trends in sulphur consuming industries, particularly phosphate fertilizer manufacturing, suggest that consumption in 1967 may reach 1.4 million tons.

TABLE 2

Consumption of Elemental Sulphur in Canada, 1964-65

(short tons)

	1964	1965
Chemicals	140,526	162,008
Pulp and paper	306,830	424,523
Rubber products	2,257	3,158
Fertilizers	59,857	113,746
Foundry	8,445	13,106
Other industries*	26,477	22,682
Total	544,392	739,223

*Includes cleansers, detergents, soaps, glass and glass products, adhesive, explosives, starch, sugar processing and titanium and uranium processing.

TABLE 3

Sulphur – Production, Trade and Consumption, 1957-66

(short tons)

	Production				Imports	Exports		Consumption
	In Pyrites Shipped[1]	In Smelter Gases[2]	Elemental Sulphur[3]	Total	Elemental Sulphur	In Pyrite[4]	Other Sulphur[5]	Elemental Sulphur[6]
1957	515,096	235,123	93,327	843,546	416,930	$2,852,753	12,364	480,941
1958	512,427	241,055	94,377	847,859	375,331	1,879,251	7,608	515,047
1959	465,611	277,030	145,656	888,297	332,430	1,018,608	26,526	483,482
1960	437,790	289,620	274,359	1,001,769	328,765	1,259,151	143,040	507,810
1961	255,376	277,056	394,762	927,194	329,556	899,755	217,866	513,048
1962	257,084	292,728	695,098	1,244,910	195,089	890,055	400,026	522,903
1963	235,410	353,243	1,249,887	1,838,540	150,637	937,883	820,929	558,450
1964	173,182	443,448	1,788,165	2,404,795	149,567	878,545	1,294,587	544,392
1965	186,960	444,758	2,068,394	2,700,112	162,201	978,828	1,497,947	739,223
1966P	158,547	470,467	1,980,716	2,609,730	145,465	981,000	1,399,096	..

Source: Dominion Bureau of Statistics.

1 Sulphur content of pyrite and pyrrhotite shipped by producers, not necessarily all recovered. Pyrite used to make byproduct iron sinter in 1961, 1962 and 1963 not included.
2 Sulphur in liquid sulphur dioxide and sulphuric acid from the smelting of metal-sulphide ores. For 1956 and years following includes sulphur in acid made from roasting zinc-sulphide concentrates.
3 Elemental sulphur produced from natural gas. Production for the year 1956 and sales from 1957 on. Starting in 1957 elemental sulphur derived from the treatment of nickel-copper sulphide matte at Port Colborne, Ontario, is included.
4 Dollar values of exports of pyrite. Quantities are not available for publication.
5 Exports of sulphur produced from natural gas and other sources.
6 Consumption of elemental sulphur by industries as reported by consumers.

PPreliminary; .. Not available.

PYRITES – PYRITE, PYRRHOTITE AND OTHER SULPHIDES

Pyrites have been produced in Canada, for domestic use and export, for more than 70 years. Until the start of elemental sulphur production from sour gases in western Canada in 1952, pyrites and smelter gases were the sole domestic sources of sulphuric acid and substantial imports of elemental sulphur were required to serve some industries.

In Canada pyrites resources are very large and byproduct pyrite or pyrrhotite is available at several large base metal mining and smelting plants. These concentrates, since they have been mined and partially processed, are low-cost sources of sulphuric acid and iron. Pyrrhotite concentrates have been used for many years by Cominco Ltd. at Kimberley, B.C. and by Canadian Industries Limited at Copper Cliff, Ont. (from The International Nickel Company of Canada, Limited's nickel mines) as a source of sulphuric acid and iron ore. Pyrite concentrates are used by Allied Chemical Canada, Ltd. at Valleyfield, Que. and, in small amounts, by several other Canadian companies. It is planned to use pyrite for sulphuric acid, and possibly elemental sulphur manufacture at Belledune, N.B. and as a source of iron and, presumably, sulphuric acid at Regina. The large amounts of pyrite concentrate which will be available from the Texas Gulf Sulphur Company base metal complex near Timmins, Ont., will very likely serve as a source of sulphuric acid or elemental sulphur. Sherritt Gordon Mines, Limited and Falconbridge Nickel Mines, Limited have investigated their pyritic materials as possible sources of sulphur and iron products and the latter company is considering the construction of a large iron-sulphur plant. Numerous other possibilities for such recoveries exist in Canada. Only limited use of this potential sulphur source has been made in the past because when elemental sulphur is available and low in price it is both technically and economically a more attractive source of sulphuric acid. The current shortage and increased price of elemental sulphur has encouraged the use of pyrites and improvements in the technology of processing have made the production of elemental sulphur and a useful iron product more efficient and more attractive economically.

Canadian producers of pyrites are listed in Table 4 with general information on the nature of their operations.

SMELTER GAS

Smelter gas has been used as a source material for sulphuric acid in Canada since 1928 and between 1936 and 1943 was the source of elemental sulphur at Trail, B.C. Production, reported as tons of sulphur, has increased steadily and in 1966 was at a new high of 470,467 tons. It should be noted that this figure includes the sulphur, recovered as sulphuric acid, from the pyrites operations at Kimberley, B.C., Copper Cliff, Ont. and Valleyfield, Que. It is also of interest and importance to note that whereas elemental sulphur is consumed to produce sulphuric acid, the production of sulphuric acid from

TABLE 4

Producers of Pyrite and Pyrrhotite for Sulphur Content

Company	Location	Raw Material	Products	Uses
Cominco	Kimberley, B.C.	pyrrhotite	SO_2 iron ore	H_2SO_4 steel plant
Inco	Copper Cliff, Ont.	pyrrhotite	SO_2 iron ore	CIL H_2SO_4 steel plant
Noranda Mines Ltd.	Noranda, Que.	pyrite	pyrite conc	sale
Quemont Mining Corp.	Noranda, Que.	pyrite	pyrite conc	sale
Normetal Mining Corp.	Normetal, Que.	pyrite	pyrite conc	sale

TABLE 5

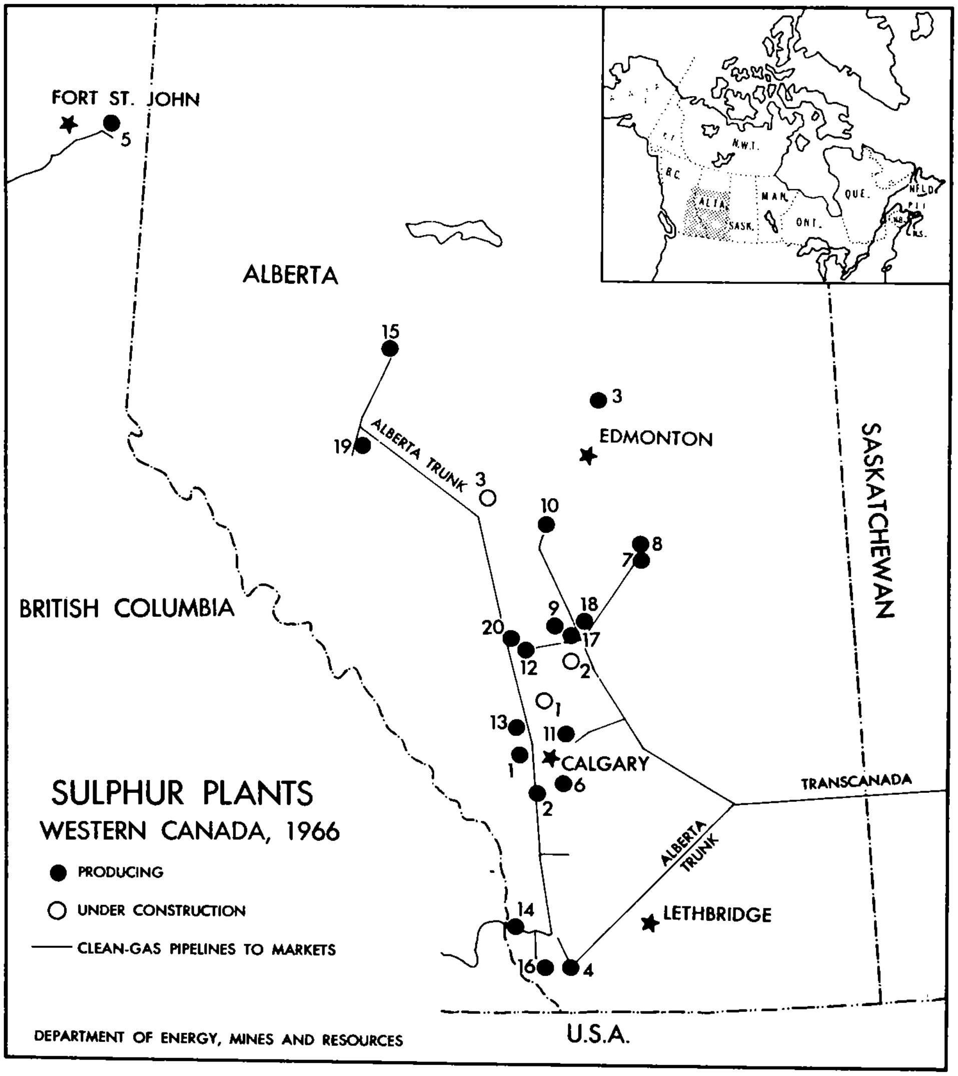
Sulphur Plants, Western Canada, 1966

Operating Company	Source Field or Plant Location	Plant Built	Approx. % H_2S	Capacity in Short Tons Daily	Capacity in Short Tons Annual(1)
Producing plants	(indicated by "O" on map)				
1 Shell Canada(2)	Jumping Pound, Alta.	1951	4	110	38,500
2 Royalite Oil Company	Turner Valley, Alta.	1951	4	33	11,500
3 Imperial Oil	Redwater, Alta.	1956	3	10	3,500
4 British American Oil	Pincher Ck., Alta.	1957	10	755	264,000
5 Jefferson Lake Petrochemicals	Taylor Flats, B.C.	1957	3	330	115,500
6 Texas Gulf Sulphur	Okotoks, Alta.	1959	35	415	145,000
7 British American Oil(2)	Nevis, Alta.	1959	4 - 6	85	30,000
8 Chevron Standard	Nevis, Alta.	1959	6	130	45,500
9 Shell Canada	Innisfail, Alta.	1960	14	110	38,500
10 British American Oil	Rimbey, Alta.	1961	2	360	126,000
11 Petrogas Processing(2)	Crossfield, Alta.	1961	16	965	338,000
12 Home Oil(2)	Carstairs, Alta.	1961	1	56	19,600
13 Canadian Fina Oil	Wildcat Hills, Alta.	1961	4	117	41,000
14 Jefferson Lake Petrochemicals	Savannah Ck., Alta.	1961	14	420	147,000
15 Texas Gulf Sulphur	Windfall, Alta.	1961	15 - 20	1,500	525,000
16 Shell Canada(2)	Waterton, Alta.	1962	22 - 27	1,340	469,000
17 Amerada Petroleum(2)	Olds, Alta.	1964	7	120	42,000
18 Mobil Oil Canada	Wimborne, Alta.	1965	16	270	94,500
19 Hudson's Bay Oil and Gas	Edson, Alta.	1966	2	269	94,100
20 Canadian Superior Oil	Harmattan-Elkton Leduc, Alta.	1966	42 - 53	335	117,250
21 Steelman Gas(3) (not on map)	Steelman, Sask.	1961	1	15	5,200
Total capacity at end of 1966				7,745	2,710,650
Plants under construction	(indicated by "O" on map)				
1 Pan American Petroleum	East Crossfield, Alta.	1967	38	1,350	472,500
2 Hudson's Bay Oil and Gas	Lone Pine Creek, Alta.	1966	?	55	19,250
3 Canadian Delhi Oil	Minnehik-Buck Lake, Alta.	1967	5	28	9,800
4 Petrogas Processing (expansion)	Crossfield, Alta.	1967	16	1,000	350,000
5 Shell Canada(2) (expansion)	Jumping Pound West, Alta.	1967	5	155	54,250
6 Shell Canada(2) (expansion)	Waterton, Alta.	1967	22 - 27	504	176,400
7 British American(2) Oil (expansion)	Nevis, Alta.	1967	4 - 6	60	21,000
8 Home Oil(2) (expansion)	Carstairs, Alta.	1966	1	47	16,450
9 Amerada Petroleum(2) (expansion)	Olds, Alta.	1967	7	77	26,950
				3,276	1,146,600
Expected capacity at end of 1967				11,021	3,857,250

Source: Oil and Gas Conservation Board and others.
(1) Calculated on the basis of 350 operating days a year.
(2) See expansion in second part of table.
(3) Plant closed 1963 re-opened 1966 at expanded capacity.

smelter gas (and pyrites) is essentially sulphur production.

Additions to capacity under construction in 1966, particularly at Copper Cliff, Ont., and Belledune, N.B., will increase output in 1967 and 1968. At the end of 1966 smelter gas was the source of about one third of the sulphuric acid capacity in Canada which amounted to more than 1.0 million tons per year from five operations.



ELEMENTAL SULPHUR FROM SULPHIDES

Elemental sulphur is obtained by the electrolytic refining of nickel sulphide matte in the Inco refineries at Port Colborne, Ont., and Thompson, Man.

By different processes, sulphur was also produced from smelter gas by Cominco at Trail, B.C., between 1936 and 1943, and from the roasting of pyrite concentrate by Noranda Mines Limited at Port Robinson, Ont., from 1954 to 1959. The iron residue from the Noranda process was pelletized and marketed as an iron ore.

The continuing shortage of sulphur, and repeated price increases, have revived interest in processes to recover elemental sulphur from sulphide materials. The use of smelter fumes and pyrites as sources of sulphuric acid are highly attractive where captive use or markets for sulphuric acid are available close to the producer. Sulphuric acid, however, is costly to ship and therefore has a relatively small market area. When elemental sulphur from Frasch and other large scale sources was plentiful and low priced, the cost of converting sulphur dioxide, from smelter fumes or pyrites, to elemental sulphur was only rarely and marginally attractive. In the present sulphur situation of restricted supply and high prices, the production of elemental sulphur from sulphide materials has become much more attractive, particularly when credits for byproduct steam and iron may be obtained. A recent paper* presents data indicating this possibility.

SULPHUR FROM OIL REFINERIES

Crude oil from certain producing areas of the world (the Middle East and South America for example) contain appreciable amounts of sulphur which may be released as hydrogen sulphide during refining and recovered by the processes used in gas-sulphur plants. In Canada, such oils refined in Nova Scotia, New Brunswick and near Montreal, Quebec, are a source of elemental sulphur. Similar recovery plants have been built near Toronto and Sarnia and a small plant is in operation at a refinery in Winnipeg. The total capacity of those plants is some 140,000 tons per year. Production in 1966 amounted to some 80,000 tons of sulphur.

Although this output is not large compared to other sources of sulphur in Canada it can be marketed readily near its source and output will probably increase steadily as demand for refinery products increases.

OTHER SULPHUR

The Fort Saskatchewan, Alberta, refinery of Sherritt Gordon Mines, Limited, uses an ammonia leach process to treat nickel sulphide ores for the recovery of nickel, and recovers ammonia sulphate as a byproduct. It is estimated that the equivalent of more than 20,000 tons of sulphur was recovered by this process in 1966.

NATURAL GAS SULPHUR

Canada has become a major sulphur producer by accident and indirectly. Oil exploration in western Canada, starting about 1910, disclosed natural gas reserves, some of which were 'sour' (containing hydrogen sulphide). For many years the accumulating gas reserves were of little interest because markets were limited in western Canada and the large scale potential markets in eastern Canada and the United States would require costly pipelines. Two conditions had to be satisfied before pipelines to move gas to these markets were justified. First, ample reserves to satisfy both domestic and export demands over a long period had to be proven, and second, the approval of both export and import agencies obtained and satisfactory long term contracts negotiated. By 1960 both conditions had been satisfied and major pipeline construction began.

By the time pipelines were completed gas demands had increased so that sweet gas reserves were largely committed and it was necessary to use sour gases to fulfil the contracts. Sour gases cannot be moved by pipelines or used as fuel with safety because hydrogen sulphide is both toxic and highly corrosive. Therefore, to produce a marketable fuel, gas-cleaning plants were built to remove hydrogen sulphide, excess liquid petroleum gases, and some inert gases, and to produce a fuel gas of standard specifications. Methods were available to convert H_2S to sulphur and, because many gas fields contained considerable amounts of H_2S, the potential sulphur recovery was large and much too valuable to waste. Many natural gas producers were thus required to produce sulphur in order to market gas and the Canadian sulphur industry became a reality.

H_2S is recovered by passing the raw sour gas stream through a solution (usually monoethanolamine) which has an affinity for hydrogen sulphide. The H_2S collects in the solution and, when concentrated, is distilled off and passed to a Claus furnace where it is burned with a controlled amount of air to produce a mist of

*"Sulphur Dioxide and Sulphur from Fluosolids Systems" by John T. Graves and Thomas D. Heath, A.I.M.E. Los Angeles, Feb. 21, 1967.

sulphur droplets. These are condensed to a liquid and pumped to storage vats.

Two significant facts are implicit in the production of elemental sulphur from sour gas. First, the removal of H_2S and the recovery of sulphur is obligatory if the gas is to be marketed, and second, at least two products of value, and sometimes as many as five, are separated from the raw gas. This means that the cost of exploration, production and treatment of the gas may be shared by several end products of which sulphur is but one. A gas with a very high content of H_2S may be primarily a source of sulphur and the value of the sulphur would have to cover most of the production cost. Such gases would be used as sources only when sulphur prices were high. On the other hand, a gas with a medium to low H_2S content would be most valuable for its hydrocarbon content and, in some cases, the sulphur may be regarded as a free byproduct of the necessary cleaning process. The significance of the wide variation in the H_2S content of Canadian gases and the effect that changing sulphur prices exert on such operations can be seen in western Canada. A few years ago, with sulphur prices low, very sour gases were avoided if possible. Now, with sulphur prices higher and still rising, aggressive development of these sources is underway.

Estimated reserves of sulphur in sour gas in the province of Alberta were reported to be in excess of 123 million tons at the end of 1966. Smaller reserves in British Columbia and Saskatchewan would increase this total.

Table 5 lists 19 plants in Alberta, one in British Columbia and one in Saskatchewan which produced a total 1.94 million tons of sulphur from sour natural gases in 1966. This amount represents an increase of nearly 10 per cent over 1965. However, shipments of sulphur from these plants, at 1.98 million tons, were lower by some 87,000 tons than in 1965, because in spite of urgent needs and several increases in price, sulphur stockpiles had been so depleted that any further reduction would cause problems in marketing and shipment. It is expected that for the next few years Canadian sulphur shipments will approximate production. Demand for sulphur is still rising and although production from western Canada sour gas is expected to increase to some 4.0 million tons by 1970, there is as yet no assurance that this, or other world sources, will be adequate to satisfy sulphur demands.

Sulphur production capacity in western Canada at the end of 1966 was about 8,300 tons per day or 2.9 million tons per year. Output will rarely if ever approach capacity because the plants are designed primarily to process gas, and sales gas contracts thus control sulphur production. Plants must be capable of meeting peak gas demands but will operate at such rates only briefly. Additional capacity under construction in 1966 and due for operation in 1967 will add some 3,600 tons per day and bring annual capacity to about 4.0 million tons. This is an increase of more than 30 per cent in sour gas sulphur capacity. New plants and those being expanded are listed in the lower section of Table 5.

Plans for further expansion, announced in early 1967, indicate additional capacity of more than 1.0 million tons of sulphur in 1968 and at least 0.5 million ton in 1969. It is probable that other additions will be started by that time.

ATHABASCA OIL SAND SULPHUR

The Great Canadian Oil Sands Limited project, near Fort McMurray in northern Alberta, was nearing completion at the end of 1966, and sulphur production from the oil treatment facilities is expected late in 1967. Capacity will be about 330 tons per day or 115,000 tons per year. Three other companies have shown interest in producing oil from the sands.

Reserves of oil, and sulphur, in these deposits are very large. Estimates of the oil content range from 100 billion to 600 billion barrels. Assuming 300 billion barrels, the sulphur content of the oil, at a basis of 5 per cent by weight, would total about 1 billion tons. Since sulphur is recovered by the same processes used in sour gas processing its production cost, as an obligatory co-product, would be low. Large-scale production of oil from these sands would thus provide substantial amounts of sulphur.

SULPHURIC ACID

Production of sulphuric acid increased for for the sixth consecutive year to a new high estimated at more than 2.52 million tons (100 per cent H_2SO_4) in 1966. During the year 18 plants with an estimated capacity of more than 3 million tons were in operation using three sources of raw material. About 40 per cent of sulphuric acid production is based on elemental sulphur and the remaining 60 per cent on smelter gas and pyrites in approximately equal amounts.

TABLE 6

Available Data on Consumption of Sulphuric Acid by Industries, 1964

(short tons — 100% acid)

Iron and steel mills	67,896
Other iron and steel	14,784
Electrical products	5,352
Vegetable — oil mills	79
Sugar refineries	271
Leather tanneries	2,550
Textile dyeing and finishing plants	57
Pulp and paper mills	53,985
Processing of uranium ore	143,162
Manufacture of mixed fertilizers	362,883
Manufacture of plastics and synthetic resins	24,491
Manufacture of soaps and cleaning compounds	17,315
Other chemical industries	12,104
Manufacture of industrial chemicals[1]	1,004,555
Petroleum refining	14,612
Mining[2]	47,549
Miscellaneous[3]	85,275
Total accounted for	1,856,920

Source: Dominion Bureau of Statistics.

[1]Includes consumption of own make or captive acid by firms classified to these industries [2]Includes metal mines, nonmetal mines, mineral fuels and structural material. [3]Includes synthetic textiles, explosives and ammunition, and other petroleum and coal products.

Current construction and announced plans indicate a continuing strong growth in sulphuric acid production. Operations based on elemental sulphur will increase, particularly in western Canada, to serve the phosphate fertilizer and other industries. Even larger increases, based on smelter gas and pyrites, mainly in eastern Canada, are predicted. In the near future the increases in acid production are related mainly to the expansion of phosphate fertilizer capacity but after 1970 substantial amounts of acid will be required for the treatment of uranium, possibly 1.0 million tons by 1975.

TABLE 7

Sulphuric Acid — Production, Trade and Apparent Consumption, 1957-66

(short tons — 100% acid)

	Production	Imports	Exports	Apparent Consumption
1957	1,290,000	1,046	29,550	1,261,496
1958	1,586,000	39,345	23,252	1,602,093
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
1966p	2,526,000	6,948	54,948	2,478,000

Source: Dominion Bureau of Statistics.

Imports of sulphuric acid, at 6,948 tons increased more than 100 per cent over those of 1965 and exports, at 54,948 were lower than the 57,110 tons shipped in 1965. Estimated consumption, at 2,478,000 tons, was 12 per cent higher than in 1965. Tables 6 and 7 provide details of use and trade in sulphuric acid.

Liquid sulphur dioxide is produced at Copper Cliff, Ont., from a rich sulphur dioxide gas drawn from Inco's flash smelting process. Capacity is about 100,000 tons of liquid sulphur dioxide per year.

WORLD REVIEW AND OUTLOOK FOR CANADIAN SULPHUR

World sulphur production in all forms is estimated at 31.7 million metric tons for 1966. Free world production, by preliminary reports, was 24.5 million tons and production in the nations of the Communist Bloc is estimated at some 7 million tons. In the western world production in 1966 comprised 14.20 million tons of elemental sulphur, 6.14 million tons in pyrites and 4.17 million tons in other forms (smelter gas etc).

The 1966 world consumption in all forms is estimated at about 32 million metric tons. Free world consumption has been reported at 25.3 million tons and Communist Bloc countries used about 7 million tons. The excess of consumption over production, for the fourth consecutive year, resulted in further lowering of world sulphur stocks by nearly one million tons. Stocks of sulphur are now at an all-time low and cannot be further reduced. Current sulphur consumption together with all new demands must be met from production.

Table 8 gives available and estimated figures on world sulphur output. The production of elemental sulphur from United States and Mexican Frasch operations increased about 13 per cent to a new high of 8.6 million tons. Elemental sulphur from other sources (mainly sour gas) was slightly lower in the United States and France and slightly higher in Canada. Pyrites sulphur production in the Free World, at 6.2 million tons, increased about 2 per cent and consumption was higher by some 5 per cent as stocks were reduced and imports from eastern to western Europe increased. Sulphur production in other forms (mainly smelter gas converted to sulphuric acid) increased about 3 per cent to 4.17 million tons in the Free World.

TABLE 8

World Production of Sulphur in all Forms [1]
('000 Metric Tons)

	1966					1965 [4]
	Frasch	Other Elemental	In Pyrites	In Other [2] Forms	Total	Total
USA	7112	1271	450	1081	9914	8842
USSR		1350	1900	870	4120	5
Japan		283	1450	759	2492	5
Canada [3]		1847	144	427	2418	2308
Mexico	1636	66	—	21	1723	1605
France		1531	38	134	1703	5
Spain		2	1144	23	1169	5
Italy		95	596	210	901	5
China		170	500	70	740	5
West Germany		84	643	270	997	5
Poland		477	105	110	692	5
Cyprus		—	470	—	470	5
Norway		1	314	31	346	5
East Germany		120	115	130	365	5
Finland		74	71	126	271	5
Others		262	1933	1169	3364	16747
Total	8748	7633	9873	5431	31685	29502

[1]Source: British Sulphur Corp. Ltd., except for Canadian data. [2]Sulphur in smelter gas, anhydrite-gypsum, spent oxide etc. [3]Output rather than shipments. [4]From "Sulphur" 1965. [5]Included in "Others".

The outlook for sulphur during 1967 and up to 1970 is unclear. Production has expanded substantially over the past four years but consumption has increased even more with the result that all current and new production has been consumed promptly and even depletion of sulphur stockpiles has failed to satisfy demands. At the present time sulphur producing facilities throughout the world are being operated at or near capacity and major expansions of elemental production are underway or planned in the United States, Canada, Mexico and the Middle East. Appreciable, though smaller additions are expected from other countries. The uncertainty in the sulphur situation stems from the fact that some of the current supply sources may not be able to maintain current production and some of the new projects may not achieve or maintain the outputs hoped for.

It must be stressed that the shortage is not due to lack of sulphur raw materials which, in various forms are fully adequate, but to the problem of economically producing sulphur.

The physical shortage could be solved, at current sulphur prices, by aggressive development of production from sources such as smelter gases and pyrites. There is some hesitation about this solution. If current and planned elemental production proves to be adequate and sulphur prices fall from their present high level, many of the new pyrites and smelter gas sources might become economically unattractive again. The decisions to be made are difficult and important because pyrites and smelter sources of sulphur are most attractive in large-scale facilities and these require major capital investments which in turn need the assurance of long-term utilization.

The basic cause of the sulphur shortage is the lack of food in many parts of the world. This has resulted in a world-wide surge in construction of phosphate fertilizer facilities to increase fertilizer supply for food production. The need for fertilizer is world-wide, urgent and long-term. It has been estimated that by 1971-72 the sulphur required for fertilizer production alone will be 24 million tons per year. This amount is equal to the total Free World output in 1966 which was nearly 1.0 million tons lower than demand. In the next five years some 12 million tons of new sulphur must be found while current production is fully maintained. At the present time there is no certainty that either can be done. It appears likely that sulphur supply will continue to be short and that prices will remain high.

Canada is one of a very few countries with sulphur resources in several forms available for immediate development. A large part of domestic needs, in the form of sulphuric acid, can be supplied by smelter gas and pyrites, and most of the rapidly increasing production of elemental sulphur, from sour gas sources, can be directed to export. At current sulphur prices, sulphur and sulphuric acid production from these sources is highly attractive and the availability of other raw materials and sources of energy in a stable political setting will be a powerful incentive to rapid and continuous industrial development in Canada.

The outlook for Canadian sulphur is thus highly promising. Resources are large, recovery processes are available, production costs are low, markets are world-wide and expanding rapidly and at current and expected prices sulphur production is profitable.

PRICES

The Canadian price for sulphur as quoted in Canadian Chemical Processing, October 1966 was as follows:

sulphur, elemental, carloads, f.o.b. works, per ton	$ 24	$ 32.40

United States prices, per long ton quoted by the Oil, Paint and Drug Reporter of December 26, 1966 were as follows:

crude, domestic dark, bulk, f.o.b. cars mines	27.00
crude, domestic dark, f.o.b. vessels, gulf ports (for U.S. and Canada)	28.50
domestic bright $1.00 per long ton extra	

TARIFFS

Canada

Sulphur, crude or in roll or flour form	free
Sulphuric acid	
British preferential	17½¢ per 100 lbs
Most favoured nation	22½¢ " " "
General	25 ¢ " " "
Sulphuric acid, not including glass containers when in packages weighing not more than 100 lbs	
British preferential	free
Most favoured nation	22½¢ per 100 lbs
General	25 ¢ " " "

United States

Pyrites	free
Elemental sulphur	free
Sulphuric acid	free
Sulphur compounds	10.5% ad val.
Sulphur dioxide	12½% ad val.

Talc and Soapstone; Pyrophyllite

D. H. STONEHOUSE*

As a result of increased output from Ontario, Canada's talc and soapstone production for 1966 was up by nearly 4,000 tons over the 1965 total. Total value reflects a slightly higher unit price for the 1966 shipments. All pyrophyllite production in Canada is from the province of Newfoundland. In 1966 pyrophyllite shipments increased by more than 10,000 tons and total value was proportionately higher than for 1965.

Imports of talc, from United States, Italy and France, were nearly 3,000 tons less than 1965 imports but remain only slightly less than domestic production. The material brought in from the United States is of relatively high quality and is used in the paint, ceramics and paper industries. Talc from Italy and France is imported for use in the manufacture of cosmetics and pharmaceuticals and is of high quality.

Small amounts of talc and soapstone have been exported each year, but the entire yearly production of pyrophyllite is exported to the eastern United States.

PRODUCERS

QUEBEC

At South Bolton, 60 miles southeast of Montreal, talc and soapstone are produced from an underground operation by Baker Talc Limited. The mined talc is milled at Highwater, about 10 miles south of the mine site. The processing consists of primary and secondary crushing, fine grinding and air classification. The products are shipped in sacks or in bulk and are relatively low grade. Rough and sawn blocks of soapstone are sold for sculpturing.

Broughton Soapstone & Quarry Company, Limited quarries talc and soapstone from two separate deposits near Broughton Station in the Eastern Townships. Several low-priced grades of ground talc are produced and soapstone is sawn into metal workers' crayons and blocks for sculpturing and refractory use.

*Mineral Processing Division, Mines Branch.

TABLE 1

Production, Trade and Consumption

	1965		1966P	
	Short Tons	$	Short Tons	$
Production (shipments)				
Talc and soapstone				
Quebec*	14,675	172,834	15,100	191,100
Ontario**	8,028	137,458	11,500	195,500
Total	22,703	310,292	26,600	386,600
Pyrophyllite				
Newfoundland	30,134	452,010	40,548	608,220
Imports (talc)				
United States	26,849	1,174,491	23,906	1,097,000
Italy	998	67,597	994	70,000
France	11	821	18	1,000
Total	27,858	1,242,909	24,918	1,168,000
	1964		1965	
	Short Tons		Short Tons	
Consumption (ground talc, available data)				
Ceramic products	10,977		11,897	
Paints and wall-joint sealers	7,178		6,678	
Roofing	7,350		6,157	
Paper	1,653		954	
Rubber	1,930		1,905	
Insecticides	1,468		809	
Toilet preparations	1,346		1,294	
Cleaning compounds	931		711	
Pharmaceutical preparations	286		471	
Linoleum and tile	1,941		541	
Other products(a)	986		3,254	
Total	36,046		34,671	

Source: Dominion Bureau of Statistics.
*Ground talc, soapstone blocks and crayons. **Ground talc.
P Preliminary.
(a) Chiefly chemicals, foundries, gypsum products, and other minor uses.

ONTARIO

Underground operations at Madoc produce crude talc from which several low-quality grades of ground talc are obtained. The mines are operated by Canada Talc Industries Limited. Shipments of a high-grade, flaky talc, from a zone developed in 1965, were sent to the north-eastern United States for processing to cosmetic- and pharmaceutical-grade products.

NEWFOUNDLAND

Pyrophyllite of relatively high quality is quarried at Long Pond near Manuels by Newfoundland Minerals Limited. Their entire output is shipped to American Olean Tile Company, Inc. at Lansdale, Pennsylvania, where it is processed and used in the manufacture of ceramic wall tile.

TABLE 2

Production and Trade, 1957-66
(short tons)

	Production*			Imports	Exports
	Talc and Soapstone	Pyrophyllite (All Exported)	Total Talc, Soapstone and Pyrophyllite	Talc	Talc
1957	29,039	5,686	34,725	14,949	2,353
1958	27,951	7,454	35,405	16,593	1,931
1959	24,733	14,443	39,176	18,501	2,053
1960	21,411	20,225	41,636	19,153	1,660
1961	23,691	24,425	48,116	20,205	2,000[e]
1962	23,367	22,794	46,161	24,148	2,300[e]
1963	22,467	31,783	54,250	27,539	2,200[e]
1964	25,316	32,816	58,132	31,598	2,600[e]
1965	22,703	30,134	52,837	27,858	3,500[e]
1966[p]	26,600	40,548	67,148	24,918	..

Source: Dominion Bureau of Statistics.
*Producers' shipments.
[e] Estimated, not available as a separate trade class after 1960.
[p] Preliminary.
.. Not available.

TECHNOLOGY

Talc is a hydrous magnesium silicate. It is soft and flaky, has a greasy feel or 'slip' and grinds to a near-white powder. It is relatively inert chemically and has a high fusion point and low electrical and thermal conductivity.

Many kinds of commercial talc are mixtures of talc and other minerals. The deposits in southern Quebec were formed by the alteration of serpentinized peridotite and contain, in addition to talc, serpentine, magnesite and iron-bearing minerals such as chlorite. The ground products are somewhat off-white but can be used where colour specifications are not exacting. Higher quality products are possible if impurities are removed by some beneficiation process. The Madoc deposits are altered near-white dolomitic marble consisting principally of talc, tremolite and dolomite in various proportions. Ground products are near-white and naturally low in iron but are limited in use because of variable amounts of dolomite. Control of the dolomite content could result in widely acceptable high-quality products. Tremolite and similar fibrous minerals contribute properties desirable to some applications of commercial talc.

The processing of talc in Canada is relatively simple, the important step being grinding and particle-size classification. Some beneficiation is achieved during grinding but high-quality products would require the application of electromagnetic separation or flotation.

Soapstone is essentially an impure talcose rock from which blocks and crayons can be readily sawn. The grey soapstone in southern Quebec was altered from serpentinized peridotite.

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.

USES AND SPECIFICATIONS

Commercial talc is used mostly in a fine-ground state although soapstone and steatite are used to a limited extent in the massive or block form. There are many industrial applications for ground talc but major consumers are limited to less than a dozen.

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 such minerals as the carbonates, a near-white colour, a fine particle size with controlled distribution and a specific oil-absorption are important. However, because of the variety of paints and, therefore, of talc pigments, precise specifications are generally based on agreement between consumer and supplier. Paper manufacturers require talc of high reflectance, high retention in the pulp, low abrasiveness and freedom from chemically active substances. The ceramics industry specifies fine particle size and freedom from impurities that would discolour the fired product. Talc of high purity is demanded for use in cosmetic and pharmaceutical preparations.

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 the main specification; colour and impurity content are generally of little importance, although for asphalt pipeline enamels, low carbonate 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 refractory brick or block but, because of its resistance to heat and its 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 basically minus 325 mesh and contain a minimum of quartz and sericite.

PRICES

Quoted prices for talc vary greatly and are generally based on a wide range of specifications. A product of high purity, fine particle size and a high degree of whiteness would command a greater price than darker, coarser material. There is no published Canadian price list for talc products.

Talc prices in the United States as quoted in *E & MJ Metal and Mineral Markets* of December 26, 1966 were as follows:

per short ton, f.o.b. mine or mill, containers included unless otherwise specified:

New Jersey: mineral pulp, ground (bags extra)	$10.50 – $12.50
Vermont: 100% through 200 mesh, extra white	12.50
99½% through 200 mesh, medium white	11.50 – 12.50
New York: 96% through 200 mesh	28.00
99.9% through 325 mesh	38.00
100% through 325 mesh (fluid energy ground)	80.00
California:	
Standard	$35 – $41
Fractionated	35 – 68.50
Micronized	60 – 98.50
Cosmetic/steatite	42.50 – 59

TARIFFS

Tariffs in effect at the time of writing include:

	British Preferential (%)	Most Favoured Nation (%)	General (%)
Canada			
Talc or soapstone	10	15	25
Pyrophyllite	free	free	25
Micronized talc	free	5	25

United States

Talc, steatite or soapstone:	
crude and unground	0.05¢ per lb
cut or sawed, or in blanks, crayons, cubes, disks or other forms	0.5¢ per lb
Ground, powdered, pulverized or washed	12½%
Other, not specially provided for	24%

Tin

W.H. JACKSON*

Tin is not smelted in Canada and there is no significant production of tin concentrate. For 1966, supply was derived from imports and from drawdown of consumer stocks. Imports of 4,254 tons had a value of $16.9 million. Consumer stocks totalled 657 tons on December 31, 1966, a decrease of 258 tons from a year earlier, probably reflecting the increased availability of tin and lower price levels. Consumption of primary tin has increased surprisingly little the last few years considering the high level of Canadian industrial production. In 1966, consumption was 4,972 tons compared with 4,892 tons in 1965 and 4,822 tons in 1964.

The small tonnage recorded as Canadian production, 327 tons in 1966, is from Cominco Ltd. Cassiterite is recovered as byproduct in milling lead-zinc ores at Kimberley, B.C. and is exported for smelting. Tin in the form of a lead-tin alloy is also obtained from the treatment of lead bullion dross in the indium circuit of the Trail smelter.

A small tonnage of cassiterite concentrate is expected to be recovered in 1967 from the milling of lead-zinc ores in New Brunswick by Brunswick Mining and Smelting Corporation Limited. Cassiterite is also a component of some sections of the copper-lead-zinc-silver orebody, near Timmins, Ontario, of Texas Golf Sulphur Company. Other base-metal sulphide deposits being mined in Canada either do not have tin minerals associated or the quantity in them is so minor that recovery is not worthwhile. There was little work reported by industry on other tin deposits. The Geological Survey of Canada, as part of its metallogenic studies, continued the investigation of potential tin occurrences in British Columbia and was conducting a structural-petrographic study in the Mount Pleasant-St.Stephen area of New Brunswick.

M & T Products of Canada Limited has the only industrial laboratory in Canada devoted entirely to the study of tin chemistry. The company recovers tin from tinplate scrap for the manufacture of potassium and sodium stannates used to coat automotive pistons, proprietary chemicals to electroplate aluminum, organotin stabilizers for polyvinyl chloride plastics and tin catalysts for urethane foam and vinyl coatings.

WORLD DEVELOPMENTS

Tin is the only metal for which there is formal co-operation between producer and consumer interests and between industry and government to modify problems of price and supply.

The Third International Tin Agreement became operative on July 1, 1966, for a five-year period. Canada is a consumer member as

*Mineral Resources Division.

TABLE 1

Canada, Tin Production, Imports and Consumption, 1965-66

	1965		1966P	
	Long Tons	$	Long Tons	$
Production				
Tin content of tin concentrates and lead-tin alloy	168	725,554	327	1,335,123
Imports				
Blocks, pigs, bars				
Malaysia-Singapore	4,258*	18,502,824	3,052	12,110,000
United States	734	3,177,293	771	3,153,000
Thailand	—	—	400	1,494,000
Britain	1	2,301	31	127,000
Total	4,993	21,682,418	4,254	16,884,000
Tinplate				
United States	3,460	544,739	3,997	815,000
Britain	631	182,728	146	70,000
Total	4,091	727,467	4,143	885,000
Tin fabricated materials, not elsewhere specified				
United States	12	45,487	9	36,000
Britain	14	27,359	...	1,000
Total	26	72,846	9	37,000
Consumption				
Tinplate and tinning	2,507		2,531	
Solder	1,659		1,651	
Babbitt	212		254	
Bronze	221		249	
Galvanizing	7		1	
Other uses (including collapsible containers, foil, etc.)	286		286	
Total	4,892		4,972	

Source: Dominion Bureau of Statistics.

PPreliminary; — Nil; ... Less than one ton.
*Malaysia only.

TABLE 2

Canada, Tin Production, Imports and Consumption 1957-66

(long tons)

	Production[1]	Imports[2]		Consumption[3]
		Blocks, Pigs, Bars	Tinplate	
1957	317	4,155	4,884	3,622
1958	355	3,461	5,960	3,292
1959	334	4,183	4,977	4,223
1960	278	3,768	5,626	3,880
1961	500	3,525	3,080	3,953
1962	291	2,274	3,712	4,507
1963	414	4,193	3,726	4,942
1964	157	4,849	4,735	4,822
1965	168	4,993	4,091	4,892
1966P	327	4,254	4,143	4,972

Source: Dominion Bureau of Statistics.

[1]Tin content; [2]Gross weight; [3]Virgin tin.
PPreliminary.

TABLE 3

Estimated World[1] Production of Tin in Concentrates 1956 and 1965-66

(long tons)

	1956	1965	1966
Malaysia	62,296	63,670	68,886
Bolivia	26,842	23,037	25,522
Thailand	12,481	19,047	22,537
Indonesia	30,055	14,699	12,526
Federation of Nigeria	9,167	9,547	9,534
Republic of the Congo	12,832	6,211	7,000
Australia	2,078	3,871	4,486
Total, including countries not listed	166,400	152,300	163,100

Source: International Tin Council, Statistical Bulletin.

[1]Excludes communist countries, except Czechoslovakia.

Table 4

Estimated World[1] Production of Primary Tin Metal, 1965-66

(long tons)

	1965	1966
Malaysia	72,469	71,049
Britain	16,494	17,499
Thailand	5,524	16,940
Netherlands	18,114	12,139
Federation of Nigeria	9,332	9,933
Belgium	4,232	4,978
United States	3,097	3,855
Australia	3,179	3,665
Spain	1,678	3,064
Total, including countries not listed	149,400	155,700

Source: International Tin Council, Statistical Bulletin.

[1]Excludes communist countries, except Czechoslovakia.

in the two previous agreements. The 17 consumer members represent 50 per cent of consumption and have votes, in proportion to their consumption, equal to those of producer members in the International Tin Council which are Bolivia, Congo (Dem. Rep.), Indonesia, Malaysia, Nigeria and Thailand. There are a significant number of countries including Russia, Mainland China, and United States that are not members, but production of tin in concentrate by members of the Council represents 95 per cent of world production, excluding that of Russia, Mainland China and East Germany.

For the Third Agreement, producer members have agreed to contribute to a Buffer Stock an initial £10 million with another £10 million to be contributed if required. In addition, a bank credit of £10 million has been arranged. The ranges of permissible prices are set by 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 1949 to 1966 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 supply. On July 6, 1966, the floor and ceiling prices for tin were raised to £1,100 and £1,400 a long ton respectively. In the last quarter of 1966, 35 tons of tin were purchased for the Buffer Stock, the first time since 1963 that tin was held.

Owing to the cessation of governmental stockpile accumulations in the 1950s coupled with a period of slack demand, declining prices and over-production led to Buffer Stock accumulation and curtailment of production from 1957

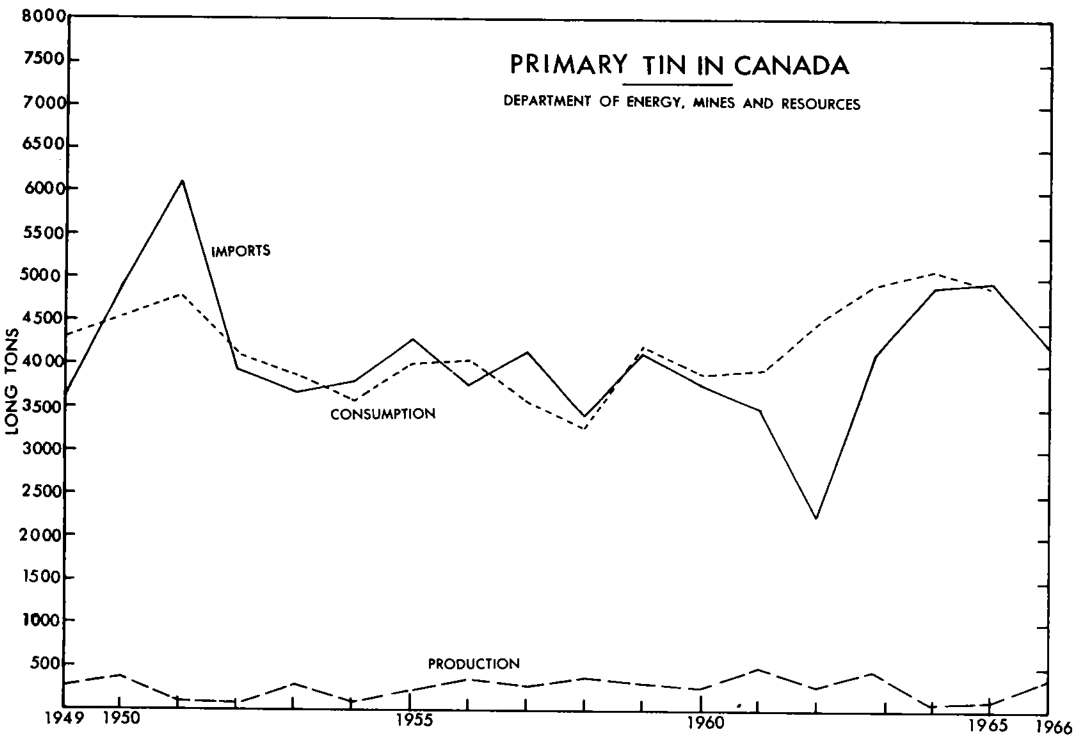


TABLE 5

Estimated World[1] Tin Production, 1964-66

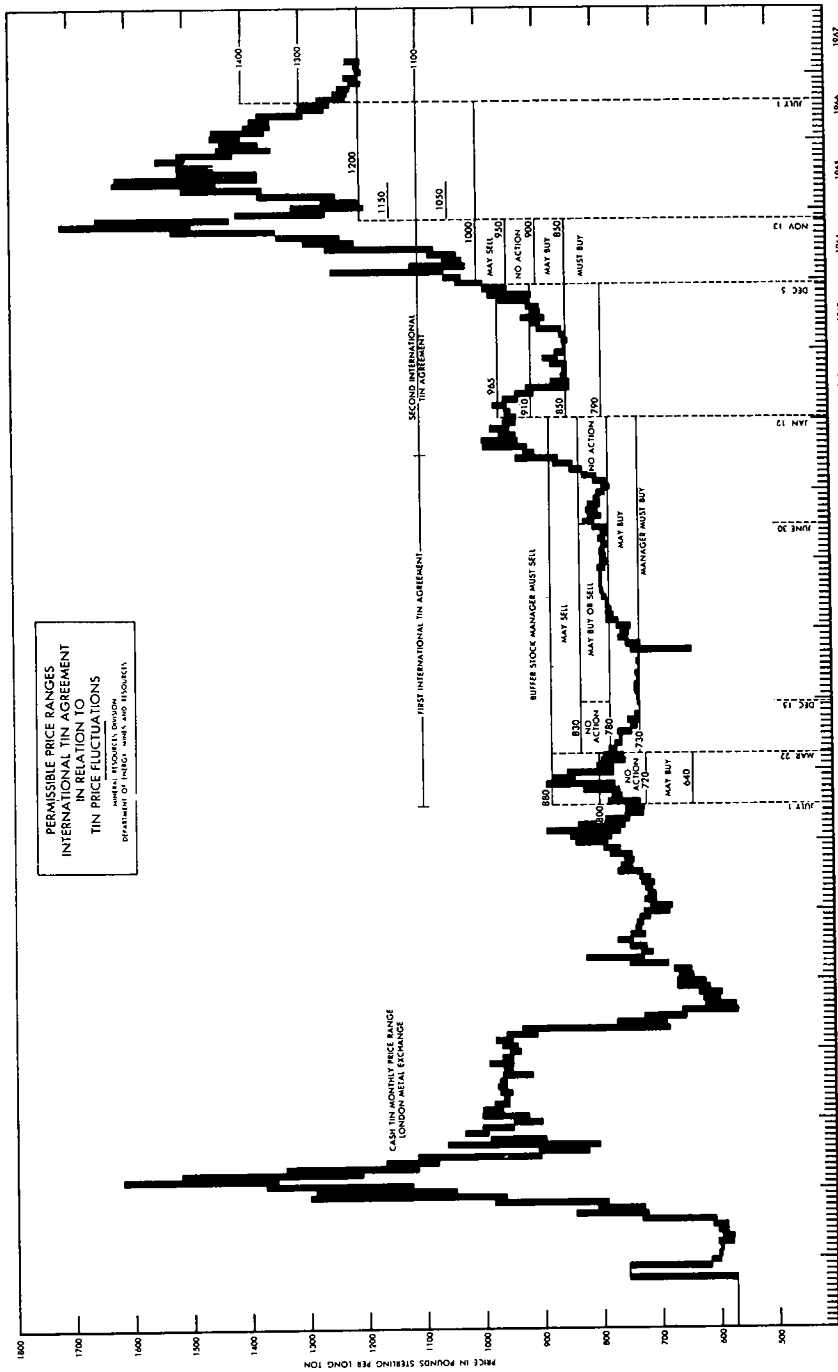
(long tons)

	1964	1965	1966
Ore Supply			
Production of tin in concentrates	147,300	152,300	163,100
Stocks at year's end	20,500	19,500	24,700
Primary Metal Supply			
Smelter production of tin metal	142,400	149,400	155,700
Net trade with centrally planned countries	541-	1,750-	2,792-
Government stockpile sales	32,147	23,365	16,276
Buffer stock, sales +, purchases-	Nil	Nil	35-
Commercial stocks at year's end	50,400	52,100	49,800
Primary metal consumption	168,300	165,100	168,500

Source: International Tin Council, Statistical Bulletin.

[1]Excludes communist countries, except Czechoslovakia.

to 1960. In the last few years production has been gradually recovering to pre-control levels but not equally in all countries as shown in Table 3. Consumption rose from a low of 143,000 tons in 1957 to 168,500 tons in 1966. Commencing in 1963 government stockpile sales of a few countries became a significant factor in balancing supply-demand but the favourable


PERMISSIBLE PRICE RANGES
INTERNATIONAL TIN AGREEMENT
IN RELATION TO
TIN PRICE FLUCTUATIONS
MINERAL RESOURCES DIVISION
DEPARTMENT OF ENERGY, MINES AND RESOURCES
CASH TIN MONTHLY PRICE RANGE
LONDON METAL EXCHANGE
FIRST INTERNATIONAL TIN AGREEMENT
SECOND INTERNATIONAL TIN AGREEMENT
BUFFER STOCK MANAGER MUST SELL
MAY SELL
MAY BUY OR SELL
NO ACTION
MAY BUY
MANAGER MUST BUY
MUST BUY
PRICE IN POUNDS STERLING PER LONG TON

price levels have encouraged exploration and development by both the small interests and the larger companies. The outlook, barring unforeseen political or economic factors, is for mine production of tin in concentrate to be in balance with consumption in late 1967. Consequently, the trend of consumption and the rate of stockpile releases will be of interest. Only the United States has tin remaining in stockpile, the amount of which was reduced by 16,175 tons in 1966 to leave 68,579 tons surplus to the objective of 200,000 tons.

A large proportion of the higher grade tin ores are now smelted in the major producing countries. Indonesian ores are currently processed in the Netherlands but a new smelter at Muntok, Indonesia, is expected to commence operations in 1967 at an initial rate of 40 per cent of its 25,000-ton-a-year designed capacity. The new smelter of Thailand Smelting and Refining Co. Ltd. (Thaisarco) encountered startup difficulties which resulted in a buildup of concentrate on hand. Addition of a fourth furnace will raise capacity to 40,000 tons of concentrate a year, or about 30,000 tons of metal which is enough to cope with the entire production from Thailand. In addition to the flurry of activities in the main centres of tin production, exploration and development are particularly high in Australia and in Brazil where a new placer district is being developed in Rondonia.

USES

The manufacture of tinplate is the main use for tin with approximately half of the world output going into this product. Of the alloying uses, tin solders are indispensable in the manufacture of electronic equipment and are needed in current industrial practice for sealing purposes such as in radiators and metal containers. Direct casting processes for brass and bronze have improved quality of rods and tubes for bolts, screws and bushings. With improved quality there has been renewed interest in such items. Aluminum-tin alloys are used in motor car bearings and some engine blocks now have about 0.1 per cent tin content to improve machining and wear qualities. Some titanium alloys contain tin as an alloying agent.

Demand in the field of tin chemicals continues to improve although tonnages involved are still relatively small. Organotin compounds are used in the manufacture of polyvinyl chloride and polyurethane foam, in antifouling paints, for the control of plant diseases and as fungicides.

PRICES

The average price in cents (US) for a pound of Straits brand tin, exworks, on the Penang, Malaysia, market in 1966 was 158.09. For Cash tin on the London Metal Exchange (LME), the term includes a number of brands, the average was 161.98 and for Prompt delivery in New York, USA, the average price for Straits tin during the year was 164.02. In Canada, the larger consumers pay the equivalent of the New York price but smaller consumers who purchase requirements from merchants, who finance and hold stocks in inventory, pay higher prices.

The payment for tin concentrate to a mine producer is less than its gross value calculated on the quoted price of tin because of smelting charges, which vary among smelters, and the cost of transportation from the mine to the smelter. The approximate value for concentrate delivered to Britain can be derived using data published in the Metal Bulletin of London. In 1966, the payment for a concentrate assaying 70 to 75 per cent tin was computed by deducting 1 unit (22.4 lb.) from the tin assay plus the smelter charge of £12-15 a long ton of concentrate treated. (£1 sterling = $2.80 U.S.) The average LME price quotations for a stipulated period following delivery is the basis on which payment is calculated. Using the average price for 1966 as an example, the approximate payment for a long ton of tin concentrate assaying 75 per cent tin was (75 – 1)22.4 x $1.62 less $33.60. The payment for other grades of concentrate in Britain can be calculated in a similar manner using the following criteria: for 40 to 65% tin deduct 1.3 units plus £24-26, and for 20 to 35% tin deduct £65-70, which includes the unit deduction. The main impurities that affect smelting rates are Fe, WO_3, S, As, Cu, Pb, Bi, Sb.

TARIFFS

	British Preferential %	Most Favoured Nation %	General %
Canada			
Tin in blocks, pigs, bars or granular form for use in Canadian Manufactures	free	free	free
Tin-strip waste and tinfoil	free	free	free
Phosphor tin and phosphor bronze in blocks, bars, plates, sheets and wire	5	7½	10
Oxide of tin	free	15	15
Bichloride of tin and tin crystals	free	10	10
Sheet or strip of iron or steel, corrugated or not, rolled with surface pattern or not, coated with tin	10	15	25
Sheet or strip of iron or steel coated with lead or with an alloy of lead and tin	free	free	15
Manufactures of tinplate, painted, japanned, decorated or not, and manufactures of tin not otherwise provided for	15	20	30

United States

Tin ore and black oxide of tin	free
Tin, other than alloys of tin	free
Tin alloys	
Containing, by weight, over 5% lead	1.0625¢ per lb on lead content
Other	free
Tin waste and scrap	free
Plates, sheets and strips, wrought of tin, cut or not, pressed, or stamped to nonrectangular shapes	
Not clad	12% ad val.
Clad	24% ad val.
Tin wire	
Not coated or plated with metal	12.5% ad val.
	0.1¢ per lb plus 12% ad val.
Tin bars, rods, angles,shapes, and sections	12% ad val.
Tin powder and flakes	12% ad val.
Tin pipes and tubes, and blanks therefor, pipe and tube fittings	12% ad val.
Tinfoil	35% ad val.
Tin compounds and salts	12.5% ad val.

1

Titanium

G.P. WIGLE*

Production of titanium-dioxide slag was reduced by a strike in 1966 and the value of slag shipped was $21.6 million compared with the record high of $22.4 million in 1965. Titanium dioxide (TiO_2) slag is a basic material in the manufacture of pigments, titanium metal and ferrotitanium. The metal is used to make corrosion-resistant titanium metal products and special titanium-bearing alloys; the ferroalloy is used as an additive in steelmaking and in cast irons. Canadian manufacturers of TiO_2 pigments increased production facilities and operated at, or near, full capacity throughout the year. Consumption of titanium pigments in 1966 was about 45,000 tons.

Pigment production was the major consumer of titanium mineral output in 1966 but titanium metal production and consumption in the United States increased at an accelerated rate in response to the requirements of the commercial and military aircraft industries. This growing demand coupled with sustained consumption growth in general industrial use brought US titanium ingot consumption in 1966 to 22,317 tons compared with the previous record of 14,694 tons in 1965.(1)

Non-communist world production of titanium ores for 1966 was estimated at 2.75 million tons of ilmenite and 282,000 tons of rutile, Australia's rutile production was about 280,000 tons.(2)

PRODUCTION

CANADA

The Canadian titanium mineral industry is based principally on the mining of ilmenite for the production of titanium-dioxide (TiO_2) slag and minor intermittent production of ilmenite for use as heavy aggregate in special concrete.

Ilmenite mined by Quebec Iron and Titanium Corporation (QIT) in the Allard Lake area of Quebec is smelted in electric-arc furnaces at Sorel, Quebec, to produce titania (TiO_2) slag and a range of specialty pig irons. The titania slag contains 70 per cent titanium dioxide and is sold in the United States and Canada. The Canadian consumers are the pigment producers—Canadian Titanium Pigments Limited at Varennes and Tioxide of Canada Limited at Ville-de-Tracy, both in Quebec. The combined

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*Mineral Resources Division.
[1]United States Bureau of Mines Mineral Industry Surveys, April 3, 1967.
[2]Australian Mineral Industry, Volume 19, No. 2.

TABLE 1

Canadian Titanium Production, Imports, and Exports to the US 1965-66

	1965		1966P	
	Short Tons	$	Short Tons	$
Production*, shipments				
Titanium dioxide	410,255	22,425,094	395,523	21,615,610
Imports				
Titanium dioxide, pure				
United States	783	429,021	820	459,000
Britain	712	283,348	661	265,000
West Germany	70	29,695	109	43,000
Other countries	—	—	37	17,000
Total	1,565	742,064	1,627	784,000
Titanium dioxide, extended				
United States	9,534	1,816,869	9,744	1,856,000
Titanium metal				
United States	769	4,005,127	1,376	7,049,000
Britain	..	903	42	156,000
Other countries	34	66,752	1	7,000
Total	803	4,072,782	1,419	7,212,000
Exports to the United States				
Titanium, unwrought, waste and scrap, wrought and alloyed**	38	12,952	64	105,837
Titanium dioxide**	3,202	1,344,580	1,334	519,997

Source: Dominion Bureau of Statistics
* Producers' shipments of slag, TiO_2 content. ** As reported by the US Department of Commerce, US Imports for Consumption, Report FT 125. No identifiable classes are available from Canadian export statistics.
P Preliminary; — Nil; .. Not available.

annual output capacity of the two producers is over 100 million pounds of titanium-base pigments. Both companies manufacture many grades of titanium dioxide pigments and supply the major part of domestic requirements as well as exporting substantial amounts to the United States and Britain.*

QUEBEC IRON AND TITANIUM CORPORATION (QIT)

QIT is owned two-thirds by Kennecott Copper Corporation and one-third by The New Jersey Zinc Company (Gulf & Western Industries, Inc.). In 1950, the company started operating its ilmenite open-pit mine in the Lac Tio-Allard Lake area of Quebec, a 27-mile railroad from the mine to Havre St. Pierre, and an electric smelting plant 550 miles up the St. Lawrence River at Sorel. The company owns one of the world's largest known reserves of ilmenite containing a minimum of 150 million tons averaging 35 per cent TiO_2 and 40 per cent iron. The ilmenite ($FeO.TiO_2$ or $FeTiO_3$) occurs with finely disseminated hematite in orebodies consisting of dykes, irregular lenses, and sill-like bodies within a large mass of anorthosite.

The ilmenite, averaging 86 per cent total oxides of titanium and iron, is upgraded to 93 per cent combined oxides in a beneficiation plant at Sorel before smelting. The concentrates are calcined in rotary kilns to lower the sulphur content, cooled, and mixed with powdered anthracite in preparation for smelting. Electric-arc smelting of the concentrate-coal mix yields

*Company correspondence reports overseas sales of TiO_2 pigments, mainly to Britain, but DBS does not list these exports.

two grades of titania slag, and molten iron. Pigment-grade titania slag contains 70 to 72 per cent TiO_2 and metal-grade slag runs 74 to 76 per cent TiO_2. The iron, as tapped from the furnaces, contains 1.80 to 2.50 per cent carbon, 0.11 per cent sulphur and 0.025 per cent phosphorus. The iron is desulphurized in the ladle; manganese and silicon may be added to produce various grades of foundry pig irons, which are cast into 50-pound pigs.

A new product research facility was completed by QIT at Sorel and an expansion program, begun in 1965, to increase smelter capacity by 20 per cent was scheduled for completion in the first quarter of 1967. Production of titania slag in 1966 was 468,547 long tons, down slightly from 1965.

TABLE 2

Titanium Slag and Iron Production, Quebec Iron and Titanium Corporation, 1965-66

(long tons)

	1965	1966
Ore treated	1,177,145	1,129,181
Titanium slag produced.	487,425	468,547
Iron produced	332,785	315,606

Source: Kennecott Copper Corporation Annual Report, 1966.

Canadian Titanium Pigments Limited

This company, a wholly-owned subsidiary of National Lead Company, New York, operated its titanium dioxide plant at Varennes, Quebec, close to capacity throughout 1966. Further improvements in pigment quality were made. Titanium dioxide slag was purchased from Quebec Iron and Titanium Corporation and liquid sulphur for manufacture of sulphuric acid was obtained from Laurentide Chemicals & Sulphur Ltd. in Montreal East. Most pigment output was sold to the domestic market but significant quantities were exported to the US and overseas, particularly to Britain. Preliminary work was done on the company's expansion program at Varennes and major construction is to start on a new chloride process unit in the spring of 1967. The plant capacity is to be increased to 40,000 tons of pigment a year with 10,000 tons of it using the new chloride process and 30,000 tons using the sulphate process.

Tioxide of Canada Limited

This company is a wholly-owned subsidiary of British Titan Products Company Limited, London, England. The company's productive capacity was increased from 22,000 tons to 27,000 tons of pigment a year in 1966. A

TABLE 3

Canadian Titanium Production, Trade and Consumption, 1957–66

(short tons)

	Production		Imports			Consumption	
	Ilmenite[1]	Titanium Dioxide Slag[2]	Titanium Dioxide Pure	Titanium Dioxide Extended	Total Titanium Dioxide Pigments[3]	Titanium Dioxide Pigments[4]	Ferro-Titanium[5]
1957	824,432	186,422	..	..	34,234	32,622	252
1958	420,932	161,312	..	..	29,439	35,795	210
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[r]
1965	1,318,402	545,916	1,565	9,534	11,099	..	65
1966[p]	1,264,683	524,773	1,627	9,744	11,371	..	..

Source: Dominion Bureau of Statistics and company annual reports.

1. Producers' shipments of ilmenite from Allard Lake and St. Urbain area. For 1957 from DBS, and 1958 onwards ore treated, from company annual reports. 2. TiO_2 content of slag for 1957 and 1958 from DBS; from 1959, gross weight of 70–72% slag produced, from company reports. 3. 1957 to 1961 titanium and other oxide pigments containing not less than 14% by weight of TiO_2; from 1962 on, includes pure and extended TiO_2, usually in the order of 35 per cent TiO_2. 4. Includes pure and extended TiO_2 pigments. 5. 1957 and 1958 gross weight; from 1959, Ti content.

[p]Preliminary; [r]Revised; .. Not available.

shortage of sulphuric acid in eastern Canada prevented full use of the additional capacity which came into operation in the spring, at the Tracy, Quebec, plant.

OTHER COUNTRIES

The United States is the largest producer and consumer of ilmenite; it is also the largest consumer of rutile with 99 per cent of its supply coming from Australia, the principal of the few producers of rutile. Estimated US production of ilmenite in 1966 was 950,000 tons compared with 969,000 tons in 1965.(1) Consumption of ilmenite and rutile was estimated at 1,150,000 tons and 160,000 tons respectively in 1966 compared with 1,071,000 tons and 117,376 tons in 1965. Increased consumption of ilmenite and rutile was due largely to increased US production of titanium metal products for use in aircraft, missiles and spacecraft.(1)

Ilmenite is produced in the United States by six companies with eight mining operations in New York, Florida, Georgia, Virginia and New Jersey. Over half is produced in New York state and one-third in Florida; the remainder came from Virginia, Georgia and New Jersey. Domestic and imported ilmenite is consumed by some 100 firms of which six titanium pigment producers in the eastern United States use the major part. United States rutile production in 1966 came from one company in Virginia.

Major programs for expansion of titanium metal production facilities have been undertaken by United States producers. Titanium Metals Corporation of America has a three-year expansion program underway to increase sponge production of plants at Toronto, Ohio, and Henderson, Nevada. Reactive Metals Inc. plans to spend $70 million over four years to expand its Niles, Ohio, titanium sponge plant.

Preliminary estimates from the Australian Bureau of Mines indicate that, with two newly commissioned rutile producers, production for 1966 should be some 280,000 tons of concentrates. Production of ilmenite concentrates for the nine months ended September 30, 1966, was 433,223 tons of concentrate. Australia's annual production capacity is estimated at 575,000 tons of ilmenite concentrate.

Preparation for mining very large alluvial rutile reserves in Sierra Leone by Sherbro Minerals Ltd. was completed in 1966 and shipment of concentrates was expected in May 1967, following a period of break-in operation. The plant capacity is rated at 100,000 tons of rutile concentrates a year. Recovery of sands is by a floating suction dredge from which a slurry is pumped to a 'wet' and a 'dry' concentrating plant. The rutile concentrate will be trucked 16 miles to Niti on the Gbangbaia River and transferred to 2,000-ton barges for transport 18 miles down river to bulk carriers in the Sherbro River estuary. Sherbro Minerals Ltd. is owned by Pittsburgh Glass Company (80 per cent) and British Titan Products Company Limited (20 per cent).

TABLE 4

Non-communist Production of Ilmenite Concentrates, 1965-66

(thousand short tons)

	1965	1966e
United States	969	950
Canada	546*	525*
Australia..................	504	575
Norway	311	300
Malaysia	136	..
Finland	118	..
Other countries	144	..

Sources: US Bureau of Mines Commodity Data Summaries, January 1967; Australian Mineral Industry, Volume 19, No. 2; and company reports.

*Titania slag containing 72% TiO_2.

eEstimate; .. Not available.

TABLE 5

Non-communist Production of Rutile Concentrates, 1965-66

(short tons)

	1965	1966e
Australia	240,746	280,000
India	1,452	..
Brazil	298	..
United States	8	..

Sources: US Bureau of Mines Commodity Data Summaries, January 1967; US Mineral Trade Notes, August 1966; Australian Mineral Industry, Volume 19, No. 2.

eEstimate; .. Not available.

(1) United States Bureau of Mines Commodity Data Summaries, January 1967.

USES AND CONSUMPTION

Ilmenite ($FeTiO_3$) and rutile (TiO_2) are the only commercially important minerals of titanium. The theoretical titanium-dioxide content of ilmenite is 53 per cent and that of 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 massive mineral deposits and from sands. The most important occurrences of rutile are in beach sands but it is also found as an accessory mineral in rocks. Ilmenite and rutile are the two mineral sources of the world's production of titanium dioxide pigment and of titanium metal.

Manufacturers of titanium-dioxide pigments use the major part of titanium mineral production. Titanium dioxide owes its value as a pigment to its high index of refraction which accounts for its opacity. Pigment-grade TiO_2 is manufactured principally by treating finely-ground ilmenite or titanium slag with sulphuric acid, removing the iron as ferrous sulphate and recovering titanium sulphate, which is calcined to form the oxide then ground to pigment fineness. Ilmenite mined by Quebec Iron and Titanium Corporation does not lend itself to this process because of the associated fine hematite that would consume an excessive amount of acid. The pyrometallurgical process carried out at Sorel removes iron and produces a high-titania slag that can be processed with low acid consumption.

The chloride process for producing titanium dioxide pigments uses a mixture of titanium-bearing material - rutile, ilmenite or slag - and carbon. The mix is chlorinated to produce titanium tetrachloride which is then purified and oxidized to titanium dioxide.

In addition to superior opacity, titanium-dioxide pigments have a high degree of whiteness and brilliance, enhance the durability of many media into which they are incorporated and are chemically inactive and non-toxic. Because of this combination of qualities, titanium-dioxide pigments have largely replaced materials formerly used as white pigments.

Consumption of TiO_2 pigments in Canada is estimated at approximately 45,000 tons in 1966 with no significant change from 1965 in their use by industry in percentage terms that are approximately as follows:

Use	Per Cent
Paint	66
Floor covering	10
Paper	10
Rubber and plastics	7
Ink	1
Ceramics	2
Textiles	2
Others	2
Total	100

Rutile is used in producing titanium metal, welding rod coatings and pigment. The United States imported a record 160,000 tons of rutile concentrates in 1966 with 99 per cent of them coming from Australia. (1)

Titanium is also used in three major grades of master alloys with iron for use as additives in the iron and steel industry. High-carbon ferrotitanium contains 7 to 8 per cent carbon and 15 to 17 per cent titanium; medium-carbon ferrotitanium contains 3 to 5 per cent carbon and 16 to 20 per cent titanium; low-carbon master alloys have 0.03 to 0.1 per cent carbon and 20 to 45 per cent titanium.

TITANIUM METAL PRODUCTION AND FABRICATION

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 65 per cent heavier than aluminum 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 chief disadvantages are high cost, difficulties of fabrication and reactivity at high temperature.

Titanium sponge is the metal product made by reducing titanium tetrachloride with magnesium or sodium. Titanium ingot can be produced using sponge metal by powder metallurgy techniques but most commercial metal is produced by the consumable electrode-arc melting process. The double-melting process, carried

(1) United States Bureau of Mines Commodity Data Summaries, January 1967.

out in an inert atmosphere or vacuum, produces ingots which can be hot-worked by forging, extrusion and blooming. Billets or slabs are then processed into plate, sheet, strip, bars, rods, pipe and tubing, wire and special shapes.

Titanium ingot production in the United States increased to 24,253 tons in 1966 from 15,294 tons in 1965. Net shipments of titanium mill products in 1966 were 28,034,566 pounds compared with 18,716,051 pounds in 1965. (1) Jet engines and airframe requirements in 1965 and 1966 accounted for a large part of the increases in mill-product shipments.

Atlas Titanium Limited, a subsidiary of Atlas Steels Division of Rio Algom Mines Limited, Welland, Ontario, continued to carry out second stage remelting of imported titanium ingots and process the metal to mill products for sale in domestic and export markets.

Macro Division of Kennametal Inc., Port Coquitlam, British Columbia, is the only Canadian manufacturer of titanium carbide powder. It also uses titanium in the manufacture of tungsten-titanium carbide and several other multicarbides. 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. Rutile or titanium dioxide are raw material for the production of the carbides.

PRICES

United States prices quoted in *E & MJ Metal and Mineral Markets* of December 26, 1966, were as follows:

Titanium ore	
f.o.b. cars, Atlantic ports, TiO_2	
Rutile, 96%, per short ton, delivered within 12 months	\$119–\$121
Ilmenite, imported, long ton, shiploads, 54%	\$ 21–\$ 25
Ilmenite, domestic, 60% short ton, f.o.b. shipping point	\$ 30–\$ 35
Slag, per long ton, 70%, f.o.b. shipping point	\$ 43
Titanium metal	
per lb , delivered	
maximum 120 Brinell, 99.3%, 500 lb	\$1.32
Japanese sponge, 99.3%	\$1.23–\$1.25
maximum 90 Brinell, 99.9%, 25 lb	\$1.90
maximum 75 Brinell, 99.9%, 10.lb	\$4.00
Ferrotitanium	
Delivered	
Low-carbon, per lb Ti, 25-40% Ti	\$1.35
Medium-carbon, per net ton, 17-21% Ti	\$375.00
High-carbon, per net ton, 15-19% Ti	\$310.00

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

(1) United States Department of Commerce, Titanium Ingot and Mill Products, February 15, 1967.

TARIFFS (cont'd)

	British Preferential	Most Favoured Nation %	General %
Titanium sponge and sponge briquettes, ingots, blooms, slabs, billets of titanium, or titanium alloys for use in Canadian manufactures (expires June 30, 1968)	free	free	25
Ferrotitanium	free	5	5
United States			
Titanium ore crude	free		
Titanium metal, unwrought waste and scrap* ...	20% ad val		
Titanium, wrought	18% ad val		
Ferrotitanium	10		
Titanium dioxide	15		
Titanium compounds	15		

*Duty temporarily suspended on scrap to June 30, 1967.

Tungsten

G.P. WIGLE*

Canada Tungsten Mining Corporation Limited, operating Canada's only tungsten mine, produced 213,022 short-ton units of tungstic oxide (WO_3)(1) and shipped 207,793 short-ton-units of WO_3 in 1966. It also shipped 334,087 pounds of copper in concentrates, which are recovered as a byproduct. The concentrator treated 115,568 tons of ore grading 2.43 per cent WO_3 and 0.45 per cent copper. The crushing plant and concentrator were destroyed by fire on December 26 but a new 350-ton-a-day plant is being constructed and operations are expected to resume by the end of 1967. Capital cost of the new plant is estimated at $2.8 million. The open-pit mine and concentrator is in the Northwest Territories near the Yukon border about 135 miles north of Watson Lake. Because of high transportation costs on process supplies to the NWT the company built and operated at North Vancouver a leaching and roasting plant for final treatment of concentrates.

Reduced supplies of tungsten from communist countries, mainly China, and increasing demand for tungsten contributed to a price increase from $32.25 a short-ton unit of WO_3 in 65-per-cent-WO_3 concentrates in January to $43 a short-ton unit in December. The prices are c.i.f. US ports and include the US import duty of 50 cents a pound of contained tungsten (W) or $7.93 a short-ton unit of WO_3. During the depressed price period in the early 1960's, the quoted price in New York for imported tungsten concentrates dropped from $24 a short-ton unit of WO_3 in July 1961 to $15 in August 1962. The market remained depressed until August 1963 but the price rose steadily since then to $38 by the end of December 1965, and to $43 a short-ton unit in the last quarter of 1966.

Canada's imports of tungsten in ores and concentrates increased from 357,400 pounds in 1965 to 523,600 pounds in 1966. The unit cost of imported material rose nearly 50 per cent. Imports of ferrotungsten dropped considerably below the 1965 figure but still showed an increase of 20,000 pounds compared with 1964.

The two principal minerals of tungsten are wolframite ($FeMnWO_4$) and scheelite ($CaWO_4$). Scheelite is the tungsten mineral at Canada Tungsten's mine. Ore reserves at the end of 1966 were estimated by Canada Tungsten at 816,000 tons having an average grade of 2.5 per cent WO_3 and 0.45 per cent copper. The orebody is a replacement-type zone in limestone which lends itself to open-pit mining. Scheelite is also found in gold-bearing ores at many gold mines in Canada although usually in minor amounts. Wolframite is found in quartz veins and in stream gravels in British Columbia and the Yukon.

*Mineral Resources Division.

(1) A short-ton unit is 1% of a short ton, i.e., 20 pounds.

TABLE 1

Canadian Tungsten Production, Imports and Consumption, 1965-66

	1965		1966P	
	Pounds	$	Pounds	$
Production (shipments WO_3)	3,736,324	..	4,185,000	..
Imports				
Tungsten in ores and concentrates				
China (communist)	—	—	258,100	414,000
United States	320,300	370,019	147,500	279,000
Bolivia	—	—	82,500	139,000
Korea	—	—	35,500	69,000
Other countries	37,100	43,690	—	—
Total	357,400	413,709	523,600	901,000
Ferrotungsten[1]				
Britain	168,000	124,931	154,000	233,000
Austria	138,000	199,900	30,000	41,000
United States	48,000	59,891	6,000	11,000
West Germany	—	—	2,000	2,000
Total	354,000	384,722	192,000	287,000
Consumption, W content				
Tungsten ore	449,341		450,211	
Tungsten metal and metal powder	262,511		402,716	
Tungsten wire	11,613		7,412	
Other[2]	154,149		80,868	
Total	877,614		941,207	

Source: Dominion Bureau of Statistics.
1. Gross weight. 2. Includes ferrotungsten, tungsten carbide powder, tungsten rod, tungstic oxide and sodium tungstate.
P Preliminary; — Nil; .. Not available.

TABLE 2

Canadian Tungsten Production, Trade and Consumption, 1957-66
(pounds)

	Production[1]	Imports		Exports	Consumption
	(WO_3 content)	Tungsten ore[2]	Ferro-tungsten[3]	Scheelite (W content)	(W content)
1957	1,921,483	230,700	170,200	1,524,851	277,972
1958	690,976	884,100	199,000	477,079	316,738
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
1966P	4,185,000	523,600	192,000	..	941,207

Source: Dominion Bureau of Statistics.
1. Producers' shipments of scheelite (WO_3 content). 2. Prior to 1964 reported in gross weight; commencing with 1964 reported in W content. 3. Gross weight.
P Preliminary; .. Not available; — Nil

The Buchans unit of American Smelting and Refining Company started underground exploration on a high-grade tungsten zone at the mouth of the Grey River on the south coast of Newfoundland. The first drilling on this occurrence was done 10 years ago; diamond drilling during the summer of 1966 was followed by a decision to go underground for further exploration and possible mine development.

WORLD PRODUCTION AND TRADE

World mine production of tungsten ores and concentrates in 1966 contained an estimated 62 million pounds of tungsten of which some 34 million pounds came from communist countries.(1)

Production of tungsten in the United States was estimated at about 9 million pounds in 1966. The principal producers are the Mining and Metals Division of Union Carbide Corporation, and American Metal Climax, Inc.

During 1966, the United States General Services Administration released from stockpile approximately 514,000 short-ton units of WO_3 in concentrates.

TABLE 3

World Production of Tungsten in Concentrates, 1964-66
(short tons, 60% WO_3 basis)

	1964	1965	1966e
Canada	–	3,113r	3,487
China	22,500	18,700	..
USSR	12,100	12,700	..
United States	9,244	7,949	..
South Korea	5,988	4,935	5,500
North Korea......	4,400	4,850	..
Bolivia	2,285	2,043	2,600
Australia	1,860	2,197	2,300
Other countries ...	6,023	4,358	..
Total	64,400	60,845r	65,000

Source: U.S. Bureau of Mines Mineral Trade Notes, October 1966 and U.S. Bureau of Mines Commodity Data Summaries, January 1967, and company reports.

– Nil; .. Not available; e Estimate; r Revised.

Canada became the leading supplier of tungsten concentrates to the United States in 1965, the year that Canada Tungsten came into production. Canada supplied 24 per cent of US imports of 3.5 million pounds of tungsten in 1965 and 23 per cent of the 4.2 million pounds in 1966.

Australian mine production of tungsten has been stimulated by the sustained improvement in prices of tungsten concentrates on world markets and by the relative stability introduced by securing long-term contracts covering the bulk of domestic production. During the first 6 months of 1966 Australia's production of 65 per cent WO_3 concentrates was at the rate of about 2,100 tons a year.(2)

The United Nations Committee on Tungsten held its fifth session in New York in May to review the tungsten market. The meeting, May 16 to 19, was attended by representatives of 25 countries for discussions of the desirability of intergovernment arrangements regarding the tungsten market and of establishing an international tungsten institute. Producers throughout the non-communist countries are anxious to maintain an orderly market for tungsten and avoid the erratic price changes which have been characteristic for tungsten concentrates.

CONSUMPTION AND USES

United States is the largest consumer of tungsten, used by some 15 steel producers and 22 firms producing metal powder and tungsten carbides. The major-use categories, approximate amounts, and proportions consumed are listed in an accompanying table

Consumption of Tungsten in the United States, 1965-66

Uses	1965 (000 lb)	1966 (000 lb)	1966 By Use %
Carbides	6,240	7,550	45
Steel alloys	3,190	3,850	23
Tungsten metal ..	2,774	3,350	20
Other	1,664	2,010	12
Total	13,868	16,750	100

(1) United States Bureau of Mines, Commodity Data Summaries, January 1967.
(2) Australian Mineral Industry, January 1967.
(3) United States Bureau of Mines, Commodity Data Summaries, January 1967; and Mineral Industry Surveys, Tungsten, March 2, 1967.

The preliminary estimate of US consumption of 16.75 million pounds of tungsten was an all-time high; final 1966 statistics may show that consumption was over 17.5 million pounds.(1) The consumption pattern in Canada is outlined in Table 4.

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 also used by the mining industry as carbide-tipped rock-drill bits. The use of sintered carbide tire studs contributed to the growing market for tungsten products. Plasma-spray metal powders composed of tungsten carbide and a fused-cobalt binder are used to provide a wear-resistant coating on metal parts. Tungsten carbide in tiny spherical pellets is used in ball-point pens.

In high-temperature nonferrous and super-alloy 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.(2) 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 principally 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.

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:(3)

		Per Cent (dry weight)
Tungsten trioxide (WO_3)	Minimum	65.00
Tin (Sn)	Maximum	.10
Copper (Cu)	"	.10
Arsenic (As)	"	.10
Bismuth (Bi)	"	.25
Antimony (Sb)	"	.10
Molybdenum (Mo)	"	.10
Phosphorus (P)	"	.05
Sulphur (S)	"	.50
Lead (Pb)	"	.10
Zinc (Zn)	"	.10
Manganese plus iron (Mn + Fe)	"	2.00

(1) United States Bureau of Mines, Commodity Data Summaries, January 1967; and Mineral Industry Surveys, Tungsten, March 2, 1967.

(2) Oregon Metallurgical Corporation, Albany, Oregon.

(3) United States Bureau of Mines, Bulletin 630, 1965.

TABLE 4

Consumption of Tungsten in Canada, by Use, 1965
(lb of contained W)

Carbides	401,359
Electrical and electronic	11,698
Other[1]	464,557
Total	877,614

Source: Compiled in Mineral Resources Division from data supplied by the Dominion Bureau of Statistics.

[1] Includes ferrous alloys, nonferrous alloys, chemicals and pigments.

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*, Kennametal of Canada, Limited, Victoria; 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 *E & MJ Metal and Mineral Markets* of December 26, 1966, tungsten prices in the United States were:

	$ US
Tungsten ore, per short-ton unit of WO_3 (20 lb), basis 65%, foreign, c.i.f. U.S. ports	
Wolfram	43.00
Scheelite	43.00
(50¢ per lb W duty included)	
Tungsten metal, per lb	
98.8% min., 1,000-lb lots	2.75
Hydrogen reduced, 99.99%	4.60 to 5.44
Ferrotungsten, per lb contained W 70-80%	
Regular	3.00 (nominal)
"UCAR"	2.03
Tungstic acid, 92.5%, per lb, 1,000-lb lots in drums (according to Oil, Paint and Drug Reporter, Dec. 26, 1966)	1.90

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 for use in Canadian manufacturing	free	free	free
Ferrotungsten	free	5%	5%
Tungsten rod and tungsten wire when used in Canadian manufacture	free	free	25%
Tungsten metal, in lumps, powder, ingots, blocks, or bars, and scrap of alloy metal containing tungsten, for use for alloying purposes	free	free	free

United States

Tungsten ore	50¢ per lb on tungsten content
Tungsten metal	
Unwrought:	
Other than alloys	
Lump, grains and powders	42¢ per lb on tungsten content + 25%
Ingots and shots	21%
Other	25.5%
Alloys	
Containing by weight not over 50% tungsten	42¢ per lb on tungsten content + 12.5%
Containing by weight over 50% tungsten	25.5%
Waste and scrap	
Containing by weight not over 50% tungsten	42¢ per lb on tungsten content + 12.5%
Containing by weight over 50% tungsten	21%
Wrought	25.5%
Ferrotungsten	42¢ per lb on tungsten content + 12.5% ad val.

Uranium and Thorium

R.M. WILLIAMS*

Uranium

Canada's uranium industry has been responsible for a short but dramatic chapter in the history of Canadian mining. The value of Canadian uranium production rose from essentially nothing prior to World War II to a record $331,143,043 in 1959, when it led all metallic minerals. The subsequent decline of the industry resulted in a drop in production to 3,822 tons of uranium oxide (U_3O_8) valued at $54,345,000 in 1966.

The industry is now on the verge of entering a new period of development based on the rapidly expanding demand for long-term supplies of nuclear fuel for the generation of electric power. The great impetus for the change in outlook came from the United States where a remarkable 55 per cent, or 21,224 electrical megawatts (MWe), of all new steam-electric generating capacity announced in 1966 by domestic utilities was to be nuclear-fired. Of this total, 21 plants, representing 16,550 MWe, were ordered and scheduled for operation in 1971 or 1972. Nuclear power developments in other countries, although less dramatic, are progressing at an accelerated pace. In early 1966, it was predicted that by 1980 the non-communist world would have an installed nuclear capacity equal to some 225,000 MWe and that uranium production would be required at an annual rate of 65,000 tons of U_3O_8 to provide the fuel necessary to support this capacity. Authorities now believe these predictions to be conservative.

In 1959, Canada's peak production year, shipments of U_3O_8 were 15,892 tons from 23 mines and 19 treatment plants. In 1966 the 3,822 tons of U_3O_8 came from four producers and one of these, Stanrock Uranium Mines Limited at Elliot Lake, Ontario, produced solely by underground bacterial leaching. Only Rio Algom Mines Limited's Nordic mine, also at Elliot Lake, operated at full capacity. Denison Mines Limited's Elliot Lake operation produced at less than 50 per cent capacity, and Eldorado Mining and Refining Limited's Beaverlodge mine, at Beaverlodge, Saskatchewan, continued at approximately 75 per cent capacity.

*Mineral Resources Division.

TABLE 1

Uranium Production in Canada, by Province, 1965-66

	1965		1966p	
	Pounds	$	Pounds	$
Production (U_3O_8) shipments				
Ontario	6,825,046	47,234,892	5,843,813	40,545,000
Saskatchewan	2,060,167	15,126,485	1,800,000	13,800,000
Total	8,885,213	62,361,377	7,643,813	54,345,000

Source: Dominion Bureau of Statistics.
p Preliminary.

TABLE 2

Uranium Production by Major Producing Countries 1956-66
(short tons U_3O_8)

Year	Canada	United States	South Africa	Congo	Australia	France*	Non-Communist World
1956	2,281 $ 45,732,145	6,000	4,365	1,300	300	–	14,470
1957	6,636 $136,304,364	8,640	5,700	1,300	400	535	23,270
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	34,600
1963	8,352 $136,909,119	14,218	4,532	–	1,200	2,692	31,100
1964	7,285 $ 83,509,429	11,847	4,445	–	420	2,588	26,700
1965	4,443 $ 62,361,377	10,442	2,942	–	370	2,570	20,800
1966p	3,822 $ 54,345,000	9,476	3,200e	–	100e	2,500e	19,200e

Sources: United States Bureau of Mines (USBM) Minerals Yearbooks; USBM Mineral Facts and Problems, 1965 Edition; USBM Mineral Preprint, 1965, Uranium, by Charles T. Baroch; USBM Commodity Data Summaries, January 1967; for South Africa, Department of Mines Quarterly Reports; and, for Canada, Dominion Bureau of Statistics, producers shipments.

*Includes Gabon and Malagasy Republic. p Preliminary; e Estimate.

Canadian producers witnessed the growing demand for nuclear fuel when towards the end of 1966 two new contracts* were consummated for uranium supply throughout the 1970's. In all probability, there will be negotations for further substantial contracts perhaps in 1967, thus justifying a reactivation and expansion of presently idle production capacity and increased expenditures on exploration. Such reactivation could raise Canadian production from the current level of 4,000 tons to about 11,000 tons of U_3O_8 a year. This would require an

*See Market Developments.

expenditure of $25 million to $50 million and might take up to 5 years to complete. Geologically speaking, Canada has the potential for even higher production and there is every reason to believe that new mines will be discovered and that the Canadian industry will be able to maintain its position as supplier of at least 30 per cent of the non-communist world's uranium.

INDUSTRY DEVELOPMENTS

DENISON MINES LIMITED

Since July 1965 Denison has been producing to meet a Canadian Government stockpile contract which permits the company to deliver up to 3 million pounds of U_3O_8 a year until June 30, 1970. In 1966 the company produced 2,748,602 pounds of U_3O_8 from 981,709 tons of ore milled. Average grade was 2.86 pounds of U_3O_8 a ton, in treating an average of 2,922 tons of ore a day.

One of Denison's major developments was the completion of a $1-million, 12-unit pachuca circuit in a new addition to its mill. This installation resulted in a more efficient, lower cost operation, the removal of the old wooden-stave agitator tanks and the installation of an yttrium oxide* recovery circuit in the space made available. Investigations and research are being carried out on a pre-concentration technique designed to decrease the volume and to increase the grade of solids fed to the leaching circuit. This would allow for increased milling capacity and further improvements in efficiencies and costs.

Two other developments were of significance in Denison's efforts to prepare for the expected increase in uranium demand. To facilitate development of its vast ore reserves to the south and east of the present workings, Denison began a 6,200-foot drive eastward to the Can-Met mine. This project is expected to take up to two years to complete and will provide a main artery for subsequent development. Also, mining in the northeast and southwest portions of the mine is being phased out and a new conveyor system is being installed to handle the planned production in the south and east. This conveyor system together with the automatic skip system in No. 2 shaft will enable Denison to increase its ore-hoisting capacity to about 10,000 tons a day.

RIO ALGOM MINES LIMITED

Rio Algom's Nordic mine produced 2,741,340 pounds of U_3O_8 in 1966 from 1,285,400 tons of ore grading 2.13 pounds of U_3O_8 a ton. Due to the anticipated lower grade of the ore it was necessary, in February 1966, to raise the ore production rate to meet delivery requirements with the result that the average daily mill rate reached 3,704 tons. In addition, 102,515 pounds of U_3O_8 were recovered by treatment of mine water from the Quirke mine, which was dewatered in preparation for its reactivation. Deliveries were primarily to the United Kingdom Atomic Energy (UKAEA) under the original "master" contract with Eldorado Mining and Refining Limited. Upon completion of this contract in 1968, Rio Algom must still deliver its allotment of a later contract which Eldorado made on behalf of the Canadian producers in 1962. This contract called for Eldorado to deliver to the UKAEA a total of 24 million pounds of U_3O_8 at an average price of $5.03 a pound. Rio Algom has been able to "stretch-out" its deliveries under both these contracts until October 1971 to about 2.4 million pounds of U_3O_8 a year. In addition, Rio Algom is permitted to make deliveries to the Canadian Government stockpile at rates up to 600,000 pounds a year until June 30, 1970.

With the consummation of two new contracts at the end of 1966, continued production by Rio Algom at Elliot Lake is assured. Due to the approaching depletion of ore at present price levels, the Nordic mine is expected to close during 1968 when it is planned to transfer operations to the Old Quirke mine. The shaft has been dewatered and the mill is being prepared for reactivation.

Meanwhile, preparations for the development of the New Quirke mine proceeded on schedule. The surface facilities for the shaft, located some 6,000 feet south and east of the Old Quirke plant, were completed in 1966 and shaft sinking began in January 1967. The shaft will be

*See 1966 Mineral Review No. 43, "Rare-Earth Elements," by W.H. Jackson.

sunk to 2,260 feet and will be designed to hoist up to 6,000 tons of ore a day. The New Quirke mine, which will cost from $8 million to $9 million, is being developed to supplement production from the Old Quirke mine with small quantities in 1968 and with larger quantities as total commitments increase and the Old Quirke is depleted. Rio Algom has no immediate plans to rehabilitate its other Elliot Lake properties*, with a potential production capacity totalling perhaps 6,000 tons of ore a day, which are being kept on a care-and-maintenance basis.

In December 1966, the assets of Rio Tinto Nuclear Products Limited were absorbed by Rio Algom and its activities are now carried on as a department of the mining division. This department produces rare-earth and thorium concentrates in a special recovery circuit at the Nordic mill, and is in a position to market natural ceramic uranium-dioxide powder of nuclear grade. This powder can be produced at its recently-completed Quirke refinery that has a capacity of 150 tons of UO_2 a year.

STANROCK URANIUM MINES LIMITED

In May 1966 Stanrock completed its allotment of the 1962 UKAEA contract and began deliveries under a Canadian Government stockpile contract, which allows it to deliver up to 16,500 pounds of U_3O_8 a month until June 30, 1970. Production valued at $818,681**, was recovered by the treatment of mine water and averaged about 13,000 pounds of U_3O_8 a month. The water, which is acidic and pregnant with uranium and rare earths, is the product of a natural acid-leaching process promoted by bacteria. A combination of fast, high-pressure washing and rewashing of stopes on a predetermined cycle and the intermittent sprinkling of low grade heaps, using both fresh water and recirculated acid water, has proved successful.

During the latter half of 1966, recoveries declined in some areas of the mine with the result that production dropped to an average of about 11,000 pounds of U_3O_8 a month. In a special report to its shareholders, issued in February 1967, the company indicated that this experience showed it will not be able to deliver the maximum permitted amounts to the stockpile by this method. Further, the company stated that it "cannot presently mine and mill such tonnage (its deposit) profitably by conventional methods at sales prices obtainable at the present time".

Near the end of 1966 Stanrock began negotiations to acquire the assets of the Stanward Corporation, of Marion, Ohio, which controls some 6,700 acres in the central portion of the Quirke Lake syncline within a 5-mile radius of Stanrock's property. This acreage consists of 138 claims held by Stanward and 31 claims held by Stanatomic Uranium Mines Limited, a company in which Stanward holds a 70 per cent interest. When negotiations are completed an exploration program is planned.

ELDORADO MINING AND REFINING LIMITED

In December 1966, Eldorado made final deliveries to the United States Atomic Energy Commission (USAEC), thus ending a close association of more than 23 years. In January 1967, Eldorado will also complete its allotment of the 1962 UKAEA contract and begin deliveries to the Canadian Government stockpile at rates up to 1.8 million pounds of U_3O_8 a year. Production from its Beaverlodge mine in 1966 amounted to 1,687,501 pounds of U_3O_8 recovered from 511,446 tons of ore milled with an average recovery of 3.30 pounds of U_3O_8 a ton.

The drop in production of some 54 tons of U_3O_8 from 1965 was attributed to difficulties in maintaining a work force satisfactory in numbers and experience. This, together with rising costs and increased development, resulted in an 8 per cent increase in the cost per pound of U_3O_8 produced. To prepare for the expected increase in uranium demand, development activity continued and ore reserves were increased by over 30 per cent to 2 million tons of proved, probable, and pillar ore grading 0.21 per cent U_3O_8.

A new orebody of sufficient size (300,000 tons at 6 pounds U_3O_8 a ton) to warrant underground development has been outlined about

*The Panel mine at 3,000 tons a day; The Stanleigh, Milliken and Lacnor mines at a total of 3,000 tons a day.

**About $44,000 of this total was from the sale of yttrium oxide concentrate.

seven miles north of the Beaverlodge mine on Eldorado's Hab property. A road was completed to the site and preparation of surface facilities is planned for 1967 with shaft sinking to begin in 1968. The estimated cost of bringing the property into production, at an average rate of 250 tons of ore a day, is about $2 million.

Eldorado's refinery at Port Hope, Ontario, continued to be Canada's only producer of refined uranium products. Upon converting its refinery to a modern solvent extraction system in 1955, Eldorado was in a position to develop facilities for the production of nuclear-pure natural and enriched ceramic uranium dioxide (UO_2) powders, uranium metal, and various uranium alloys. Since then it has produced over 30,000 tons of orange oxide (UO_3), almost entirely on a refining contract for the USAEC, about 300 tons of uranium metal, about 300 tons of natural ceramic UO_2 powder, and very close to 33,000 kilograms of enriched and depleted ceramic UO_2 powder. A significant portion of the UO_2 powder production has been for export markets, primarily in Europe.

The conversion of yellow cake to ceramic UO_2 powder is the first step in the manufacture of nuclear fuel and accounts for 8 to 10 per cent of the total fuel cost. Due to the expected heavy demand for its product, Eldorado is planning to convert its ceramic powder operation from a batch process to a more efficient continuous circuit. It is anticipated that a reduction in production costs of some 25 per cent may be realized. A part of the orange oxide circuit will be maintained for conversion to UO_3 of concentrates received by Eldorado as agent under the Canadian Government's stockpile program.

EXPLORATION

Exploration for uranium in Canada revived in 1966 and activity was widespread with most of it being centred around Elliot Lake, Ontario, and Beaverlodge, Saskatchewan. Much of the activity consisted primarily of land acquisition, but several companies began intensive exploration programs and at least one new area, near Agnew Lake, Ontario, emerged as one of promise.

TABLE 3

Canadian Uranium Production, by Company, 1966

Company and Plant Location	Mill Capacity (tons ore/ day)	Production (tons U_3O_8)	Ore Treated (millions of tons)	Millhead Grade (lb U_3O_8/ ton)	Mill Recovery (%)	Ore Reserves All Categories millions of tons	lbs. U_3O_8 ton
Elliot Lake Area, Ont.							
Denison Mines Limited...	6,000	1,374	0.982	2.86	94.97	120.000	2.50
						3.200(1)	2.50
Rio Algom Mines Limited .							
Nordic Mine	3,700	1,371	1.285	2.13	93.9	12.967(2)	2.02
Old Quirke Mine.......	3,000	51	..	..	..	47.963(3)	2.52
Stanrock Uranium Mines Limited	3,000	77e	0.568(4)e	0.27(5)	..	3.318	1.70
Beaverlodge Area, Sask.							
Eldorado Mining and Refining Limited	2,000	844	0.512	3.30(6)	..	2.000(7)	4.20

Source: Company annual reports.

(1) Developed ore. (2) December 1964. (3) December 1964. Includes the Panel, Milliken, Stanleigh and Lacnor mines. (4) Millions of tons of water. (5) Pounds of U_3O_8/ton of water. (6) Average recovery. (7) Proved, probable and pillar.

e Estimate: Based on first nine months when 441,909 tons of water were treated to recover 120,531 pounds of U_3O_8. Total 1966 production value was $881,681 of which $44,000 was for yttrium oxide concentrate.

. . Not available or applicable

In the Agnew Lake area, in Hyman and Porter townships and about 45 miles east of the town of Elliot Lake, Kerr Addison Mines Limited continued to explore a property in which it acquired an 80 per cent interest from Quebec Mattagami Minerals Limited. Kerr Addison completed some 22,500 feet of diamond drilling that indicated five separate beds of quartz-pebble conglomerate, similar to the Elliot Lake ore horizon. The important No. 3 zone, at least 3,000 feet long, and about 2,000 feet deep is estimated to contain within those dimensions five million tons averaging two pounds of U_3O_8 a ton. Unlike the Elliot Lake deposits, this conglomerate has also indicated thorium oxide (ThO_2) content of about four pounds a ton. Approximately 450 additional claims were staked by Kerr on its own account and several other companies have taken ground in townships to the south and west. Drilling is underway on some of the properties.

One of the most significant developments in the Elliot Lake area was the acquisition of a large number of claims, covering a major portion of the centre of the Quirke Lake syncline, by Kerr-McGee Corporation. Kerr-McGee, one of the largest uranium producers in the United States, opened an exploration office in Toronto and plans to carry out a major deep drilling program on its Elliot Lake ground. Many other companies have been acquiring land either by staking or by making deals with private claim holders. Several companies are planning exploration programs in the near future.

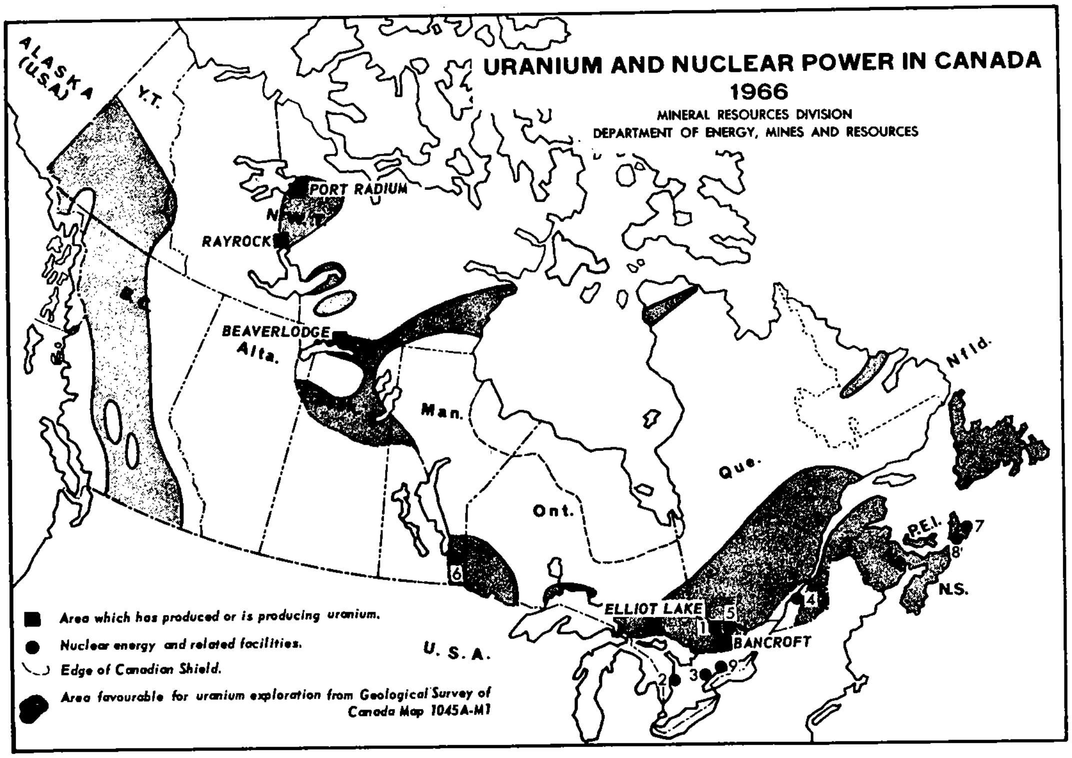
Rio Tinto Canadian Exploration Limited has been conducting a continuous uranium exploration program and in 1966 carried out drilling on its Moon Lake property, about ten miles north and west of the town of Elliot Lake. Silvermaque Mining Limited continued diamond drilling its property, bounded by Rio Algom's Milliken property on the east, with promising results. Denison completed an agreement late in 1966 with Candore Explorations Limited to undertake 5,000 feet of drilling on Candore's claims that adjoin to the west of Rio Algom's Quirke property.

Staking and exploration activity in the Beaverlodge area of northern Saskatchewan was also brisk during 1966. The French company, Mokta (Canada) Ltée., acquired mineral permits and claim blocks in the Uranium City and Stony Rapids areas where it carried out detailed geology and scintillometer surveys and a minor amount of drilling. Western Nuclear Inc., a major American uranium producer, acquired some claim blocks in the Uranium City area and conducted airborne scintillometer surveys on its holdings. Numac Oil & Gas Ltd. joined with Imperial Oil Limited to explore ground that Numac holds in the Uranium City, Stony Rapids, and Charlebois Lake areas. The team had four field crews in the area during the 1966 season.

In the Bancroft area of eastern Ontario, Metal Mines Limited did further development work on its property. The company also negotiated an option agreement with Federal Resources Corporation of Salt Lake City, Utah, which produces uranium from the Gas Hills area of Wyoming. Federal will gain a 51 per cent interest in the Bancroft area mine by advancing all the funds necessary to put it back into production. Work will commence on the property in the spring of 1967.

Minor activity was reported in other areas, primarily in Labrador and the Northwest Territories. Several new companies were formed and many companies, idle since the late 1950's, indicated their properties were again receiving attention. Japanese interests have indicated they are prepared to enter Canadian exploration for uranium to assure supplies of nuclear fuel for Japan. Four West German firms have entered into a joint exploration venture with British Newfoundland Exploration Limited for work in the Makkovik area on the Labrador Coast. Considerable staking activity was also reported at year-end in the Johan Beetz, Quebec, area on the north shore of the St. Lawrence River, about 450 miles downstream from Quebec City.

While some American companies have come to Canada in search of uranium, Rio Algom and Denison have become active in the western United States. Rio Algom, through a wholly-owned Delaware-incorporated company, acquired the right to purchase an 1,850-acre uranium prospect that is about 30 miles south of Moab, Utah. Purchase would follow an exploration program now underway that will be carried out over a three-year option period. Rio Algom is also carrying out a 3-year joint exploration program with Mitsubishi Metal Mining



FACILITIES

1. Nuclear Power Demonstration Station, Rolphton, Ontario.
2. Douglas Point Nuclear Power Station, Kincardine, Ontario.
3. Pickering Nuclear Power Station, Pickering, Ontario.
4. Gentilly Nuclear Power Station, Pointe aux Roches, Quebec.
5. Atomic Energy of Canada Limited's Chalk River Nuclear Laboratories, Chalk River, Ontario.
6. Atomic Energy of Canada Limited's Whiteshell Nuclear Research Establishment, Pinawa, Manitoba.
7. Deuterium of Canada Limited's Heavy Water Production Plant, Glace Bay, Nova Scotia.
8. Canadian General Electric Limited's Heavy Water Production Plant, Point Tupper, Nova Scotia.
9. Eldorado Mining and Refining Limited's Refinery, Port Hope, Ontario.

Company on a 14,000-acre uranium prospect in the Shirley Basin district of Wyoming. Denison has opened an exploration office in Denver, Colorado, and is planning an exploration program on acreage it acquired in the Tallahassee Creek area of Colorado.

NUCLEAR POWER IN CANADA

Canada's first full-scale nuclear power station went into operation on November 15, 1966, and began delivery of electricity into the Ontario Hydro grid in early 1967. The 200-MWe Douglas Point Nuclear Power Station, on the east shore of Lake Huron near Kincardine, Ontario, is fueled with natural uranium and moderated and cooled with heavy water. Built by Atomic Energy of Canada Limited (AECL), in co-operation with The Hydro-Electric Power

Commission of Ontario at a cost of $85 million, it is expected to produce electricity at about 6 mills a kilowatt hour (kwh). Canada's 20-MWe Nuclear Power Demonstration Station at Rolphton, Ontario, has been operated successfully at full capacity by AECL and Ontario Hydro since 1962.

Canada's third nuclear power station is under construction at Pickering, Ontario, and the first 540-MWe unit is expected to go on stream in October 1970. The plant, costing $266 million for the first two contracted units, is expected to produce power at about 4 mills a kwh. It is planned to expand the Pickering plant to six 540-MWe units by 1975 as part of Ontario Hydro's plan to build 500 MWe of nuclear capacity each year from 1970 to 1980.

A fourth nuclear power station will be built by AECL, in co-operation with Hydro-Quebec, on the south shore of the St. Lawrence River midway between Becancour and Gentilly. The CANDU-BLW station will have a capacity of 250 MWe, will be fueled with natural uranium, moderated with heavy water and cooled with light water. The facility, to be completed in 1971, will cost an estimated $106 million and is expected to produce power at less than 4 mills a kwh. The Gentilly site has been laid out for the 250-MWe prototype plus four additional 500-MWe units.

In June 1966, Canadian General Electric Company Limited (CGE) announced that it would build a 400-ton-a-year heavy water production plant at Point Tupper near Port Hawkesbury on Cape Breton Island. The $65-million plant will initially supply heavy water to AECL which has issued a contract for the delivery of 5,000 tons of heavy water over 12.5 years at an average price of $18.15 a pound, beginning in 1969.

In September 1966, AECL was authorized to purchase additional heavy water from Deuterium of Canada Limited. The original contract for delivery of 200 tons a year will be enlarged to give an overall contract similar to that negotiated with CGE. The new arrangement also authorizes AECL to purchase an additional 830 tons at $20.50 a pound from Deuterium until CGE's Point Tupper plant comes into production in 1969. Negotiation of the new contract had been postponed for some time, pending clarification of how Deuterium would finance the necessary plant expansion. All interest in the Deuterium plant was purchased by the Government of Nova Scotia for $3 million in August. Production from the first 200-ton-a-year Glace Bay unit should begin in 1967.

Canada's heavy-water reactor systems have shown a strong competitive position in the world export market. Two Canadian reactors are under construction abroad, one in India and the other in Pakistan. Several other countries, notably Finland, Italy, Spain and Yugoslavia, have indicated a preference for the Canadian design. CGE has submitted a bid on a 300-MWe unit for Imatran Voima Oy, the state-owned utility in Finland.

MARKET DEVELOPMENTS

At the end of 1966, final deliveries under contracts made in the mid-1950's with the USAEC were completed. Total shipments over this period were valued at over $1.5 billion. At the year-end, approximately 11.5 million pounds of U_3O_8 remained to be delivered to the UKAEA, almost entirely from Rio Algom, at an annual rate of 2.4 million pounds until October 1971. The amount includes Rio Algom's 7.42 million pound allotment of the 1962 UKAEA contract.

In June 1965, the Government of Canada announced that it would purchase limited quantities of uranium at $4.90 a pound of U_3O_8 from companies that had previously produced uranium. The purchase would be for a five-year period beginning July 1, 1965. As 1967 began, the continued operation of three of Canada's four producers depended on deliveries to the stockpile. Deliveries under this program in 1966 were 322,000 pounds below the maximum permitted amounts. Total cost to the Government of the U_3O_8 in its stockpiles at the end of 1966 was about $50 million*.

In June 1965, the Government of Canada announced that from then on it was prepared to

*Includes 2,683 tons of U_3O_8 delivered at $4.60 a pound under the first stockpile program, July 1, 1963 to June 30, 1964.

grant export permits with respect to sales of uranium only if the uranium is to be used solely for peaceful purposes and an agreement to this effect is made between Canada and the importing country. While the bulk of Canadian uranium has been marketed through the crown corporation, Eldorado Mining and Refining Limited, producers are at liberty to negotiate their own sales contracts consistent with the Government's policy. Canada has bilateral agreements with Australia, Euratom, India, Japan, Pakistan, Spain, Sweden, Switzerland, United Kingdom, United States and West Germany. Sales have been made since 1958 by private producers to several countries other than the United Kingdom and United States, primarily to West Germany and Japan.

Rio Algom negotiated a contract in 1966 with the UKAEA for the delivery of a minimum of 8,000 tons of U_3O_8, which can be increased to a maximum of 11,500 tons of U_3O_8 at the option of the UKAEA. Deliveries will begin when the current UKAEA contracts are completed in October 1971 and will continue at a basic annual delivery rate of 1,000 tons of U_3O_8 until 1980. The uranium will be subject to inspection and control consistent with official Canadian Government policy. The value of the contract has not been disclosed.

In December 1966, The Hydro-Electric Power Commission of Ontario completed negotiations with Rio Algom and Eldorado for the purchase of a total of 6,500 tons of uranium concentrates. Rio Algom will supply more than 90 per cent of the uranium with deliveries beginning about 1970 and continuing on an expanding scale until the early 1980's. Eldorado will supply the balance of the contracted amount and, during the early years of the agreement, will provide refining services at its Port Hope refinery. The value of the contract was not disclosed.

Canadian uranium producers are looking forward to other long-term contracts in the near future. Delegations from Japan, West Germany and Mexico visited Canada during 1966 on fact-finding missions relative to uranium procurement. Initial contracts will likely come from countries other than the United States as it has substantial uranium reserves of its own and has placed a ban on imports of foreign uranium until 1975. All three major Canadian uranium producers have active sales promotion staffs and have participated in sales missions abroad, primarily in Europe and Japan. Of particular significance is an agreement, consummated in December 1966, between Denison and Mitsui and Company Ltd., a major Japanese trading company, whereby Mitsui will purchase uranium only from Denison for sales to the Japanese nuclear industry and Denison will sell uranium to Japan only through Mitsui.

TABLE 4

Exports of Uranium Concentrate from Canada
(thousands of dollars)

Year	United States	United Kingdom	West Germany	Japan	Switzerland	India	Others	Total
1956	45,777	–	–	–	–	–	–	45,777
1957	127,935	–	–	–	–	–	–	127,935
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(1)	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(2)	137,531
1964	34,863	39,627	159	4	–	–	–	74,653
1965	14,749	38,948	–	–	–	–	–	53,697
1966p	13,761	22,605	–	–	–	–	–	36,366
Total	1,435,225	248,554	1,615	482	123	590	53	1,686,642

Source: Dominion Bureau of Statistics, exports as reported in Trade of Canada radioactive concentrates that cleared customs.

(1) Includes Sweden ($27,720). (2) Brazil
p Preliminary.

URANIUM RESOURCES AND REQUIREMENTS

Production of electricity in the industrialized countries of the non-communist world has been increasing at about 7 per cent a year, with Western Europe, Canada and Japan supplying about 45 per cent of the non-communist world's electrical energy and the United States supplying about 40 per cent. As 1967 began, nuclear power stations accounted for less than one per cent of the total generating capacity. This proportion is expected to increase so that by 1985 over 20 per cent of installed electrical generating capacity will be nuclear-fueled.

Several independent forecasts of the future nuclear generating capacity have been made and although they vary for individual countries the totals are in close agreement. These forecasts show that for the non-communist world the 6,000 MWe of nuclear capacity available in 1965 will rise to over 200,000 MWe in 1980 and to perhaps 500,000 MWe in 1985.

The basic reason for the accelerated growth in nuclear power demand is an economic one. For example, in 1962 the USAEC estimated the cost of producing electricity from a base-load 500-MWe nuclear plant, of American design, at 6.2 mills a kwh. Current estimates (1970-1971 start-up) of the expected economic performance of light water nuclear electric plants in larger sizes and with investor financing are in the range of 3.5 to 4.2* mills a kwh for base-load operation. For those that are publicly financed, the range is 2.6 to 3.0 mills a kwh. Generally speaking, given a high plant capacity factor, nuclear power can be available at less than 5 mills in plants of 500 MWe or larger almost anywhere in the United States, as well as in many other areas of the world.

The uranium required to fuel the projected nuclear capacity can be calculated by examining the fuel requirements of the different types of reactors. Unfortunately, the requirements vary from type to type and it is impossible to predict with any degree of certainty in what proportions they will be installed over the next twenty years. However, by using reasonable assumptions it is possible to estimate future requirements. Such a forecast has been made by the USAEC which estimates that the annual non-communist world uranium requirement will rise from 12,000 tons of U_3O_8 in 1970 to 65,000 tons of U_3O_8 in 1980. It is important to note that nuclear power installation programs can be delayed or accelerated throughout this period and consequently forecasts of this nature require frequent revision.

At the end of 1966 the estimated resources of uranium in the non-communist world, reasonably assured at less than $10 a pound U_3O_8, were about 690,000 tons of U_3O_8. These resources will more than meet the non-communist world's projected requirements to 1980, and it is estimated that additional possible resources in the same price category will be adequate for a further 10 years. However, continued programs

TABLE 5

Uranium Requirements to 1980 for Non-Communist World

(short tons U_3O_8)

		United States	Other Non-Communist World	Total
1970	Annual	5,000	7,000	12,000
	Cumulative*	13,000	25,000	38,000
1975	Annual	14,000	18,000	32,000
	Cumulative	65,000	91,000	156,000
1980	Annual	28,000	37,000	65,000
	Cumulative	172,000	237,000	409,000

* Beginning 1966. Source: USAEC

*See projected power costs for Canadian plants.

of exploration and development will be required to assure that the estimated additional resources are transformed into available reserves.

With the advent of commercial advanced converter and breeder type reactors, which are expected before the end of this century, some 75 per cent of the energy content of uranium may be available rather than the 1.5 per cent available with present nuclear power plants. Such a development will not only reduce the cost of nuclear power in the future, but will significantly extend the life of nuclear fuel resources available at that time.

TABLE 6

Estimated Non-Communist-World Resources of Uranium, Reasonably Assured, $5 to $10 a lb U_3O_8
(short tons U_3O_8)

Canada	200,000
United States	200,000
South Africa	190,000
France	37,000
Europe (Other) (1)	23,000
Africa (Other) (2)	17,000
Australia	15,000
Argentina	5,000
Total	687,000

Sources: OECD, August 1965, USAEC, January 1967.
(1) Includes Spain and Portugal.
(2) Includes Congo, Gabon and Morocco.

Thorium

Rio Tinto Nuclear Products Limited continues to be Canada's only producer of thorium concentrates. Operations, which are now carried on as a department of Rio Algom Mines Limited's mining division, are centred at the Nordic mine in Elliot Lake, Ontario, and have a capacity of 150 to 200 tons of thorium concentrates a year. Production and sales of thorium oxide (ThO_2) were substantially higher than in 1965 and are expected to increase in 1967.

The average grade of the Elliot Lake ore deposits, where the principal ore minerals are uraninite, brannerite and monazite, is 0.12 per cent U_3O_8 and 0.05 per cent ThO_2. At the Nordic mine, the thorium and rare-earth values are recovered from the barren effluent solutions following removal of the uranium by ion exchange in the Nordic mill. This barren liquor assays about 0.13 grams a litre Th and 0.10 grams a litre total rare earths, and is treated in a separate part of the mill by the Nuclear Products Department using a solvent extraction process. An immiscible organic phosphorus compound, dissolved in kerosene, is used to extract the thorium and rare earths from the waste leach solutions, and the thorium is then recovered as thorium sulphate by stripping the pregnant organic solvent with moderately strong sulphuric acid. The thorium sulphate, which is insoluble in the sulphuric acid, precipitates and is filtered and dried. Until recently the thorium cake thus produced averaged about 25 per cent ThO_2, but near the end of 1966 modifications to the process were made and the product was upgraded to 35 to 40 per cent ThO_2. The economics of this operation have been significantly improved with the associated recovery of an yttrium oxide* concentrate.

Essentially all 1966 production was shipped to Thorium Ltd. in the United Kingdom. However, small quantities of thorium cake are transferred, as required, to the Nuclear Products Department's Quirke refinery, where it is refined to metallurgical-grade thorium oxide (99.8 + % ThO_2) and shipped to Dominion Magnesium Limited, Haley, Ontario. At Haley, Dominion Magnesium produces sintered pellets of pure thorium, thorium powder, and thorium-magnesium master alloy (40% Th). Although the plant has a capacity of 200,000 pounds of thorium metal a year, production in 1966 was only 1,275 pounds compared with 6,534 pounds in 1965.

TABLE 7

Prices for Thorium Products in the United States, February, 1967

Compound	Price Range* (U.S. dollars a lb.)
Thorium metal, pellets or powder	15.00 – 50.00
Thorium nitrate	2.75 – 6.00
Thorium oxide	5.00 – 20.00
Thorium-magnesium hardener (30-40% Th)	10.00

Source: Baroch, C.T., U.S. Bureau of Mines, Engineering and Mining Journal, February 1967.
*Range according to the quality of the material and the quantity purchased.

*See 1966 Review No. 43 on "Rare-Earth Elements", by W.H. Jackson.

USES

The use of thorium nitrate as an essential ingredient in the manufacture of gas lamp mantles began in the period 1890 to 1911, and continues to account for a substantial 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, in the manufacture of electrodes for inert-arc welders, as a refractory material, and in the manufacture of special optical glass.

The biggest potential use for thorium 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 can be used in a nuclear reactor as a fertile material. A fertile material is one which can be converted into a fissionable material, which in this case is U_{233}. In this respect Th_{232} is similar to U_{238} which is a fertile material and can be converted into the fissionable plutonium 239 (Pu_{239}).*

The fissionable U_{233} is of particular interest because in an ordinary thermal reactor it releases more neutrons per fission than either U_{235} or Pu_{239}. Consequently, greater efficiency can be obtained using the Th_{232}-U_{233} fuel cycle than the U_{238}-Pu_{239} fuel cycle, or more simply Th_{232} is a better fertile material than U_{238}.

Normally, when an atom of fissionable material undergoes fission in a reactor core there are more neutrons emitted than are required to maintain the chain reaction. These excess neutrons either escape or are absorbed by the reactor shielding. In an advanced converter or breeder type of reactor the excess neutrons are used to better advantage. The reactor core is surrounded by a "blanket" of fertile Th_{232} or U_{238} which will absorb the excess neutrons and be converted to U_{233} and Pu_{239} respectively.

Theoretically it is possible to produce more fissionable material in this manner than is burned in the reactor core but tremendous engineering problems remain to be solved before a commercial breeder is available. In spite of these problems, development of breeder reactor technology is progressing and with it the development of the thorium-uranium fuel cycle.

OUTLOOK

The non-communist world's resources of thorium, reasonably assured at prices less than $10 a pound ThO_2, were estimated in 1965 by the European Nuclear Agency at about 565,000 tons of ThO_2. More than half of these resources are associated with placer deposits, primarily in India, while the remainder are in veins in the United States, and in the conglomerate ores of the Elliot Lake area**, Ontario. All production of thorium is currently contingent either on the processing of monazite sand for rare-earth elements or on the production of uranium, as in the Elliot Lake area of Ontario. The recent rapid growth in demand for certain rare-earth elements has resulted in an oversupply of thorium far in excess of demand.

Consumption of thorium by manufacturers of gas mantles and magnesium alloys, the principal users, has remained fairly constant. Research in other uses of thorium is being carried out with promising results and some increase in the consumption of thorium for industrial uses is anticipated. A major increase in demand for thorium as a nuclear fuel must, however, await the full development of breeder reactor technology, which authorities estimate will not be complete before 1985. For the forseeable future, perhaps 10 or 15 years, non-communist world requirements for thorium will increase only slightly and probably will not exceed about 100 tons of ThO_2 a year.

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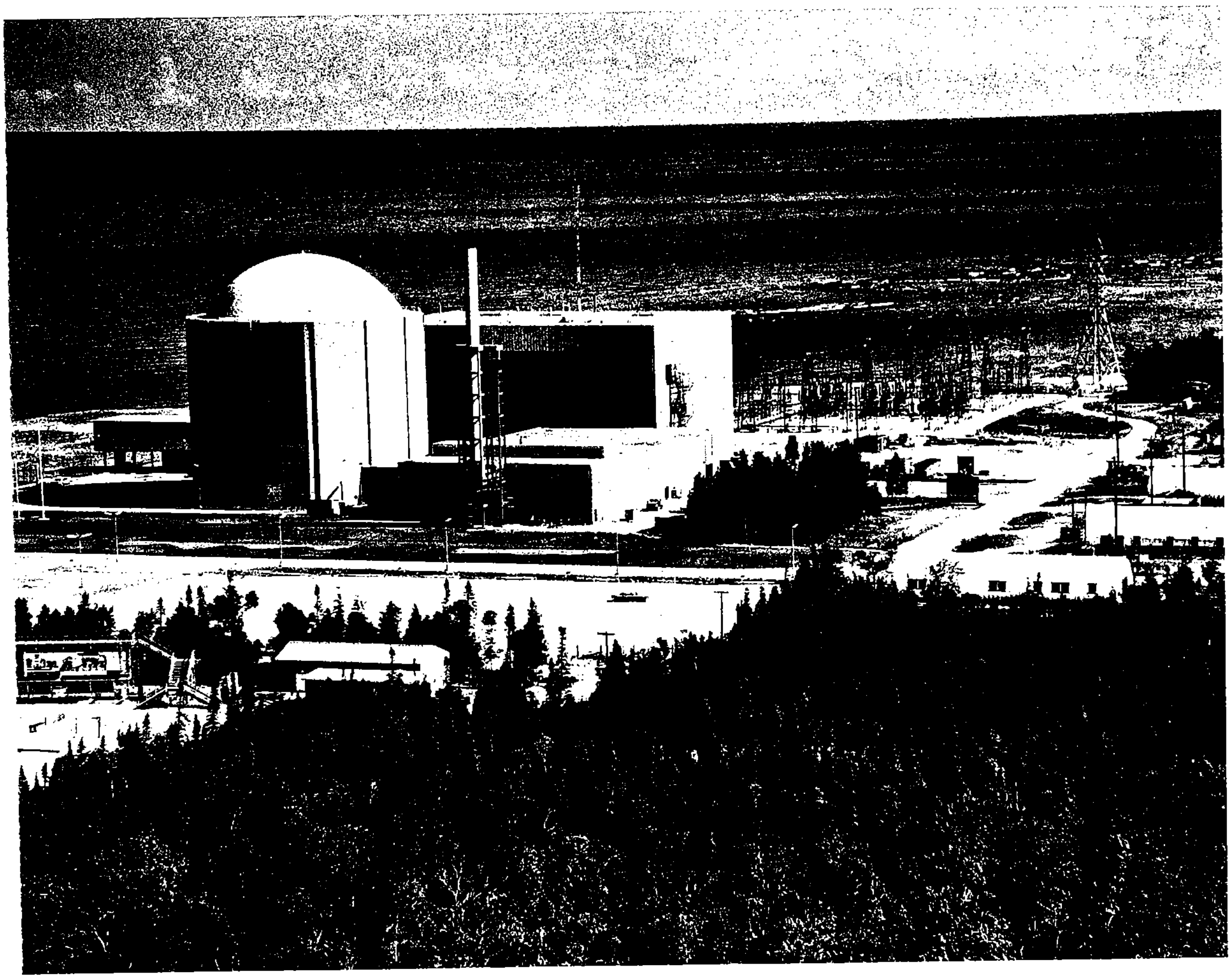
*U_{238} absorbs a neutron to become U_{239} which decays by beta particle emission to Np_{239} which decays further to Pu_{239}.
Th_{232} absorbs a neutron to become Pa_{233} which decays by beta particle emission to U_{233}.

**About 80,000 tons ThO_2.

Despite the fact that thorium reactor technology is at a much earlier stage than uranium reactor technology, research and development is being carried out in almost a dozen countries. Numerous thorium-experimental reactors have been built and a few commercial prototypes are experimenting with combinations of thorium-uranium fuel. The economic incentive for the development of both advanced converter and breeder type reactors is great. Converter reactors will require lower fuel inventories thus decreasing fuel costs and making power costs less sensitive to increases in uranium prices. The establishment of thorium-based power systems may make several countries, with small domestic sources of uranium and thorium, self-sufficient in terms of energy resources. In the long term, the development of a commercial breeder industry will allow the most efficient use of this civilization's energy fuels for centuries to come.



CANADA'S FIRST FULL-SCALE NUCLEAR POWER STATION: The 200-MWe Douglas Point plant, on the east shore of Lake Huron near Kincardine, Ontario, began feeding electricity into Ontario Hydro's grid in January 1967.

Vanadium

G.P. WIGLE*

Vanadium is recovered in Canada, from Venezuelan crude oil, in the form of vanadium pentoxide (V_2O_5), by Canadian Petrofina Limited at its refinery near Pointe-aux-Trembles, Quebec. The Petrofina byproduct plant recovers vanadium from fly-ash collected from the burning of coke, produced and used in the oil refining process. It is the first plant in Canada to recover vanadium commercially.

Most crude oils contain traces of vanadium. The content of North American crude is usually less than 50 parts per million (ppm) but Venezuelan crude, of the type processed by Petrofina has about 130 ppm (.013%).[1] The vanadium remains in the residual fuel after the recovery of the lighter components and part of it can be recovered from the fly-ash produced in the burning of the coke portion of the residue product.

Although no vanadium has been produced commercially from deposits in Canada many minor occurrences are known. Vanadium has been found in association with asphaltum, coal, chromium, copper, iron, lead, phosphate rock, titanium, uranium and petroleum. The amount seldom exceeds one per cent and is most frequently less than one tenth of one per cent. In the United States, most vanadium is recovered as a byproduct of uranium mining but it is also a byproduct of phosphorus production from phosphate rock in Idaho. The phosphate rock contains from 0.06 to 0.17 per cent vanadium.[2]

The Athabasca tar sands in northern Alberta contain an estimated 240 parts per million (0.024 per cent) of vanadium, which could be partially recovered from the coke residue of the distillation process.

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*Mineral Resources Division.
[1]Chemical Engineering, March 1, 1965, W. Whigham.
[2]United States Bureau of Mines, Mineral Facts and Problems, 1965.

TABLE 1

Canadian Imports and Consumption of Vanadium, 1965–66

	1965		1966	
	Short Tons	$	Short Tons	$
Imports				
Ferrovanadium				
United States	216	816,692	379	1,743,000
Britain	33	104,252	49	199,000
Belgium and Luxembourg	54	156,724	37	214,000
France	–	–	13	72,000
Other countries	22	73,985	–	–
Total	325	1,151,653	478	2,228,000
Consumption				
Ferrovanadium				
Gross weight	218		314	
Vanadium content	133		216	

Source: Dominion Bureau of Statistics.
– Nil

MINERALS AND OCCURRENCES

Among the more important vanadium minerals are the complex sulphide, patronite; the vanadium mica, roscoelite; a potassium uranium vanadate, carnotite; and the lead vanadates, vanadinite and descloizite. 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 United States. Vanadium occurs in some clays, shales and phosphate rocks. Some coals and petroleums have sufficiently high vanadium content to permit its recovery from soot and ash residues.[1]

WORLD PRODUCTION AND CONSUMPTION

CANADA

The Canadian Petrofina vanadium recovery plant started operation in 1965. The fractional distillation step in the oil refining process removes the lighter components and leaves a residual fuel which can be used as bunker oil, for asphalt production, or for the manufacture of petroleum coke. Nearly all the vanadium in the crude is concentrated in the residual fuel product. The portion 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 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 precipitated with ammonia. The V_2O_5 is dried, fused and cast into flakes containing 99 per cent vanadium pentoxide.

Great Canadian Oil Sands Limited will start oil recovery from the Athabasca tar sands near Fort McMurray in northern Alberta in September 1967. The operation will produce and use nearly 3,000 tons of petroleum coke a day in producing 45,000 barrels of oil a day. Some of the ash from the coke is reported to contain about 4 per cent vanadium, the recovery of which is planned.

[1] United States Bureau of Mines, Mineral Facts and Problems, 1965.

TABLE 2

World Production of Vanadium in Ores and Concentrates, 1963–66
(short tons)

	1963	1964	1965	1966[e]
United States	3,862	4,362	5,226	6,538
Republic of South Africa	1,392	1,282	1,519	1,710[e]
South West Africa	1,134	1,111	1,275	..
Finland	770	1,084	1,102	..
Other countries	4	1	28	..
Total	7,162	7,840	9,150	10,412[e]

Source: US Bureau of Mines Mineral Trade Notes, September 1966, and US Bureau of Mines Commodity Data Summaries, January 1967.

.. Not available; [e] Estimated.

OTHER COUNTRIES

The United States Bureau of Mines estimated the 1966 non-communist world production of vanadium at 10,412 tons of which the United States produced 6,538 tons. The comparative figures in 1965 were 9,150 tons and 5,226 tons. Industrial consumption in the United States was estimated at 5,500 tons in 1966 compared with 4,708 tons in 1965. The steel industry used 84 per cent, nonferrous alloys 11 per cent; and the chemical industry 3 per cent as catalysts.[1]

United States supply came partly through the sale of 3,346 tons of vanadium pentoxide from the national stockpile. The sales were overbid and quantities were allocated to successful bidders. Imports of ore, concentrates or ferrovanadium were of little significance to the United States domestic supply in 1966.[2]

United States vanadium production came as a byproduct from four uranium mines and from two plants producing phosphorus from Idaho phosphate rock. Union Carbide Corporation was preparing for vanadium production in 1967 at a new 1,000-ton-a-day plant at Wilson Springs, Arkansas. The material to be treated for its vanadium content is a highly-altered exposed rock which also contains some titanium.

The vanadium output of South West Africa is derived as a co-product of lead-vanadium concentrates containing about 18 per cent V_2O_5. Production in 1966 was 13,425 tons of concentrates compared with 12,650 tons in 1965.[3]

TABLE 3

Vanadium Consumed in the United States by End Use, 1966
(pounds of vanadium)

Steel	
High-speed	1,001,780
Hot-work tool	197,832
Other tool	346,031
Stainless	75,305
Other alloy[1]	5,887,148
Carbon	1,635,466
Grey and malleable castings	73,515
Nonferrous alloys[2]	1,188,697
Chemicals	360,817
Other[3]	169,145
Total	10,935,736

Source: US Bureau of Mines, Mineral Industry Surveys, December, 1966.

[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.

[1] United States Bureau of Mines Mineral Industry Surveys, February 1967.
[2] Engineering and Mining Journal, February 1967, Gilbert L. DeHuff, Jr.
[3] Republic of South Africa, Department of Mines, Quarterly Report 127.

The Republic of South Africa produced 3,054 tons of vanadium pentoxide in 1966 compared with 2,713 tons in 1965 and exported 2,982 tons and 2,368 tons. Highveld Steel and Vanadium Corporation has taken over Transvaal Vanadium Company at Witbank, in the Transvaal, to form part of an iron-vanadium production operation. Titaniferous magnetite containing about 2 per cent vanadium pentoxide will be used to produce pig iron, and a slag containing about 25 per cent vanadium pentoxide.

PRODUCTS AND USES

Technical-grade vanadium pentoxide 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 analyzing 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 vanadates of sodium are supplied to the chemical industry. Vanadium is a steel-grey metallic element with a melting point of 1,900° Centigrade (3,450°F).

Vanadium is used principally as ferrovanadium, an additive used in making alloy steels and castings. Its function is to reduce and control grain size, to impart toughness and strength, and to maintain hardness at elevated temperatures. The ferrovanadium alloys are produced by a reducing process using such reductants as silicon, aluminum, or carbon in thermic, electric furnace or vacuum furnace processes. Different grades of ferro-alloys are available with the vanadium content varying from 38 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, 10.5 to 13 per cent carbon and only 2 to 3 per cent iron. As an alloying agent for steels and irons, vanadium is usually used with other alloying elements rather than alone.

Vanadium is used in nonferrous alloys, principally those of aluminum and titanium. Titanium-based vanadium alloys, having high-temperature strength qualities and good weldability, are extensively used in the commercial and military aircraft industries.

Compounds of vanadium are used in the chemical industry as catalysts for 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, the processing of coloured film, welding rods and in making phosphors for television tubes.

OUTLOOK

Growing consumption of vanadium in the United States could alter the US role as a net exporter to that of a net importer during the next few years until domestic supplies are expanded. Government surplus material if used to supplement domestic supply would tend to stabilize prices but this source is not unlimited. Vanadium consumption in Europe and Japan has increased sharply and additional supplies are sought and being obtained from South Africa, USSR and Finland.

High-grade deposits of vanadium ores are rare and supplies will likely continue to come from byproducts and low-grade sources. A continuing period of close balance between demand and supply seems likely for several years.

PRICES

E & MJ Metal and Mineral Markets of December 26, 1966, quoted the following vanadium prices in the United States:

Vanadium Ore:	per pound V_2O_5 f.o.b. mine or mill, technical grade V_2O_5 (air-dried)	
	producer (domestic market)	$1.30
	merchant (mainly export)	$1.60–1.75

PRICES (Cont'd)

Ferrovanadium:	per pound V, packed, f.o.b. shipping point, freight equalized to nearest main producer,	
	52-57%	$3.15–3.45
	merchant (export)	$3.50–3.75
	(domestic)	$3.35–3.50
	70-75% .... $2.90 "Carvan"	$2.38
	82-85%	$3.35
Vanadium metal:	per pound, f.o.b. shipping point	
	99%, 100-pound lots	$3.45

TARIFFS

	British Preferential %	Most Favoured Nation %	General %
Canada			
Vanadium ores and concentrates	free	free	free
Vanadium oxide in powder, lumps, formed into briquettes, for use in manufacture of steel	free	free	5
Vanadium metal, in lump, powder, ingot, block, (class or kind ruled to be not produced in Canada)	free	15	25
Vanadium metal, bars, rods, processed forms	15	20	25
Ferrovanadium	free	5	5

United States	%
Vanadium ore, concentrates	free
Vanadium metal, unwrought	10% ad val
Vanadium metal, wrought	18
Ferrovanadium	12.5
Vanadium waste and scrap*	10% ad val
Vanadium carbide	12.5
Vanadium pentoxide	32
Vanadium compounds, other	32
Vanadium salts	32

*Temporarily suspended to June 30, 1967.

Zinc

D.B. FRASER*

Recoverable production of zinc was 15 per cent greater in 1966 than in 1965, rising to a total of 959,294 short tons valued at $289,707,018. In terms of the assay content of zinc contained in ores and concentrates produced, without deduction for smelting losses, production in 1965 was 1,041,762 tons.

Seven new mines and mills were opened during the year, and a zinc circuit was added to an existing copper mill. Three mines closed and production was reduced at several others. The largest of the new mines was the open pit of Texas Gulf Sulphur Company at Timmins, Ontario, where production began in November 1966. New mines were opened also in western Quebec and in New Brunswick. Western Mines Limited started production on Vancouver Island late in 1966, while in the southeastern districts of British Columbia, ore production was reduced and the H.B. mine and 2 smaller mines suspended operations. Pine Point Mines Limited completed the first full year of production from its 5,000-ton zinc-lead concentrator; zinc output as a result was much higher in the Northwest Territories in 1966 than in 1965.

Production was slightly lower in the Flin Flon district of Manitoba and Saskatchewan, and also in Newfoundland. Output dropped sharply in the Yukon Territory due to a curtailment of milling by United Keno Hill Mines Limited.

Exploration was carried out in many districts, notably at Pine Point in the Northwest Territories and Ross River in the Yukon Territory. Mine development continued in the Snow Lake and Lynn Lake districts of Manitoba, in southeastern British Columbia, and in northern New Brunswick.

Production of refined zinc rose from 358,498 tons in 1965 to 382,612 tons in 1966. East Coast Smelting and Chemical Company Limited, a subsidiary of Brunswick Mining and Smelting Corporation Limited, completed construction of an Imperial Smelting Corporation blast furnace at Belledune, New Brunswick, late in 1966. Canadian Electrolytic Zinc Limited expanded capacity of its Valleyfield, Quebec, plant from 84,000 tons to 140,000 tons of zinc annually. Primary refinery capacity at the end of 1966 was:

	Annual Capacity (short tons)
Canadian Electrolytic Zinc Limited, Valleyfield, Que.	140,000
Cominco Ltd., Trail, B.C. . .	232,000
East Coast Smelting and Chemical Company Limited, Belledune, N.B..	52,000
Hudson Bay Mining and Smelting Co., Limited, Flin Flon, Manitoba	79,000

*Mineral Resources Division.

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TABLE 1

Zinc – Canadian Production, Trade and Consumption, 1965-66

	1965		1966P	
	Short Tons	$	Short Tons	$
Production				
All forms[1]				
Quebec	272,883	82,410,700	290,252	87,656,168
Northwest Territories	94,690	28,596,474	189,698	57,288,650
New Brunswick	123,595	37,325,612	146,199	44,152,194
British Columbia	158,336	47,817,355	142,227	42,952,680
Ontario	60,675	18,323,817	86,603	26,154,228
Manitoba	40,763	12,310,585	35,816	10,816,495
Newfoundland	36,187	10,928,579	34,438	10,400,276
Saskatchewan	27,983	8,450,830	28,973	8,749,705
Yukon	6,624	2,000,396	4,543	1,371,986
Nova Scotia	299	90,420	545	164,636
Total	822,035	248,254,768	959,294	289,707,018
Mine output[2]	910,929		1,041,762	
Refined[3]	358,498r		382,612	
Exports				
Zinc blocks, pigs and slabs				
United States	91,605	26,033,977	115,980	31,870,000
Britain	109,567	28,861,422	106,250	26,951,000
India	23,423	6,377,857	8,372	2,106,000
China (Communist)	–	–	5,875	1,455,000
Italy	7,083	1,477,441	5,425	1,092,000
Netherlands	13,337	3,870,630	2,745	703,000
West Germany	8,590	2,072,288	1,855	448,000
Belgium and Luxembourg	3,700	740,057	1,344	269,000
Brazil	195	55,912	1,335	349,000
Other countries	6,700	1,494,504	6,972	1,571,000
Total	264,200	70,984,088	256,153	66,814,000
Zinc contained in ores and concentrates				
United States	231,597	29,702,380	311,947	38,187,000
Belgium and Luxembourg	156,725	23,370,982	162,240	21,840,000
Netherlands	797	110,673	24,459	2,988,000
Japan	5,835	772,584	21,767	2,654,000
Poland	35,118	5,358,365	19,791	3,194,000
West Germany	22,034	3,383,200	19,131	2,420,000
France	16,661	2,564,418	13,983	2,230,000
Norway	6,936	999,464	10,135	1,345,000
Other countries	11,742	1,865,938	7,869	1,083,000
Total	487,445	68,128,004	591,322	75,941,000
Zinc fabricated materials, n.e.s.				
United States	656	335,447	1,274	677,000
Britain	943	230,286	483	264,000
Italy	–	–	77	30,000
Trinidad and Tobago	–	–	38	20,000
Japan	–	–	19	7,000
Other countries	91	37,912	41	22,000
Total	1,690	603,645	1,932	1,020,000

TABLE 1 – Cont.

Zinc – Canadian Production, Trade and Consumption, 1965-66

	1965		1966p	
	Short Tons	$	Short Tons	$
Zinc and zinc-alloy scrap, dross and ashes				
United States	6,047	1,390,321	7,356	1,537,000
Belgium and Luxembourg	1,884	180,377	2,037	204,000
Netherlands	245	26,543	221	25,000
Yugoslavia	240	37,296	165	12,000
Japan	118	24,982	67	15,000
Other countries	609	61,236	117	11,000
Total	9,143	1,720,755	9,963	1,804,000
Imports				
In ores and concentrates	8,919	1,827,973	80	5,000
Dust and granules	1,342	521,618	1,302	511,000
Slabs, blocks, pigs and anodes	17	6,808	126	36,000
Bars, rods, plates, strip and sheet	928	608,590	751	467,000
Slugs, discs, shells	441	183,212	350	148,000
Zinc oxide	1,093	303,341	1,616	466,000
Zinc sulphate	2,355	293,232	2,503	323,000
Lithopone	574	79,520	218	31,000
Zinc fabricated materials, n.e.s.	1,110	1,082,232	950	1,114,000
Total	16,779	4,906,526	7,896	3,101,000

	1965			1966p		
	Primary	Secondary	Total	Primary	Secondary	Total
		(short tons)			(short tons)	
Consumption						
Zinc used for or in the manufacture of						
Copper alloys (brass, bronze, etc.)	9,284	370	9,654	13,985	31	14,016
Galvanizing						
electro	909	61	970	1,020	56	1,076
hot-dip	45,764	517	46,281	46,304	784	47,088
Zinc die-cast alloy	20,982	–	20,982	26,884	–	26,884
Other products (including rolled and ribbon zinc, zinc oxide)	16,857	2,601	19,458	17,358	2,558	19,916
Total	93,796	3,549	97,345	105,551	3,429	108,980
Consumers' stocks on hand at end of year	9,040	691	9,731	8,374	467	8,841

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; r Revised.

TABLE 2

Zinc — Canadian Production, Exports and Consumption, 1957-66
(short tons)

	Production		Exports			
	All Forms[1]	Refined[2]	In Ores and Concentrates	Refined	Total	Consumption[3]
1957	413,741	247,316	187,141	202,007	389,148	52,713
1958	425,099	252,093	217,823	195,708	413,531	56,097
1959	396,008	255,306	181,084	179,552	360,636	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	358,498r	487,445	264,200	751,645	93,796
1966p	959,294	382,612	591,322	256,153	847,475	105,551

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.
pPreliminary; rRevised.

About 40 per cent of zinc mine production was smelted in domestic plants. Zinc concentrates produced in Manitoba and Saskatchewan were refined at Flin Flon. Most of the concentrates produced in British Columbia and the 2 Territories were treated at Trail, but some were exported to Idaho and Montana and to overseas smelters. Production from eastern mines, except that going to Valleyfield, was exported to smelters in central and eastern United States, to Belgium, and in smaller amounts to West Germany, Japan, Poland, France, Norway, Britain and Sweden. From the beginning of 1967 a portion of New Brunswick's output was treated in the new smelter at Belledune.

In addition to the roasting facilities at the 4 Canadian zinc plants, 2 zinc roasters were operated in eastern Canada for sulphur recovery, 1 by Sherbrooke Metallurgical Company Limited at Port Maitland, Ontario, and the other by Aluminum Company of Canada, Limited at Arvida, Quebec.

Producers' domestic shipments of refined zinc were 13 per cent higher during the first three quarters of 1966 than in the corresponding period of 1965. In the fourth quarter they declined, and for the full year were 3 per cent higher than in 1965.

Producers' Domestic Shipments of Refined Zinc, 1965-66
(short tons)

	1965	1966
1st quarter	22,787	29,123
2nd quarter	28,962	29,706
3rd quarter	23,539	25,839
4th quarter	29,317	22,965
Year	104,605	107,633

WORLD PRODUCTION AND CONSUMPTION

Non-communist world mine production rose in 1966 to 4.0 million short tons, 250,000 tons more than in 1965. About one-half of the increase was accounted for by Canadian mines; the remainder was due mainly to increased output in Japan, Australia, Spain and Ireland. Production declined in the United States due to strikes at mines in Tennessee, and was lower also in Algeria, Finland and the Republic of the Congo. Smelter production rose in 1966 by 175,000 tons to 3.6 million tons. Increases were reported in most countries, the largest being Japan (84,000 tons), United States (35,000), West Germany (29,000) and Canada (24,000).

Zinc consumption in the non-communist world rose by nearly 4 per cent in 1966 to an estimated 3.8 million short tons, exceeding smelter production by 200,000 tons. The United States Government released refined metal from its surplus stocks of zinc. Soviet-block countries, principally Poland, Bulgaria and the USSR, exported about 120,000 tons to non-communist countries, mostly in western Europe.

TABLE 3

World Mine Production of Zinc, 1965-66
(excluding communist-bloc countries)

	1965	1966
	(short tons)	
Canada	910,900	1,042,000
United States	671,600	640,300
Australia	359,800	377,100
Peru	285,900	351,600
Mexico	256,800	..
Japan	243,600	279,300
Congo, Dem. Rep. of	131,400	..
West Germany	128,200	132,800
Italy	127,300	128,000
Yugoslavia	101,200	96,000
Sweden	81,600	85,600
Finland	76,000	59,900
Zambia	52,200	70,000
Spain	42,000	60,000
Ireland	1,700	31,800[e]
Other countries	303,800	..
Total	3,774,000	4,024,500

Source: International Lead and Zinc Study Group.
.. Not available; [e] Estimate

During the last quarter of 1966 a number of major producers announced that production was being curtailed below capacity to prevent a build-up of excess stocks.

Estimates made by the International Lead and Zinc Study Group at its Tenth Session held in November 1966 at Munich were that exceptionally big increases in zinc mine and metal production could be expected in 1967. These increases would probably amount to 450,000 tons for mine output and 370,000 tons for metal output. Metal consumption was expected to rise by 190,000 tons to over 4 million tons. However, with zinc metal production rising faster than consumption, and taking account of estimated imports from communist countries, a statistical surplus of 135,000 tons was foreseen in 1967. This would be higher if the United States Government continued to dispose of surplus stocks of zinc.

The United States Government continued to sell zinc from surplus stocks during 1966. Disposals amounted to 54,530 tons, compared with 211,453 tons in 1965. At the end of 1966 there were 134,016 tons available for disposal from amounts previously authorized. The total amount in the government inventory at year-end was 1,212,368 tons.

PRINCIPAL DEVELOPMENTS

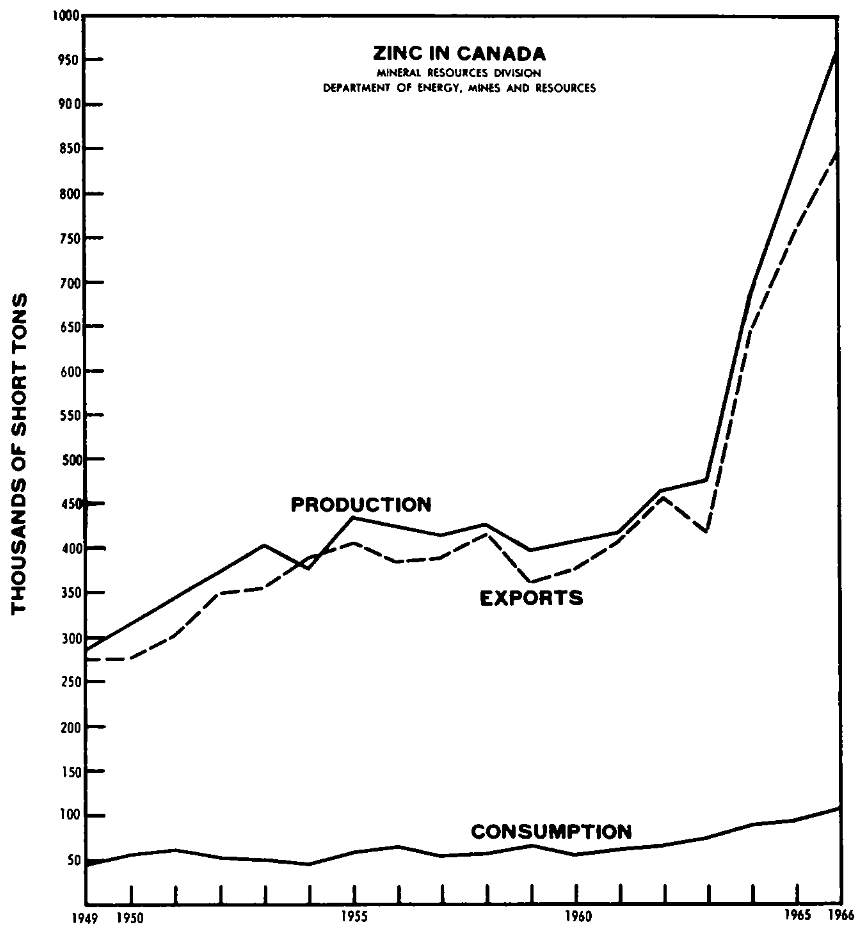
BRITISH COLUMBIA

Mine production was 10 per cent lower in 1966 than in 1965. Ore production from the Sullivan, Bluebell and H.B. mines of Cominco Ltd. totalled 2,770,180 tons, compared with 2,972,693 tons in 1965. Ore reserves at these 3 mines at September 30, 1966, totalled 71,600,000 tons containing 7,900,000 tons of lead and zinc. The H.B. mine was closed in November for an indefinite period.

Zinc concentrates from these mines, from Pine Point Mines Limited, and from custom shippers were treated at the Trail metallurgical works where zinc output was 221,871 tons. Zinc production was curtailed in the final quarter of the year. Lead and zinc production was derived approximately 38 per cent from the Sullivan mine, 47 per cent from the Pine Point mine, 10 per cent from other company mines and from accumulated slags, and 5 per cent from purchased ores and concentrates.

Western Mines Limited completed construction of a zinc-copper-lead concentrator at Buttle Lake, Vancouver Island, and began tune-up operations in December 1966. Ore reserves at September 30 were 2,109,290 tons averaging 10.0 per cent zinc, 1.1 per cent lead, 2.2 per cent copper, 2.6 ounces silver and 0.06 ounce gold per ton. The concentrator has a capacity in excess of the nominal 750 tons a day.

Giant Soo Mines Limited, near Wasa in the Kimberley district of British Columbia, began production from a 150-ton mill in August 1966, shipping zinc and lead concentrates to Trail. Two Slocan-district producers closed during the year due to exhaustion of ore reserves.



YUKON TERRITORY

Production was derived from the silver-lead-zinc mines at Elsa operated by United Keno Hill Mines Limited. The company curtailed operations in the final quarter of the year due to unfavourable development results and a critical shortage of underground miners.

Anvil Mining Corporation Limited, jointly owned by Cyprus Mines Corporation and Dynasty Explorations Limited, continued to explore the Faro property near Ross River. Reserves in the main deposit were increased to 40 million tons, and an additional 10 million tons were found in two nearby deposits. An engineering and feasibility study was carried out, and as a result the company announced its intention to proceed with production subject to the negotiation of satisfactory sales contracts for concentrates, the provision of adequate financing, and the conclusion of transportation and other arrangements with the Canadian Government. Production would be at a rate of 5,500 tons of ore daily. Annual output of zinc and lead concentrates would total 370,000 tons.

NORTHWEST TERRITORIES

Production was derived from the zinc-lead mine of Pine Point Mines Limited, which is under the management of Cominco Ltd. High-grade ore shipments to Cominco plants in British Columbia and to The Bunker Hill

Company in Idaho continued during 1966. Zinc and lead concentrates were produced from the 5,000-ton concentrator which was opened in November 1965. About 51 per cent of sales of lead and zinc concentrates were made in Canada, chiefly to Cominco Ltd., 31 per cent were made in the United States, chiefly to The Anaconda Company in Montana, 14 per cent were made in Japan, chiefly to the Mitsubishi-Cominco Company, and 4 per cent in Europe. At year-end 3 pits were in operation.

The adjoining 408 mineral claims of Pyramid Mining Co. Ltd. were acquired by Pine Point Mines Limited during the year. These contained 2 orebodies and added considerably to the total ore reserves of Pine Point Mines which at year-end were 37,800,000 tons averaging 6.8 per cent zinc and 2.9 per cent lead. The Pyramid claims were estimated at the time of purchase to contain 11,000,000 tons averaging 8.0 per cent zinc and 2.0 per cent lead.

MANITOBA AND SASKATCHEWAN

Production was from 4 mines in the Flin Flon and Snow Lake districts operated by Hudson Bay Mining and Smelting Co., Limited. The largest source was the Flin Flon mine on the provincial border, from which 1,044,200 tons of copper-zinc ore were mined. The Schist Lake mine, also at Flin Flon, and the Chisel Lake and Stall Lake mines, at Snow Lake, 90 miles to the east, provided the remainder of the ore production of just under 1,700,000 tons. Copper, zinc and lead concentrates were produced at a central concentrator at Flin Flon.

Mine development continued at Hudson Bay's Osborne Lake, Anderson Lake and Ghost Lake properties near Snow Lake, and at the Flexar property near Flin Flon. The company's ore reserves at the end of 1966 totalled 16,765,300 tons averaging 4.4 per cent zinc, 2.94 per cent copper, 0.2 per cent lead, 0.72 ounce silver and 0.042 ounce gold per ton.

Zinc concentrates were treated at the Flin Flon zinc plant, where production was 73,331 tons of slab zinc.

Sherritt Gordon Mines, Limited started sinking a production shaft at Fox Lake in the Lynn Lake district. Ore reserves remained unchanged at 12,269,000 tons averaging 2.35 per cent zinc and 1.74 per cent copper. Production of copper, zinc and pyrite concentrates is planned.

Share Mines & Oils Ltd. sank a shaft and began construction of a 350-ton mill at Hanson Lake, 35 miles west of Flin Flon. Production was scheduled to begin in 1967. Ore reserves at September 30, 1966 were reported to be 300,000 tons averaging 11.4 per cent zinc, 8.1 per cent lead, 0.6 per cent copper and 4.7 ounces silver per ton.

ONTARIO

Production was 43 per cent higher in 1966 than in 1965 due to the opening of 3 new mines and to increased output by 3 of the 4 older mines.

Operations at the Kidd Creek open pit and Hoyle concentrator of Texas Gulf Sulphur Company, near Timmins, began on November 16, 1966, when the first of three 3,000-ton milling units was started up, treating copper-zinc ore. The second and third 3,000-ton units began operation in January and February, 1967, treating copper-zinc and zinc-lead-silver ore. The second circuit is designed to handle ore of either type. The company estimated its annual production would be 250,000 tons of zinc in zinc concentrates, 10,000 tons of lead in lead concentrates, and 50,000 tons of copper in copper concentrates. Silver and cadmium would also be recovered. Zinc concentrates were shipped to custom smelters in the United States, Europe and Japan. The company reported that construction of a zinc smelter in Ontario was under study.

Canadian Jamieson Mines Limited started production in April 1966 from its copper-zinc underground mine and 450-ton mill, 10 miles northwest of Timmins. Zenmac Metal Mines Limited, near Schreiber, began operations at a small high-grade zinc mine in January 1966, producing zinc concentrates from a 150-ton mill.

Production at the Geco mine, Manitouwadge, owned by Noranda Mines Limited, was 10 per cent higher in 1966 than in 1965. Ore reserves were increased by 1,102,000 tons to a total of 25,879,000 tons averaging 4.85 per cent zinc, 2.15 per cent copper and 2.24 ounces silver per ton.

TABLE 4

Principal Zinc Mines in Canada, 1966

Company and Location	Mill Capacity (tons ore/day)	Grade of Ore (Principal Metals) Zinc (%)	Lead (%)	Copper (%)	Silver (oz/ton)	Ore Produced 1966 (1965) (short tons)	Contained Zinc Produced 1966 (1965) (short tons)	Remarks
British Columbia								
Aetna Investment Corporation Limited, Toby Creek........	500	3.89	1.54	—	0.40	114,737 (145,196)	3,809 (5,043)	Development carried out from new shaft.
The Anaconda Company (Canada) Ltd., Britannia Beach ...	2,000	..	—	..	..	.. (226,005)	.. (455)	
Canadian Exploration, Limited, Salmo.....................	1,900	3.39	0.89	—	..	417,440 (377,124)	12,875 (12,175)	
Cominco Ltd.								
Sullivan, Kimberley.........	10,000	..	..	—	..	2,135,660 (2,301,071)	83,233 (107,417)	
Bluebell, Riondel	700	..	..	—	..	246,390 (256,332)	14,636 (14,496)	Exploration continued.
H.B., Salmo	1,200	..	..	—	..	388,130 (415,290)	16,505 (20,941)	Operations suspended October 31, 1966.
Giant Soo Mines Limited, Wasa	150	11.0	5.1	—	2.1	11,141 (—)	1,090 (—)	Production started September 1966.
Johnsby Mines Limited, Silverton	150	5.52	3.00	—	7.55	5,928 (10,925)	307 (546)	Closed September 1966.
London Pride Mines Ltd., Kaslo.....................	100	..	..	—	..	.. (26,019)	.. (1,795)	Closed April 1966.
Mastodon-Highland Bell Mines Limited, Beaverdell	100	2.01	2.19	—	30.88	24,138 (23,213)	486 (298)	Mill Capacity increased by 20 per cent.

TABLE 4 (Cont.)

Reeves MacDonald Mines Limited, Remac	1,200	3.85	1.20	—	..	395,921 (409,504)	13,886 (13,690)	Explored a new area southwest of property.
Western Mines Limited, Buttle Lake, V.I.	750	..	..	..	..	.. (—)	.. (—)	Tune-up operations began December 1966.
Yukon Territory								
United Keno Hill Mines Limited (Hector-Calumet, Elsa, Keno)	500	5.61	7.60	—	36.56	120,374 (146,850)	5,413 (8,350)	Operations curtailed during fourth quarter.
Northwest Territories								
Pine Point Mines Limited, Pine Point	5,000	10.5	4.9	—	..	1,457,990 (75,356)	144,613 (..)	Active program of geophysical surveying and diamond drilling carried out.
		26.3	18.8	—	..	282,309(1) (364,168)	74,134 (..)	Crude ore.
Manitoba and Saskatchewan								
Hudson Bay Mining and Smelting Co., Limited, Flin Flon (Flin Flon, Schist Lake, Chisel Lake, Stall Lake)	6,000	3.8	0.3	2.49	0.66	1,689,550 (1,640,328)	57,109 (64,562)	Osborne Lake, Anderson Lake, Flexar mines being prepared for production.
Ontario								
Canadian Jamieson Mines Limited, Timmins	450	4.15	—	2.75	..	92,685 (—)	3,353 (—)	Production started April 1966.
Kam-Kotia Mines Limited, Timmins	1,750	1.97	—	1.67	..	464,726 (597,623)	5,143 (3,883)	Deepened shaft to 2,000 feet, 4 new levels being developed.
Noranda Mines Limited, Manitouwadge	3,700	4.15	..	1.95	2.03	1,459,586 (1,326,400)	46,123 (42,880)	Developing bottom levels to 3,850-foot level.

TABLE 4 (cont.)

Company and Location	Mill Capacity (tons ore/day)	Grade of Ore (Principal Metals)				Ore Produced 1966 (1965) (short tons)	Contained Zinc Produced 1966 (1965) (short tons)	Remarks
		Zinc (%)	Lead (%)	Copper (%)	Silver (oz/ton)			
Texas Gulf Sulphur Company, Timmins	9,000	..	..	..	..	.. (–)	.. (–)	Production started mid-November, 1966.
Willecho Mines Limited, Manitouwadge		3.89	0.22	0.63	1.79	325,738 (283,259)	11,000 (10,530)	Ore milled by Willroy Mines Limited.
Willroy Mines Limited, Manitouwadge	1,700	2.80	0.22	0.60	2.03	219,400 (293,989)	5,350 (11,164)	Explored northwestern section of property.
Zenmac Metal Mines Limited, Schreiber	150	22.6	–	0.40	..	29,839 (–)	6,280 (–)	Production started January 1966.
Quebec								
The Coniagas Mines Limited, Bachelor Lake	500	7.12	0.58	–	3.14	140,093 (123,059)	8,628 (8,809)	Completing mining of known ore.
Cupra Mines Ltd., Stratford Centre		4.25	0.48	3.40	1.40	158,130 (82,427)	3,550 (1,586)	Completed first full year of operation. Ore milled by Solbec Copper Mines Limited.
Lake Dufault Mines, Limited, Noranda	1,300	9.48	–	4.84	..	489,387 (475,007)	37,803 (30,145)	
Manitou-Barvue Mines Limited, Val d'Or	1,300	3.72	0.32	–	2.75	173,130 (168,895)	5,848 (6,992)	
		–	–	0.93	0.14	295,875	–	Copper production 2,622 tons in 1966.
						(283,875)	(–)	Copper production 2,156 tons in 1965.
Mattagami Lake Mines Limited, Mattagami	3,850	13.2	–	0.62	1.04	1,411,100 (1,406,154)	173,552 (153,897)	

TABLE 4 (Cont.)

Mines de Poirier inc., Poirier	2,500	3.49	–	1.06	0.21	575,907 (–)	13,880 (–)	Production started early 1966. Mill expanded during 1966 from 1800 to 2500 tons daily for copper ore.
New Calumet Mines Limited, Calumet Island	800	7.03	2.07	–	4.03	95,761 (97,586)	6,470 (5,837)	
New Hosco Mines Limited, Matagami[2]	1,900	5.05	–	2.66	..	315,083 (–)	946[3] (–)	Started zinc production August 1966. Copper production started in 1963.
Normetal Mining Corporation, Limited, Normetal	1,000	7.60	–	1.53	1.38	335,666 (350,693)	22,522 (24,984)	Completed shaft deepening.
Orchan Mines Limited, Matagami	2,900	10.83	–	1.25	1.06	368,030 (368,877)	36,529 (43,292)	Mill expanded to treat New Hosco zinc ore.
Quemont Mining Corporation, Limited, Noranda	2,300	1.93	–	1.08	0.70	578,171 (657,307)	7,805 (11,322)	
Solbec Copper Mines, Ltd., Stratford Centre	1,500	6.23	0.73	1.41	1.93	154,795 (403,869)	7,027 (13,579)	Operations interrupted by a strike from September 1966 to March 1967.
New Brunswick								
Brunswick Mining and Smelting Corporation Limited, Bathurst No. 12 mine	4,500	9.26	3.64	0.22	2.21	1,650,120 (1,657,519)	.. (..)	
No. 6 mine	2,250	6.19	2.75	0.35	1.72	300,676 (–)	.. (–)	Started production September 1966.
Heath Steele Mines Limited, Newcastle[3]	1,500	5.90	2.08	1.04	2.11	287,515 (..)	13,499 (13,352)	Sinking new production shaft.

TABLE 4 (Cont.)

Company and Location	Mill Capacity (tons ore/day)	Grade of Ore (Principal Metals) Zinc (%)	Lead (%)	Copper (%)	Silver (oz/ton)	Ore Produced 1966 (1965) (short tons)	Contained Zinc Produced 1966 (1965) (short tons)	Remarks
Nova Scotia								
Magnet Cove Barium Corporation, Walton	125	1.6	3.0	0.61	12.0	50,213 (48,594)	577 (876)	Exploration continued.
Newfoundland								
American Smelting and Refining Company, Buchans	1,250	12.80	7.28	1.09	4.19	355,000 (366,000)	41,267 (45,071)	
Consolidated Rambler Mines Limited, Baie Verte	1,500	2.04	–	1.36	0.73	148,737 (136,999)	2,437 (1,966)	Mill expanded by 1,000 tons daily.

[1]Direct shipping ore
[2]Data for fiscal year ended August 31, 1966
[3]About half mill capacity is used to treat copper ore from Cominco's Wedge mine.
– Nil; .. Not available.

QUEBEC

Production was derived from 12 mines and was 6 per cent greater in 1966 than in 1965. Five mining companies associated with Noranda Mines Limited accounted for about 75 per cent of total Quebec output. This group of mines (Mattagami Lake, Orchan, Normetal, Quemont, and New Hosco), together with Noranda's Geco mine in Ontario, supplied zinc concentrates to Canadian Electrolytic Zinc Limited, at Valleyfield, near Montreal. Production at this plant totalled 87,400 tons of slab zinc, 18 per cent more than in 1965. Capacity was expanded during the year to 140,000 tons annually. Operations were curtailed on November 1 to a level 10 per cent below capacity due to a general rise in world producers' stocks of refined metal.

Two new operations were started up during the year. Mines de Poirier inc., a subsidiary of Rio Algom Mines Limited, opened a 1,500-ton mill early in 1966 to treat ore from its copper-zinc mine in Poirier township, expanding capacity during the year to 2,500 tons daily in order to provide for processing copper ore from Joutel Copper Mines Limited. New Hosco Mines Limited, which came into production in 1963 as a copper mine shipping ore to the nearby Orchan mill, began shipping zinc ore as well in August 1966; a zinc circuit was added to the Orchan mill to treat the additional ore.

NEW BRUNSWICK

The principal producer was Brunswick Mining and Smelting Corporation Limited, 25 miles southeast of Bathurst, which operated the No. 12 mine and mill at a rate of 4,500 tons daily. In the last half of the year the company began production from the No. 6 mine, an open pit 6 miles south of the No. 12 mine. Its ore was trucked to a new mill adjacent to the No. 12 mill.

East Coast Smelting and Chemical Company Limited completed construction of a sinter plant, an Imperial Smelting Furnace, zinc, lead and silver refineries, and a sulphuric acid plant, at Belledune, 20 miles north of Bathurst on the south shore of Chaleur Bay. Run-in operations began in the last quarter of the year. Annual capacity is 52,000 tons of refined zinc and 48,000 tons of refined lead.

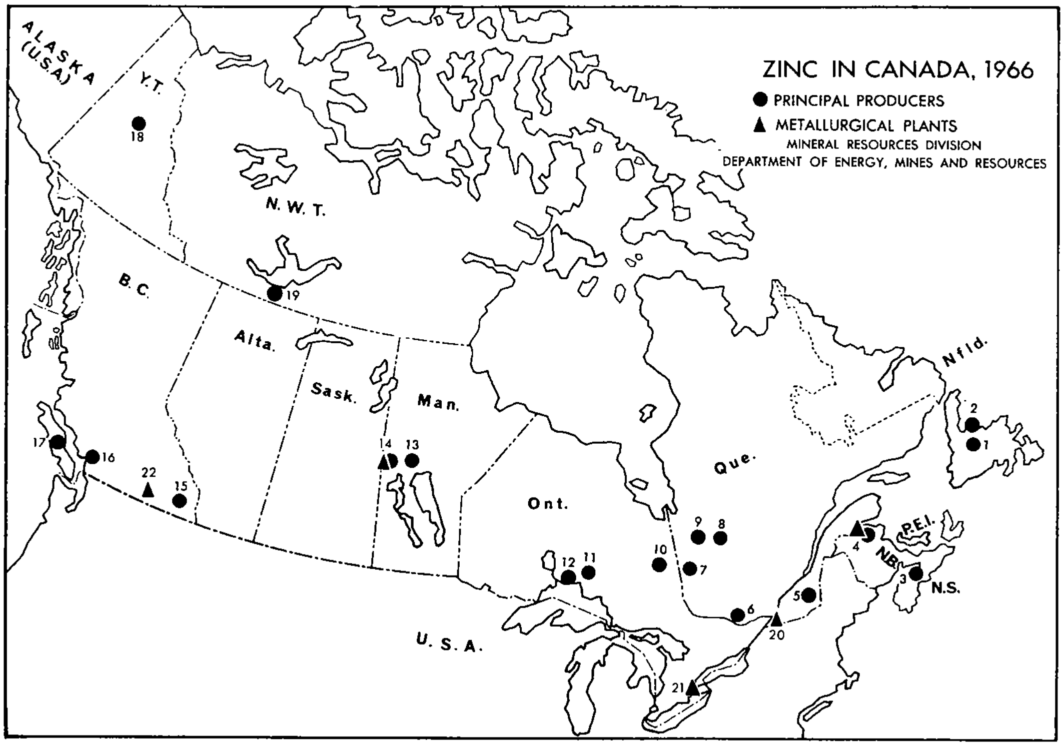
Heath Steele Mines Limited, a subsidiary of American Metal Climax, Inc., began sinking a 1,750-foot shaft on its Newcastle-district property as part of an expansion program aimed at doubling output by 1968.

Nigadoo River Mines Limited, one of the Sullivan mining group, began construction of a 1,000-ton zinc-lead-copper mill 25 miles northwest of Bathurst. Earlier estimates of ore reserves were confirmed at 1,390,000 tons to a depth of 1,000 feet, averaging 2.77 per cent zinc, 2.97 per cent lead, 0.34 per cent copper and 4.36 ounces silver per ton. Production is planned for the fall of 1967. The Sullivan group under an option arrangement also explored the Clearwater copper-zinc-lead deposit near Newcastle, owned by Chesterville Mines Limited.

NEWFOUNDLAND

The main producer was American Smelting and Refining Company's Buchan Unit in Central Newfoundland, which produced zinc, lead, copper and precious metals concentrates. These were shipped to the United States and Europe for refining.

Leitch Gold Mines Limited reported total ore reserves at its zinc property in the Great Northern Peninsula to be 3,700,000 tons averaging 7.32 per cent zinc.



PRINCIPAL PRODUCERS

(numbers refer to numbers on map)

1. American Smelting and Refining Company (Buchans Unit)
2. Consolidated Rambler Mines Limited
3. Magnet Cove Barium Corporation
4. Brunswick Mining and Smelting Corporation Limited
   Heath Steele Mines Limited
5. Cupra Mines Ltd.
   Solbec Copper Mines, Ltd.
6. New Calumet Mines Limited
7. Lake Dufault Mines, Limited
   Manitou-Barvue Mines Limited
   Normetal Mining Corporation, Limited
   Quemont Mining Corporation, Limited
8. The Coniagas Mines, Limited
9. Mattagami Lake Mines Limited
   Mines de Poirier inc.
   New Hosco Mines Limited
   Orchan Mines Limited
10. Canadian Jamieson Mines Limited
    Kam-Kotia Mines Limited
    Texas Gulf Sulphur Company
11. Noranda Mines Limited (Geco Division)
    Willecho Mines Limited
    Willroy Mines Limited
12. Zenmac Metal Mines Limited
13. Hudson Bay Mining and Smelting Co., Limited – 2 mines:
    Chisel, Stall Lake
14. Hudson Bay Mining and Smelting Co., Limited – 2 mines,
    Flin Flon, Schist Lake
15. Aetna Investment Corporation Limited
    Cominco Ltd. – 3 mines:
    Sullivan, Bluebell, H.B.
    Giant Soo Mines Limited
    Johnsby Mines Limited
    London Pride Silver Mines Ltd.
    Mastodon-Highland Bell Mines Limited
    Reeves MacDonald Mines Limited
16. The Anaconda Company (Canada) Ltd.
17. Western Mines Limited
18. United Keno Hill Mines Limited
19. Pine Point Mines Limited

METALLURGICAL PLANTS

4. East Coast Smelting and Chemical Company Limited, Belledune
20. Canadian Electrolytic Zinc Limited, Valleyfield
21. Sherbrooke Metallurgical Company Limited, Port Maitland
14. Hudson Bay Mining and Smelting Co., Limited, Flin Flon
22. Cominco Ltd., Trail

USES

Galvanizing continued to be the largest outlet for zinc in 1966, accounting for 44 per cent of total Canadian consumption. Die castings made from zinc-base alloys were the next largest use, accounting for 25 per cent. Other outlets were the manufacture of zinc oxide and zinc dust, brass and other copper alloys, and rolled zinc. The principal gains in zinc use in 1966 were made in copper alloys and die-casting alloys.

Galvanized or zinc-coated steel is corrosion-resistant, and is widely used in the construction industry and in installations such as transmission-line towers and highway equipment where resistance to weathering over long periods is required. It is used in automobile underbodies as protection against the attack of road-salt solutions in winter.

Die castings of zinc-base alloys are used by the automotive industry for such parts as grilles, head- and taillight assemblies, carburetors, fuel pumps, and door and window hardware. These castings are also used in components in household appliances and in plumbing and hardware supplies. The alloys most commonly used for die castings are made of high-purity zinc to which is added about 4 per cent aluminum, 0.04 per cent magnesium and from 0 to 1 per cent copper.

Brass, a copper-zinc alloy containing as much as 40 per cent zinc, is widely used in the form of sheets and strips, tubes, rods and wire, castings and extruded shapes. Rolled zinc is used in Canada mainly for making dry-cell batteries, terrazzo strip, weather stripping, roofing drains and gutters, and anticorrosion plates for boilers and ships' hulls. Zinc oxide is used in compounding rubber and in making paint, rayon yarn, ceramic materials, inks, matches and many other commodities. Zinc dust is used to make zinc-rich paints, to purify fats, to manufacture dyes and to precipitate gold and silver from cyanide solutions. The more industrially important compounds of zinc are zinc chloride, zinc sulphate and lithopone, a mixture of barium sulphate and zinc sulphide used for making paint.

Refined zinc is marketed in grades that vary according to the content of such impurities as lead, iron and cadmium. The principal grades produced are: Special High Grade, used chiefly for die casting , High grade, used for making brass and miscellaneous products, and Prime Western for galvanizing.

TABLE 5

United States Consumption by End Use, 1965-66
(short tons)

	1965	1966P
Galvanizing	482,421	473,951
Brass products	126,848	183,747
Zinc-base alloy.....	637,970	583,304
Rolled zinc	45,882	48,956
Zinc oxide	25,781	28,546
Other uses	35,190	38,033
Estimated undistributed consumption..	–	51,800
Total	1,354,092	1,408,337

Source: U.S. Bureau of Mines Mineral Industry Surveys, Zinc Industry in December 1966.
P - Preliminary; – Nil.

In Canada, the electrolytic process produces Special High grade and High grade zinc. To meet consumer requirement for Prime Western, Canadian producers add small amounts of lead to the higher grades.

ZINC RESEARCH IN 1966

Research on hot-dip galvanized coatings was continued in 1966 at the Mines Branch, Department of Energy, Mines and Resources, Ottawa, in co-operation with the Canadian Zinc and Lead Research Committee and the International Lead Zinc Research Organization. Prior work in the area of elevated temperature service evaluation was extended to a range of commercial thick-wall tubing, angle and bar products. As previously found with sheet coatings, deterioration due to heating was manifested in all cases by complete bond destruction at the interface between the outer zinc layer and the underlying zeta iron-zinc phase. The onset of separation of the zinc layer, and the iron-zinc alloy transformation effects preceding and following separation, were dependent on the time and temperature of heating, and on coating thickness and uniformity. An additional factor influencing the deterioration rate was the inherent chemical reactivity of the steel base. This study confirmed that the maximum temperature for long service use of this class of conventional coatings is of the order of 200°C (390°F).

Work on elevated temperature exposure of continuous strip coatings was reactivated with tests being made on recently developed commercial products, not previously examined. In these cases also, the mode and rate of deterioration conformed to the behaviour of corresponding, standard strip products investigated previously.

PRICES AND TARIFFS

The Canadian price of Prime Western zinc, f.o.b. Toronto and Montreal during 1966 was 14.50 cents per lb. The United States price, f.o.b. East St. Louis, was also 14.50 cents per pound during the year. The London Metal Exchange prompt price averaged £102.006 per long ton in 1966 compared with £112.972 in 1965.

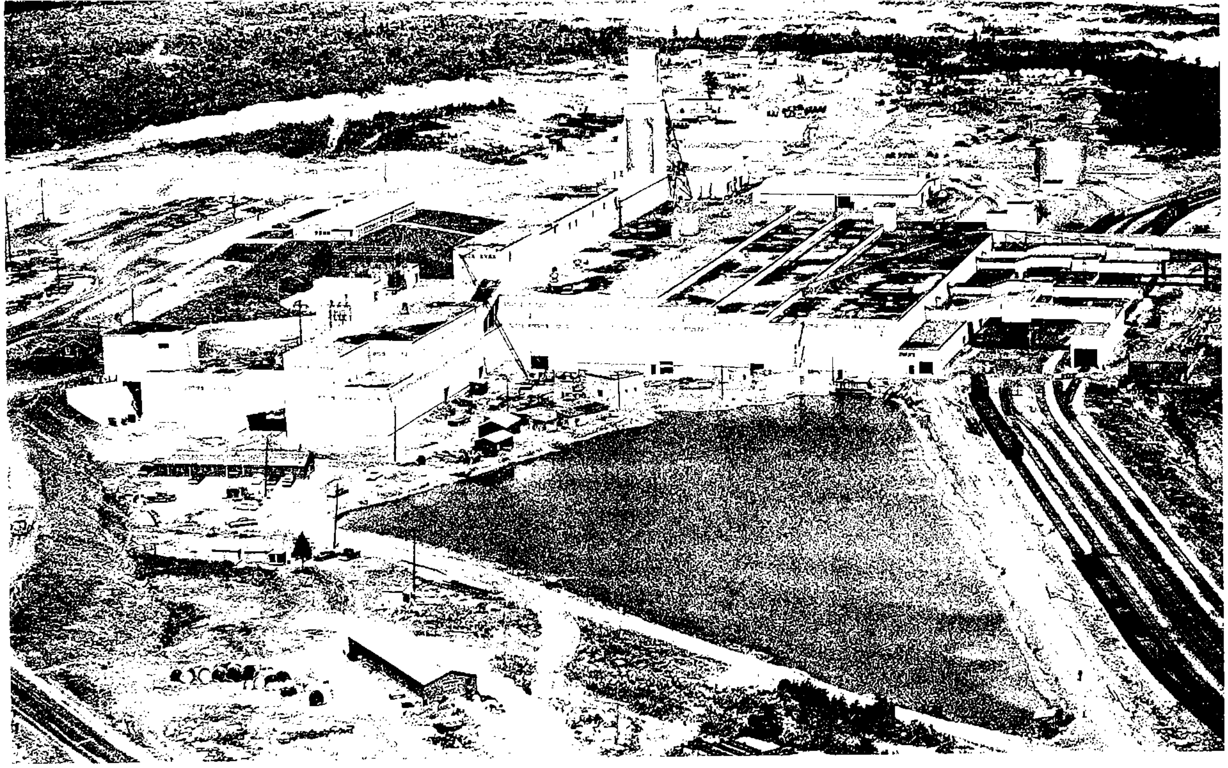
The overseas producer basis price, which in 1964 replaced the London Metal Exchange quotation as a basis for Canadian sales outside of North America, declined on March 23, 1966 from £110 to £102 per long ton (14.7¢ to 13.7¢ a pound Can.) and remained at that level for the remainder of the year. Prices on the London Metal Exchange fluctuated between a high of £115 a long ton in March to a low of £92 in August, averaging £102 for the year.

Canadian and United States tariffs in 1966 were as follows:

	British Preferential	Most Favoured Nation	General
Canada			
In ores and concentrates	free	free	free
Zinc spelter, zinc and zinc alloys containing not more than 10% by weight of other metal or metals in form of pigs, slabs, blocks, dust or granules, per lb	½¢	½¢	2¢
Zinc, or zinc alloys containing not more than 10% by weight of other metal or metals, in form of foil, ribbon, strip, plate, discs, slugs; coated or not	5%	7½%	20%
Dross and scrap for remelting or processing into zinc dust	free	free	10%
Manufactures not otherwise provided for	15%	17½%	25%
Flat rolled; strip or sheet for lithographing	free	free	10%

United States	
Ores and concentrates	0.67¢ per lb on zinc content
Unwrought:	
other than alloys of zinc	0.7¢ per lb
alloys of zinc	19% ad val
Waste and scrap	0.75¢ per lb

Varying tariffs on other forms of zinc and zinc manufactures are applied.



TWO MEMBERS OF NEW BRUNSWICK'S YOUTHFUL BASE-METAL INDUSTRY: The concentrator and #12 mine, a zinc-lead-copper-silver producer, of Brunswick Mining and Smelting Corporation Limited at Bathurst in mid-1966, their second year of full production.

The silver-lead-zinc-copper mine and concentrator of Nigadoo River Mines Limited under construction and development in the Bathurst area in preparation for operations in late 1967.

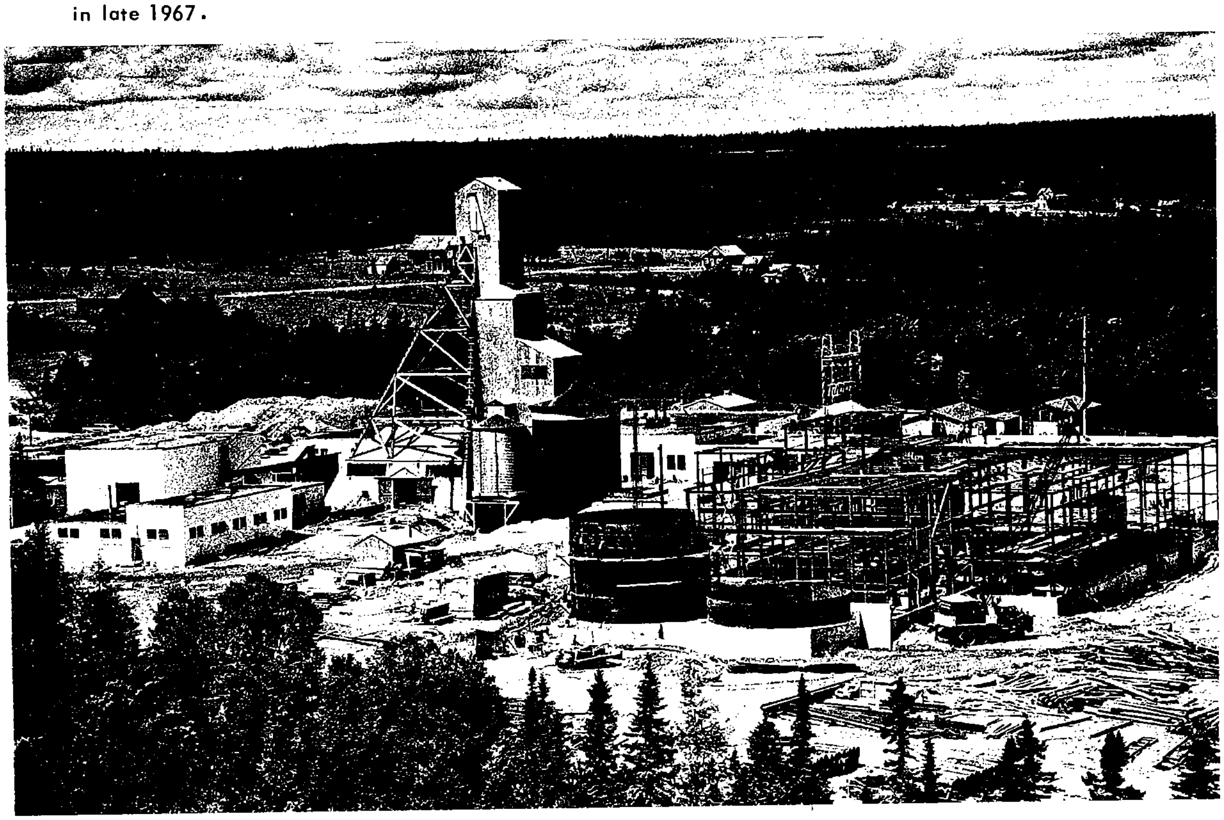


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TABLE 1

Mineral Production of Canada 1964, 1965 and 1966

	Unit of Measure	1964		1965		1966^p	
		Quantity	$000	Quantity	$000	Quantity	$000
Metals							
Antimony	000 lb	1,592	700	1,302	690	1,446	681
Bismuth	,,	400	817	429	1,195	575	2,470
Cadmium	,,	2,773	8,984	1,756	4,881	2,006	4,815
Calcium	,,	138	152	159	153	268	255
Cobalt	,,	3,185	5,991	3,648	7,529	3,428	7,404
Columbium (Cb_2O_5)	,,	2,163	2,282	2,334	2,528	2,600	3,150
Copper	000 st	487	324,468	508	380,952	510	457,790
Gold	000 t oz	3,835	144,788	3,606	136,052	3,317	125,102
Indium	000 oz	..	..	..	..	..	..
Iron ore	000 lt	34,219	404,952	35,678	413,065	36,158	419,108
Iron, remelt	000 st	429	18,700	385	18,172	355	16,895
Lead	,,	204	54,759	292	90,460	300	89,744
Magnesium	000 lb	18,706	5,588	20,216	6,067	13,573	3,868
Mercury	,,	6	23	2	12	—	—
Molybdenum (Mo content)	,,	1,225	2,057	9,557	16,731	20,419	31,650
Nickel	000 st	228	379,321	259	430,402	234	399,736
Platinum groups	000 t oz	376	25,404	463	36,110	386	31,232
Selenium	000 lb	466	2,259	512	2,484	521	2,873
Silver	000 t oz	29,903	41,864	32,272	45,181	33,342	46,645
Tellurium	000 lb	78	506	70	454	79	504
Thorium	,,	..	..	..	..	..	..
Tin	,,	352	534	377	726	734	1,335
Titanium ore	000 st	—	—	—	—	—	—
Tungsten (WO_3)	000 lb	..	..	3,736	3,116	4,185	5,000
Uranium (U_3O_8)	,,	14,570	83,509	8,885	62,361	7,644	54,345
Yttrium	,,	—	—	—	—	..	..
Zinc	000 st	685	193,991	822	248,255	959	289,707
Total metals			1,701,649		1,907,576		1,994,309
Nonmetals							
Arsenious oxide	000 lb	324	16	403	13	450	16
Asbestos	000 st	1,420	145,193	1,388	146,189	1,492	166,937
Barite	,,	169	1,574	203	2,167	214	2,011
Diatomite	st	1,143	65	82	4	326	6
Feldspar	000 st	9	212	11	253	11	255
Fluorspar	,,	..	2,259	..	2,680	..	2,191
Gemstones	000 lb	12	14	71	16	57	19
Graphite	st	—	—	—	—	—	—
Grindstone	,,	—	—	5	1	5	1
Gypsum	000 st	6,361	11,524	6,306	12,533	5,982	12,403
Helium	Mcf	..	..	..	..	..	..
Iron oxide	000 st	1	79	0.3	14	0.3	14
Lithia	000 lb	1,056	1,155	1,014	1,142	244	259
Magnesitic dolomite and brucite	000 st	..	3,570	..	4,011	..	3,928
Mica	000 lb	1,198	86	548	26	544	21
Nepheline syenite	000 st	290	3,097	340	3,415	366	4,069
Nitrogen	Mcf	..	..	..	..	..	..

TABLE 1 (Cont'd)

	Unit of Measure	1964		1965		1966P	
		Quantity	$000	Quantity	$000	Quantity	$000
Peat Moss	000 st	255	8,400	288	8,983	270	7,336
Phosphate	st	–	–	5	0.2	–	–
Potash	000 st	858	31,162	1,491	55,971	2,045	76,670
Pozzolan	st	..	35	–	–	–	–
Pyrite, pyrrhotite	000 st	352	1,126	382	1,285	324	1,102
Quartz	,,	2,117	4,506	2,434	5,124	2,262	5,472
Salt	,,	3,989	23,204r	4,584	23,986	4,328	23,163
Soapstone, talc, pyrophyllite	,,	58	828	53	762	67	995
Sodium sulphate	,,	333	5,222	345	5,527	402	6,448
Sulphur in smelter gas	,,	443	4,262	445	4,317	470	4,644
Sulphur, elemental	,,	1,788	18,638	2,068	26,395	1,981	35,876
Titanium dioxide, etc.	,,	..	21,270	410	22,425	396	21,616
Total nonmetallics		..	287,497r		327,239		375,452
Fuels							
Coal	000 st	11,319	72,735	11,589	75,901	11,392	81,833
Natural gas	000 Mcf	1,316,944r	172,967	1,442,448	186,625	1,543,281	198,817
Natural gas byproducts	000 bbl	..	78,689	..	92,378	..	99,252
Petroleum, crude	,,	274,600	674,377	296,419	721,590	328,732	812,699
Total fuels			998,768		1,076,494		1,192,601
Structural Materials							
Clay products	$		40,830		42,838		44,809
Cement	000 st	7,847	130,704	8,428	142,523	8,972	157,901
Lime	,,	1,541	19,409	1,620	20,134	1,546	19,634
Sand and gravel	,,	193,791	125,232	205,260	133,820	209,132	147,625
Stone	,,	69,794	86,883	76,758	94,847	79,837	99,650
Total structural materials			403,058		434,162		469,619
Total all minerals			3,390,972r		3,745,471		4,031,981

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

TABLE 2

Value of Mineral Production of Canada and Its Per Capita Value, Selected Years, 1928-1966

($ millions)

	Metallics	Industrial Minerals	Fuels	Total	Per Capita Value
1928	132	69	74	275	27.96
1933	147	27	48	222	20.85
1938	324	54	65	443	39.71
1943	357	81	92	530	44.94
1948	488	172	160	820	63.97
1953	710	312	314	1,336	90.02
1958	1,130	460	511	2,101	122.99
1963	1,510	632	908	3,050	161.43
1964	1,702	690r	999	3,391r	176.29r
1965	1,908	761	1,076	3,745	191.38
1966P	1,994	845	1,193	4,032	202.42

rRevised; PPreliminary.

TABLE 3

Indexes of Physical Volume of Industrial Production and Mineral Production in Canada, 1952-66

Unadjusted (1949 = 100)

	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
Total industrial production	122.4	131.3	131.1	145.5	160.7	163.3	162.4	176.5	179.8	186.2	201.7	215.3	235.3	254.9	275.1
Total mining	131.6	143.3	158.9	187.8	218.3	239.3	243.3	275.4	275.6	283.0	304.7	318.3	346.4	365.6	393.6
Metals															
All metals	111.4	118.0	130.0	147.3	160.1	188.4	210.4	242.5	236.4	220.4	225.2	227.5	245.7	249.5	256.0
Gold	106.9	97.9	104.5	107.7	103.2	104.9	109.2	107.2	109.5	104.9	96.8	92.0	85.9	80.6	73.9
Nickel	109.2	111.7	125.3	135.9	138.7	146.1	108.4	145.0	166.7	181.0	180.5	168.6	181.0	209.9	185.6
Lead	105.7	121.2	136.8	126.9	118.2	113.5	116.8	116.8	128.7	144.2	134.8	125.9	126.3	179.9	189.3
Zinc	129.0	139.4	130.6	150.3	146.6	143.5	147.5	137.4	141.1	144.3	160.7	164.3	233.7	281.2	333.3
Copper	97.9	96.1	114.9	123.7	134.7	136.3	131.0	150.0	166.7	166.7	173.6	171.8	187.8	195.6	192.9
Iron ore	137.4	178.2	203.9	406.1	519.6	544.1	395.0	587.7	578.8	558.7	781.0	916.8	1,185.3	1,236.8	1,322.7
Fuels															
All fuels	163.9	192.7	215.6	273.0	346.9	360.3	331.6	364.6	377.7	433.4	483.5	516.6	557.7	592.8	665.7
Coal	90.5	81.5	75.2	74.1	74.6	65.4	56.8	51.8	53.4	49.9	48.8	51.9	55.1	56.3	54.6
Natural gas	128.9	147.8	169.6	204.5	232.8	290.2	402.9	488.3	591.7	709.7	1,000.6	1,179.8	1,382.3	1,476.4	1,598.0
Petroleum	291.8	385.5	457.8	616.8	819.5	866.5	788.6	880.4	903.1	1,052.3	1,163.2	1,231.6	1,319.2	1,405.5	1,599.4
Nonmetals															
All nonmetals	154.7	151.4	157.6	180.4	190.3	182.0	172.4	197.6	196.5	214.7	233.6	273.0	312.8*	377.2*	405.3*
Asbestos	171.5	162.3	167.8	191.9	192.1	186.3	177.3	192.1	200.7	222.3	233.5	240.4	259.9	269.4	293.4
Other nonmetals	114.6	125.4	133.3	152.9	185.9	171.8	160.6	210.8	186.5	196.6	233.8	351.0	439.4	635.1	672.7
Quarrying and sand pits	153.6	152.9	188.6	201.3	231.9	259.4	255.4	293.8	300.1	291.5	367.1	357.8	416.5	456.5	486.4

*Includes potash production which was not included in previous years.

TABLE 4

Percentage Contribution of Leading Minerals to Total Value of Mineral Production in Canada, 1957–66

	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966[p]
Petroleum, crude	20.7	19.0	17.5	17.0	18.9	19.4	20.2	19.9	19.3	20.2
Copper	9.4	8.3	9.7	10.6	9.9	9.9	9.3	9.6	10.2	11.4
Iron ore	7.6	6.0	8.0	7.0	7.3	9.2	10.3	11.9[r]	11.0	10.4
Nickel	11.8	9.2	10.7	11.9	13.6	13.5	11.8	11.2	11.5	9.9
Zinc	4.6	4.4	4.0	4.4	4.1	3.9	4.0	5.7	6.6	7.2
Natural gas	1.0	1.5	1.6	2.1	2.6	3.8	4.9	5.1	5.0	4.9
Asbestos	4.8	4.4	4.5	4.9	5.0	4.6	4.5	4.3	3.9	4.1
Cement	4.3	4.6	3.9	3.7	4.0	4.0	3.9	3.9	3.8	3.9
Sand and gravel	4.1	4.6	4.3	4.6	4.1	4.2	4.1	3.7	3.6	3.7
Gold	6.8	7.4	6.2	6.3	6.1	5.5	5.0	4.3	3.6	3.1
Stone	2.7	2.6	2.5	2.4	2.6	2.4	2.6	2.6	2.5	2.5
Lead	2.3	2.0	1.6	1.8	1.8	1.5	1.5	1.6	2.4	2.2
Coal	4.1	3.8	3.1	3.0	2.7	2.4	2.4	2.1	2.0	2.0
Potash (K_2O)	–	–	–	–	–	0.1	0.7	0.9	1.5	1.9
Uranium (U_3O_8)	6.2	13.3	13.7	10.8	7.6	5.5	4.5	2.5	1.7	1.3
Silver	1.1	1.3	1.2	1.2	1.1	1.2	1.4	1.2	1.2	1.2
Clay products	1.6	2.0	1.8	1.5	1.4	1.3	1.3	1.2	1.1	1.1
Elemental sulphur	..	0.1	0.1	0.2	0.3	0.3	0.4	0.5	0.7	0.9
Molybdenum	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.06	0.4	0.8
Platinum metals	1.2	0.7	0.7	1.2	0.9	1.0	0.7	0.7	1.0	0.8
Salt	0.6	0.7	0.7	0.8	0.8	0.8	0.7	0.7[r]	0.6	0.6
Titanium dioxide	0.4	0.3	0.4	0.5	0.6	0.4	0.5	0.6	0.6	0.5
Lime	0.8	0.9	0.9	0.8	0.7	0.6	0.6	0.6	0.5	0.5
Gypsum	0.4	0.2	0.3	0.4	0.3	0.3	0.4	0.3	0.3	0.3
Other minerals	3.5	2.7	2.6	2.9	3.6	4.2	4.3	4.9	5.0	4.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

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

TABLE 5

Value of Mineral Production in Canada by Main Geological Regions, 1966[p]

	Metals		Industrial Minerals		Fuels		Total, all Minerals	
	$ Millions	% of Total	$ Millions	% of Total	$ Millions	% of Total	$ Millions	% of Total
Canadian Shield	1,545.2	77.5	38.6	4.6	–	–	1,583.8	39.3
Appalachian Region	146.2	7.3	207.7	24.6	59.5	5.0	413.4	10.2
St. Lawrence Lowlands	3.1	0.2	340.9	40.3	10.1	0.8	354.1	8.8
Interior Plains	92.1	4.6	185.4	21.9	1,075.5	90.2	1,353.0	33.6
Cordilleran Region	207.7	10.4	72.5	8.6	47.5	4.0	327.7	8.1
Total, Canada	1,994.3	100.0	845.1	100.0	1,192.6	100.0	4,032.0	100.0

[p] Preliminary.

TABLE 6

Value of Mineral Production in Canada by Provinces and Mineral Classes 1966P

	Metals		Industrial Minerals		Fuels		Total	
	$000	% of Total	$000	% of Total	$000	% of Total	$000	% of Total
Ontario	741,914	37.2	207,470	24.5	10,072	0.8	959,456	23.8
Alberta	7	–	70,120	8.3	821,120	68.9	891,247	22.1
Quebec	454,492	22.8	313,165	37.0	–	–	767,657	19.1
Saskatchewan	43,068	2.2	99,381	11.8	224,670	18.8	367,119	9.1
British Columbia	191,297	9.6	62,607	7.4	63,490	5.3	317,394	7.9
Newfoundland	222,577	11.2	19,287	2.3	–	–	241,864	6.0
Manitoba	142,595	7.1	26,686	3.2	12,957	1.1	182,238	4.5
Northwest Territories	116,473	5.8	–	–	734	0.1	117,207	2.9
New Brunswick	68,771	3.4	12,699	1.5	7,993	0.7	89,463	2.2
Nova Scotia	1,716	0.1	32,785	3.9	51,519	4.3	86,020	2.1
Yukon Territory	11,399	0.6	–	–	46	–	11,445	0.3
Prince Edward Island	–	–	871	0.1	–	–	871	0.02
Total, Canada	1,994,309	100.0	845,071	100.0	1,192,601	100.0	4,031,981	100.0

– Nil; P Preliminary.

TABLE 7

Value of Mineral Production in Canada by Provinces 1957-66

($ millions)

	1957	1958	1959	1960	1961	1962	1963	1964	1965r	1966P
Ontario	749	790	971	983	944	913	874	904r	993	960
Alberta	410	346	376	396	473	567	669	736	794	891
Quebec	406	366	441	446	455	519	541	685	716	768
Saskatchewan	173	210	210	212	216	240	272	292	328	367
British Columbia	179	151	159	186	188	235	261	269	280	317
Newfoundland	83	65	72	87	92	102	138	182	208	242
Manitoba	64	57	55	59	101	159	170	174	183	182
Northwest Territories	21	25	26	27	18	18	16	18	77	117
New Brunswick	23	16	18	17	19	22	28	49	82	90
Nova Scotia	68	63	63	66	62	62	66	66	71	86
Yukon Territory	14	12	13	13	13	13	14	15	13	11
Prince Edward Island	–	–	5	1	1	0.7	0.8	0.8	0.6	0.9
Total, Canada	2,190	2,101	2,409	2,493	2,582	2,851	3,050	3,391	3,745	4,032

– Nil; P Preliminary; r Revised from previously published figures.

TABLE 8

Percentage Contribution of Provinces to Total Value of Mineral Production in Canada, 1957-66

	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966p
Ontario	34.2	37.5	40.3	39.4	36.6	32.0	28.7	26.7r	26.5	23.8
Alberta	18.7	16.5	15.6	15.9	18.3	19.9	21.9	21.7	21.2	22.1
Quebec	18.5	17.4	18.3	17.9	17.6	18.2	17.7	20.2	19.1	19.1
Saskatchewan	7.9	10.0	8.7	8.5	8.4	8.4	8.9	8.6	8.8	9.1
British Columbia	8.2	7.2	6.6	7.5	7.3	8.2	8.6	7.9	7.5	7.9
Newfoundland	3.8	3.1	3.0	3.5	3.6	3.6	4.5	5.4	5.5	6.0
Manitoba	2.9	2.7	2.3	2.4	3.9	5.6	5.6	5.1	4.9	4.5
Nova Scotia	3.1	3.0	2.6	2.6	2.4	2.2	2.2	2.0	1.9	2.9
New Brunswick	1.1	0.8	0.8	0.7	0.7	0.8	0.9	1.4r	2.2	2.2
Northwest Territories	1.0	1.2	1.1	1.1	0.7	0.6	0.5	0.5	2.1	2.1
Yukon	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.3	0.3
Prince Edward Island	—	—	0.2	0.05	0.02	0.02	0.03	0.02	0.02	0.02
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; — Nil.

TABLE 9

Production of Leading Minerals in Canada,

	Unit of Measure	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.
Petroleum, crude	bbl	.	..	.	6,836	—	1,323,721
	$	—	—	—	9,592	—	4,236,503
Copper	st	18,669	—	292	6,553	172,717	202,469
	$	16,764,924	—	261,843	5,884,840	155,100,021	181,817,162
Iron ore	st	16,231,625	—	—	—	13,817,367	8,253,377
	$	186,665,832	—	—	—	128,707,024	82,969,491
Nickel	st	—	—	—	—	4,297	169,878
	$	—	—	—	—	7,364,544	291,170,674
Zinc	st	34,438	—	545	146.199	290,252	86,603
	$	10,400,276	—	164,636	44,152,194	87,656,168	26,154,228
Natural gas	Mcf	—	—	—	96,712	—	15,260,935
	$	—	—	—	91,383	—	5,835,778
Asbestos	st	64,850	—	—	—	1,336,566	1,800
	$	10,300,000	—	—	—	141,559,725	70,000
Cement	st	55,441	—	210,000	260.000	2,976,610	3,184,372
	$	1,219,700	—	3,549,000	4,290,000	49,361,015	51,307,104
Sand and gravel	st	3,647,355	406,636	7,896,332	6,054,873	49,611,123	81,224,635
	$	3,502,363	671,288	10,573,115	3,147,253	23,111,231	61,934,414
Gold	oz	24,912	—	—	1,768	948,971	1,652,279
	$	939,432	—	—	66,671	35,785,696	62,307,441
Stone	st	86,000	200,000	519,005	2,888,579	48,575,164	23,152,612
	$	108,400	200,000	1,719,465	2,896,080	55,147,020	31,002,417
Lead	st	21,112	—	1,626	47,999	3,754	1,943
	$	6,308,227	—	485,836	14,342,101	1,121,736	580,437
Coal	st	—	—	3,854,534	898,315	—	—
	$	—	—	51,518,674	7,892,427	—	—
Potash (K_2O)	st	—	—	—	—	—	—
	$	—	—	—	—	—	—
Uranium (U_3O_8)	lb	—	—	—	—	—	5,843,813
	$	—	—	—	—	—	40,545,000
Silver	oz	1,070,943	—	574,505	3,025,094	5,780,130	10,318,325
	$	1,498,249	—	803,732	4,232,107	8,086,402	14,435,337
Clay products	$	194,102	—	1,592,466	588,625	6,600,000	27,080,304
Elemental sulphur	st	—	—	—	—	—	552
	$	—	—	—	—	—	16,214
Molybdenum	lb	—	—	—	—	3,498,768	—
	$	—	—	—	—	5,423,090	—
Platinum metals	oz	—	—	—	—	—	385,741
	$	—	—	—	—	—	31,231,607
Salt	st	—	—	447,805	—	—	3,647,632
	$	—	—	4,847,188	—	—	14,340,218
Titanium dioxide	st	—	—	—	—	395,523	—
	$	—	—	—	—	21,615,610	—
Lime	st	—	—	—	3,723	352,342	1,065,449
	$	—	—	—	105,650	3,768,306	13,524,359
Gypsum	st	457,408	—	4,542,851	107,232	—	550,000
	$	1,166,390		8,587,505	231,470	—	1,508,000
Total leading minerals	$	239,067,895	871,288	84,103,460	87,930,393	730,407,588	942,066,688
Total all minerals	$	241,863,688	871,288	86,019,760	89,463,258	767,657,017	959,456,259
Leading minerals as % of all minerals		98.8	100.0	97.8	98.3	95.1	98.2

P Preliminary; — Nil; .. Not available.

by Provinces and Territories, 1966^{p}

Man.	Sask.	Alta.	B.C.	N.W.T.	Y.T.	Total Canada
5,230,904	93,208,999	211,573,305	16,638,181	749,653	—	328,731,599
12,957,358	212,889,131	545,225,966	36,665,786	714,408	—	812,698,744
30,900	19,418	—	57,962	809	—	509,789
27,747,938	17,436,814	—	52,050,177	726,429	—	457,790,148
—	—	—	2,194,826	—	—	40,497,195
—	—	—	20,765,430	—	—	419,107,777
58,171	—	—	1,715	—	—	234,061
98,260,854	—	—	2,939,510	—	—	399,735,582
35,816	28,973	—	142,228	189,698	4,543	959,295
10,816,495	8,749,705	—	42,952,680	57,288,650	1,371,986	289,707,018
—	49,821,541	1,290,753,671	187,302,388	46,241	—	1,543,281,488
—	5,648,826	170,507,751	16,714,226	19,524	—	198,817,488
—	—	—	88,700	—	—	1,491,916
—	—	—	15,007,000	—	—	166,936,725
496,180	231,070	844,500	713,966	—	—	8,972,139
11,010,300	5,921,000	16,676,000	14,566,526	—	—	157,900,645
12,821,244	9,084,891	13,633,654	24,751,616	—	—	209,132,359
9,239,383	6,271,884	12,587,480	16,586,275	—	—	147,624,686
63,077	42,938	182	119,146	421,216	42,999	3,317,488
2,378,634	1,619,192	6,863	4,492,996	15,884,055	1,621,492	125,102,472
1,228,332	—	179,090	3,007,960	—	—	79,836,742
2,368,140	—	950,305	5,258,102	—	—	99,649,929
546	—	—	100,183	115,000	8,186	300,349
162,996	—	—	29,934,731	34,362,000	2,446,126	89,744,190
—	2,078,165	3,467,254	1,087,631	—	5,670	11,391,569
—	3,717,586	11,947,258	6,710,813	—	46,390	81,833,148
—	2,045,000	—	—	—	—	2,045,000
—	76,670,000	—	—	—	—	76,670,000
—	1,800,000	—	—	—	—	7,643,813
—	13,800,000	—	—	—	—	54,345,000
533,763	596,530	14	5,411,590	1,952,634	4,078,223	33,341,751
746,734	834,545	20	7,570,814	2,731,735	5,705,434	46,645,109
544,306	1,550,296	3,256,210	3,402,860	—	—	44,809,169
4,217	34,247	1,876,000	65,700	—	—	1,980,716
60,683	673,590	33,500,000	1,625,000	—	—	35,875,487
—	—	—	16,920,638	—	—	20,419,406
—	—	—	26,226,989	—	—	31,650,079
..	—	—	—	—	—	385,741
..	—	—	—	—	—	31,231,607
27,000	89,808	116,000	—	—	—	4,328,245
662,600	1,721,057	1,591,700	—	—	—	23,162,763
—	—	—	—	—	—	395,523
—	—	—	—	—	—	21,615,610
53,090	—	71,824	—	—	—	1,546,428
898,145	—	1,337,628	—	—	—	19,634,088
108,649	—	—	215,789	—	—	5,981,929
278,211	—	—	631,380	—	—	12,402,956
178,132,777	357,503,626	797,587,181	304,101,295	111,726,801	11,191,428	3,844,690,420
182,238,288	367,118,774	891,246,781	317,393,785	117,206,801	11,445,406	4,031,981,105
97.7	97.4	89.5	95.8	95.3	97.8	95.4

TABLE 10

World Role of Canada as Producer

	Year		World Production	1	
Nickel (mine production)	1966	st	466,300	Canada	234,061
		% of world total			50
Zinc (mine production)	1966	st	4,784,747	Canada	1,041,762
		% of world total			22
Asbestos	1965	st	3,570,000	Canada	1,388,212
		% of world total			39
Uranium (U_3O_8 concentrates) (Excludes communist nations)	1965	st	20,900	USA	10,442
		% of world total			50
Titanium concentrates (ilmenite)	1965	st	2,728,000	USA	969,459
		% of world total			36
Gypsum	1965	000st	51,700	USA	10,035
		% of world total			19
Molybdenum (Excludes communist nations)	1965	st	49,300	USA	38,686
		% of world total			78
Lead (mine production)	1966	st	3,121,832	USSR	485,000
		% of world total			16
Aluminum (primary metal)	1966	st	7,703,258	USA	2,967,891
		% of world total			39
Platinum group metals (mine production)	1965	troy oz.	2,970,000	USSR	1,700,000
		% of world total			57
Cobalt (mine production)	1965	st	17,000	Republic of the Congo (Leopoldville)	9,204
		% of world total			54
Gold (mine production)	1965	troy oz.	47,700,000	Republic of S. Africa	30,553,874
		% of world total			64
Cadmium (smelter production)	1965	000 lb	26,500	USA	9,671
		% of world total			36
Iron ore	1966	000 lt	608,827	USSR	158,458
		% of world total			26
Silver (mine production)	1965	troy oz	251,355,000	Mexico	40,332,077
		% of world total			16
Copper (mine production)	1966	st	5,702,744	USA	1,407,937
		% of world total			25
Barite	1965	st	3,790,000	USA	845,656
		% of world total			22
Magnesium	1966	st	180,400	USA	79,794
		% of world total			44
Potash (K_2O equivalent)	1965	000 st	14,861	USA	3,140
		% of world total			21

Sources: For Canada, Dominion Bureau of Statistics. For other countries, nickel, zinc, aluminum, lead, uranium, cobalt, cadmium, titanium concentrates, gypsum, gold, silver, barite, molybdenum and

*Source: United States Bureau of Mines.

of Certain Important Minerals

Rank of the Six Leading Countries				
2	3	4	5	6
USSR 100,000 21	New Caledonia 66,900 14	Cuba 16,300 3	USA 13,100 3	Republic of S. Africa 6,000 1
USA 571,070 12	USSR 518,000 11	Australia 316,090 7	Peru 284,194 6	Japan 268,553 6
USSR 1,300,000 36	Republic of S. Africa 240,752 7	Southern Rhodesia 172,400 5	China 140,000 4	USA 118,275 3
Canada 4,443 21	Republic of S. Africa 2,942 14	France 1,800 9	Gabon 600 3	Australia 370 2
Canada* 545,916 20	Australia 503,686 18	Norway 311,017 11	Malaysia 136,154 5	Finland 117,947 4
Canada 6,306 12	France 5,401 10	Britain 4,911 9	USSR 4,740 9	Spain 3,147 6
Canada 4,779 10	Chile 4,200 9	Peru 724 1	Japan 315 —	Norway 249 —
Australia 395,690 13	Canada 324,490 10	USA 319,302 10	Mexico 200,697 6	Peru 159,569 5
USSR 1,185,000 15	Canada 907,659 12	France 400,698 5	Japan 369,414 5	Norway 364,750 5
Republic of S. Africa 756,000 25	Canada 463,127 16	USA 35,026 1	Colombia 11,040 —	Japan 5,804 —
Morocco 2,019 12	Canada 1,824 11	Zambia 1,702 10	USSR 1,400 8	Australia 20 —
USSR 6,100,000 13	Canada 3,606,031 8	USA 1,705,190 4	Australia 877,139 2	Ghana 755,191 2
USSR 4,200 16	Japan 2,678 10	Canada 1,756 7	Australia 1,197 5	Republic of the Congo (Leopoldville) 1,038 4
USA 91,089 15	France 54,778 9	Canada 36,158 6	China 30,511 5	India 28,768 5
USA 39,806,033 16	Peru 35,255,411 14	Canada 32,272,464 13	Britain 27,000,000 11	Australia 16,713,000 7
USSR 770,000 14	Chile 722,945 13	Zambia 684,656 12	Canada 509,789 9	Republic of the Congo 349,098 6
W. Germany 490,000 13	Mexico 406,405 11	USSR 240,000 6	Canada 203,025 5	Italy 156,412 4
USSR 36,000 20	Norway 30,000 17	Japan 11,583 6	Italy 7,191 4	Canada 6,786 4
W. Germany 2,645 18	USSR 2,500 17	France 2,071 14	E. Germany 2,000 13	Canada 1,491 10

copper and magnesium from American Bureau of Metal Statistics; asbestos, platinum group metals, potash from U.S. Bureau of Mines; Iron ore from American Iron and Steel Institute.

TABLE 11

Net Value of Production in Canada of Commodity-Producing Industries 1961-1964

($ millions)

	1961	1962	1963	1964
Primary industries				
Agriculture	1,613r	2,322r	2,568r	2,199
Forestry	666r	702	749	820
Fishing	111r	131	130	149
Trapping	12	10	12	13
Mining	1,562	1,748	1,856	..
Electric power	840	876	912	970
Total	4,804r	5,789r	6,227r	
Secondary industries				
Manufacturing	10,435r	11,430r	12,273r	13,536
Construction	3,701	3,788	3,980	4,393
Total	14,136r	15,218r	16,253r	17,929
Grand total	18,940r	21,007r	22,480r	

r Revised; .. Not available.

TABLE 12

Exports of Crude Minerals and Fabricated Mineral Products, by Main Groups, 1965 and 1966

($ millions)

	1965	1966	Increase or decrease	
			$ millions	%
Ferrous				
Crude material	369.1	379.1	+ 10.0	+ 2.7
Fabricated material	251.7	273.8	+ 22.1	+ 8.8
Total	620.8	652.9	+ 32.1	+ 5.2
Nonferrous				
Crude material	493.5r	550.0	+ 61.5	+ 12.5
Fabricated material*	959.3	1,040.3	+ 81.0	+ 8.4
Total	1,452.8	1,595.3	+142.5	+ 9.8
Nonmetals				
Crude material	229.9	259.4	+ 29.5	+ 12.8
Fabricated material	59.2	142.4**	+ 83.2	+140.5
Total	289.1	401.8	+112.7	+ 39.0
Mineral fuels				
Crude material	397.3	444.2	+ 46.9	+ 11.8
Fabricated material	22.6	28.7	+ 6.1	+ 27.0
Total	419.9	472.9	+ 53.0	+ 12.6
Total minerals and products				
Crude material	1,489.8r	1,637.7	+147.9	+ 9.9
Fabricated material	1,292.8r	1,485.2	+192.4	+ 14.9
Total	2,782.6r	3,122.9	+340.3	+ 12.2

r Revised; * Includes gold; ** Includes potash, value $76 million, not previously reported in mineral trade statistics.

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

Value of Imports of Crude Minerals and Fabricated Mineral Products, by Main Groups, 1965 and 1966

($ millions)

	1965	1966	Increase or decrease	
			$ millions	%
Ferrous				
Crude material	96.6	77.0	−19.6	−20.3
Fabricated material	550.0	491.2	−58.8	−10.7
Total	646.6	568.2	−78.4	−12.1
Nonferrous*				
Crude material	99.0	123.0	+24.0	+24.2
Fabricated material	232.5	281.8	+49.3	+21.2
Total	331.5	404.8	+73.3	+22.1
Nonmetals				
Crude material	53.6	63.4	+ 9.8	+18.3
Fabricated material	136.0	152.3	+16.3	+12.0
Total	189.6	215.7	+26.1	+13.8
Mineral fuels				
Crude material	444.7	458.1	+13.4	+ 3.0
Fabricated material	177.5	176.7	− 0.8	− 0.5
Total	622.2	634.8	+12.6	+ 2.0
Total minerals and products				
Crude material	693.9	721.5	+27.6	+ 4.0
Fabricated material	1,096.0	1,102.0	+ 6.0	+ 0.5
Total	1,789.9	1,823.5	+33.6	+ 1.9

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

TABLE 14

Value of Exports of Crude Minerals and Fabricated Mineral Products in Relation to Total Export Trade, 1965 and 1966

	1965		1966	
	$ millions	% of Total	$ millions	% of Total
Crude material	1,489.8r	17.5	1,637.7	16.3
Fabricated material*	1,292.8r	15.1	1,485.2	14.7
Total	2,782.6r	32.6	3,122.9	31.0
Total exports* all products	8,525.1r	100.0	10,070.8	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.
(See note bottom of Table 12)

TABLE 15

Value of Imports of Crude Minerals and Fabricated Mineral Products in Relation to Total Import Trade, 1965 and 1966

	1965		1966	
	$ millions	% of Total	$ millions	% of Total
Crude material	693.9	8.0	721.5	7.3
Fabricated material*	1,096.0	12.7	1,102.0	11.2
Total	1,789.9	20.7	1,823.5	18.5
Total imports* all products	8,633.1[r]	100.0	9,866.8	100.0

* Includes gold, refined and unrefined; [r] Revised from previously published figure.
(See note bottom of Table 12)

TABLE 16

Value of Exports of Crude Minerals and Fabricated Mineral Products by Main Groups and Destination, 1966

($ millions)

	Britain	United States	Other Countries	Total
Ferrous materials and products	38.0	502.6	112.3	652.9
Nonferrous* materials and products	408.5	713.3	473.5	1,595.3
Nonmetallic mineral materials and products	23.1	219.6	159.1	401.8
Mineral fuels, materials and products	0.5	459.3	13.1	472.9
Total	470.1	1,894.8	758.0	3,122.9
Percentage	15.0	60.7	24.3	100.0

*Includes gold, refined and unrefined.
(See note bottom of Table 12)

TABLE 17

Value of Imports of Crude Minerals and Fabricated Mineral Products by Main Groups and Destination, 1966

($ millions)

	Britain	United States	Other Countries	Total
Ferrous materials and products	40.7	378.8	148.7	568.2
Nonferrous* materials and products	31.5	236.2	137.1	404.8
Nonmetallic mineral materials and products	16.0	148.9	50.8	215.7
Mineral fuels,materials and products	4.3	229.1	401.4	634.8
Total	92.5	993.0	738.0	1,823.5
Percentage	5.1	54.4	40.5	100.0

*Includes gold, refined and unrefined.
(See note bottom of Table 12)

96411—35½

TABLE 18

Value of Exports of Crude Mineral and Fabricated Mineral Products From Canada, by Commodity and Destination, 1966

($000)

	USA	Britain	Other* EFTA Countries	EEC** Countries	Japan	Other Countries	Total
Iron ore	301,067	23,779	379	25,638	18,145	1	369,009
Primary ferrous metals	65,782	4,794	10	2,467	1,170	3,021	77,244
Aluminum	192,423	79,167	4,363	22,342	16,074	72,655	387,024
Copper	158,126	107,995	40,303	16,995	56,072	17,473	396,964
Lead	21,801	10,772	118	9,693	3,075	2,716	48,175
Nickel	192,386	111,354	64,795	20,608	4,671	5,345	399,159
Zinc	72,271	28,249	1,628	32,479	2,777	8,175	145,579
Uranium	13,761	22,605	—	—	—	—	36,366
Asbestos	65,953	18,696	8,676	36,878	8,308	46,342	184,853
Fuels	459,328	511	46	2	11,978	1,030	472,895
All other minerals†	351,937	62,124	7,095	41,887	22,757	119,800	605,600
Total	1,894,835	470,046	127,413	208,989	145,027	276,558	3,122,868

* 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.
(See note bottom of Table 12 in respect to crude and fabricated materials).

TABLE 19

Reported Consumption of Minerals in Canada
and Relation to Production, 1965

	Unit of Measure	Consumption	Production*	Consumption as % of Production**
Metals				
Aluminum	st	213,094	830,505	25.7
Antimony	lb	659,637	1,301,787	50.7
Bismuth	lb	48,279	428,759	11.3
Cadmium	lb	171,558	1,755,925	9.8
Chromium (Chromite)	st	69,105	—	—
Cobalt	lb	366,036	3,648,332	10.0
Copper	st	190,736	507,877	37.6
Lead	st	90,168	291,807	30.9
Magnesium	st	4,473	10,108	44.3
Manganese Ore	st	119,289	—	—
Mercury	lb	415,996	1,520	2,736.8
Molybdenum (no content)	lb	1,702,589	9,557,191	17.8
Nickel	st	8,924	259,182	3.4
Selenium	lb	15,888	512,077	3.1
Silver	oz	30,170,097	32,272,464	93.5
Tellurium	lb	1,870	69,794	2.7
Tin	lt	4,892	168	2,911.9
Tungsten (W content)	lb	877,614	3,736,324	23.5
Zinc	st	97,345	822,035	11.8
Nonmetals				
Barite	st	12,606	203,025	6.2
Feldspar	st	8,338	10,904	76.5
Fluorspar	st	167,537	..	..
Mica	lb	3,576,000	547,611	653.0
Nepheline syenite	st	50,664	339,982	14.9
Phosphate rock	st	1,606,915	—	—
Potash (muriate of potash)	st	193,951	1,491,301	13.0
Sodium sulphate	st	275,620	345,469	79.8
Sulphur, elemental	st	739,223	2,068,394	35.7
Talc, etc.		34,671	52,837	65.6
Fuels				
Coal	st	26,774,718	11,588,616	231.0
Natural gas	Mcf	573,016,494	1,442,448,070	39.7
Petroleum, Crude	bbl	352,839,269	296,418,914	119.0

* 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.

** Changes in stocks are not allowed for.

— Nil; .. Not available or not applicable.

TABLE 20

Reported Consumption of Minerals in Canada
and Relation to Production, 1966

	Unit of Measure	Consumption	Production*	Consumption as of % Production
Metals				
Aluminum	st	243,065	907,659	26.8
Antimony	lb	1,098,162	1,446,277	75.9
Bismuth	lb	56,428	574,872	9.8
Cadmium	lb	170,605	2,006,237	8.5
Chromium (chromite)	st	64,550	–	–
Cobalt	lb	392,177	3,427,926	11.4
Copper	st	262,557	509,788	51.5
Lead	st	94,947	300,349	31.6
Magnesium	st	5,187	6,786	76.4
Manganese ore	st	152,536	–	–
Mercury	lb	171,588	–	–
Molybdenum (no content)	lb	1,266,979	20,419,406	6.2
Nickel	st	8,608	234,061	3.7
Selenium	lb	20,533	521,163	3.9
Silver	oz	21,303,704	33,341,751	63.9
Tellurium	lb	862	78,900	1.1
Tin	lt	4,972	327	1,520.5
Tungsten (W content)	lb	941,207	4,185,000	22.5
Zinc	st	108,951	959,294	11.5
Nonmetals				
Barite	st	13,335	213,854	6.2
Feldspar	st	12,046	10,924	110.3
Fluorspar	st	166,290	..	
Mica	lb	2,360,000	543,800	434.0
Nepheline syenite	st	52,937	366,422	14.4
Phosphate rock	st	1,735,488	–	
Potash (muriate of potash)	st	204,846	2,045,000	10.0
Sodium sulphate	st	333,552	401,940	83.0
Sulphur, elemental	st	813,109	1,980,716	41.1
Talc, etc.	st	34,048	67,148	50.7
Fuels				
Coal	st	26,452,867	11,391,569	232.2
Natural gas	Mcf	635,508,883	1,543,281,488	41.2
Petroleum, Crude	bbl	378,730,147	328,731,599	115.2

* 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.

– Nil; .. Not available or not applicable.

TABLE 21

Apparent Consumption of Minerals in Canada
and Its Relation to Production, 1965

	Unit of Measure	Apparent Consumption*	Production**	Consumption as % of Production
Asbestos	st	68,808	1,388,212	5.0
Cement	st	8,130,434	8,427,702	96.5
Gypsum	st	1,634,424	6,305,629	25.9
Iron ore	lt	9,641,398	35,677,621	27.0
Lime	st	1,406,404	1,620,404	86.8
Quartz (silica)	st	3,162,036	2,433,685	129.9
Salt	st	3,547,500[e]	4,584,096	77.4

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

TABLE 22

Apparent Consumption of Minerals in Canada
and Its Relation to Production, 1966

	Unit of Measure	Consumption*	Production**	Consumption as % of Production
Asbestos	st	45,754	1,491,916	3.1
Cement	st	8,615,376	8,972,139	96.0
Gypsum	st	1,395,324	5,981,929	23.3
Iron ore	lt	9,787,586	36,158,210	27.1
Lime	st	1,394,813	1,546,428	90.2
Quartz (silica)	st	3,119,106	2,261,571	137.9
Salt	st	3,600,000[e]	4,328,245	83.2

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

TABLE 23

Domestic Consumption of Principal Refined Metals (a) in Relation to Production (b) in Canada, 1957-66

	Unit of Measure	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
Copper											
Domestic consumption (c)	st	118,225	122,893	129,973	117,637r	141,808	151,525	169,750	202,225	224,684	262,557
Production	st	323,540	329,239	365,366	417,029	406,359	382,862r	380,075r	407,942r	434,133	433,921
% Consumption of production		36.5	37.3	35.6	28.2	34.9	39.6	44.7	49.6	51.8	60.5
Zinc											
Domestic consumption (d)	st	52,713	56,097	64,788	55,803	60,878	65,320	73,653	88,494	93,796	105,551
Production	st	247,316	252,093	255,306	260.968	268,007	280,158	284,021	337,728	358,498r	382,612
% Consumption of production		21.3	22.3	25.4	21.4	22.7	23.3	25.9	26.2	26.2	27.6
Lead											
Domestic consumption	st	71,583	69,769	65,935	72,087	73,418	77,286	77,958	82,736	90,168	94,947
Production	st	142,935	132,987	135,296	158,510	171,833	152,217	155,000	151,372	186,484	184,871
% Consumption of production		50.1	52.5	48.7	45.5	42.7	50.8	50.3	54.7	48.4	51.4
Aluminum											
Domestic consumption (g)	st	77,984	101,886	114,344	120,831	135,575	151,893	166,833r	172,443r	213,094	243,065
Production	st	556,715	634,102	593,630	762,012	663,173	690,297	719,390	842,640	830,505	907,659
% Consumption of production		14.0	16.1	19.3	15.9	20.4	22.0	23.2	20.5	25.7	26.8

(a) Refined metal of primary and secondary origins. (b) Refined metal from all sources, including metal derived from secondary materials at primary refineries. (c) Producers' domestic shipments. (d) Primary refined zinc only. (g) Producers' domestic shipments-primary aluminum to 1958; primary and secondary aluminum consumption for 1959 and thereafter. r Revised.

TABLE 24

Annual Averages of Prices of Main Minerals*, 1965 and 1966

	Unit of Measure	Average 1965	Average 1966	Increase or Decrease: Cents or Dollars	Increase or Decrease: %
Aluminum ingot, 99.5%	cents/lb	24.507	24.500	− 0.007	−0.03
Antimony, RMM f.o.b. Laredo, Texas	cents/lb	44.000	44.000	—	—
Bismuth, ton lots delivered	$/lb	3.426	4.000	+ 0.574	+16.8
Cadmium	cents/lb	262.956	246.608	− 16.348	− 6.2
Calcium, ton lots, crowns	$/lb	0.95	0.95	—	—
Chromium metal, 98.5%, .05% C	$/lb	1.15-1.19	1.01-1.05	− 0.28	−12.0
Cobalt metal, 500 lb lots	$/lb	1.625	1.650	+ 0.025	+ 1.5
Copper, U.S. domestic, f.o.b. refinery	cents/lb	35.017	36.170	+ 1.153	+ 3.3
Gold, Canadian dollars	$/troy oz	37.73	37.71	− 0.02	− 0.05
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	16.000	15.115	− 0.885	− 5.5
Magnesium, ingot	cents/lb	35.250	35,250	—	—
Mercury	$ flask (76 lb)	570.747[r]	441.719	−129.028	−22.6
Molybdenum metal	$/lb	3.35	3.35	—	—
Molybdenite, 95% MoS_2, contained MO	$/lb	1.55	1.55	—	—
Nickel, f.o.b., Port Colbome (duty incl.)	cents/lb	78.673	78.900	+ 0.227	+ 0.3
Platinum	$/troy oz	97.583	99.167	+ 1.584	+ 1.6
Selenium	$/lb	4.50	4.50	—	—
Silver, New York	cents/troy oz	129.300	129.300	—	—
Sulphur, Mexican export price	$/metric ton	22.575	25.790	+ 3.215	+14.2
Tin, straits, New York	cents/lb	178.202	164.070	− 14.132	− 7.9
Titanium metal, 500 lb lots, 99.3%	$/lb	1.32	1.32	—	—
Titanium ore (ilmenite) 59.5% TiO_2	$/lt	22.50-25.50	—	—	—
Titanium ore (ilmenite) 54% TiO_2	$/st	—	21-24	—	—
Tungsten metal	$/lb	2.75	2.75	—	—
Zinc, prime western, East St. Louis	cents/lb	14.500	14.500	—	—

*These prices, except for gold are in United States currency and from *E & MJ Metal and Mineral Markets.*

[r] Revised.

TABLE 25

Wholesale Price Indexes of Minerals and Mineral Products, Canada, 1956 and 1964-66

(1935-39 = 100)

	1956	1964	1965	1966
Iron and products	239.8	256.4	264.4	268.0
Pig iron	277.6	290.4	289.1	290.3
Rolling mill products	222.4	251.7	260.2	263.0
Pipe and tubing	243.2	271.0	281.8	294.7
Wire	273.3	274.9	288.2	295.0
Scrap iron and steel	408.7	269.4	300.5	282.7
Tinplate and galvanized sheet	227.1	238.2	248.9	252.5
Nonferrous metals and products				
Total (including gold)	199.2	205.9	217.7	229.9
Total (excluding gold)	280.2	284.9	306.1	328.2
Antimony	177.0	417.2	412.9	362.9
Copper and products	385.9	318.9	360.8	425.0
Lead and products	323.5	280.5	323.9	312.2
Silver	230.7	360.4	360.2	360.0
Tin	189.6	330.2	367.8	339.1
Zinc and products	320.5	307.5	329.3	329.5
Solder	212.1	299.4	335.7	319.4
Nonmetallic minerals and products	180.8	190.9	191.6	193.7
Clays and clay products	237.5	242.5	243.4	247.1
Pottery	160.6	225.5	240.4	250.8
Coal	182.1	201.6	200.9	201.8
Coal tar	300.2	211.6	229.4	219.5
Coke	231.0	263.9	265.5	268.0
Window glass	270.2	310.6	320.0	342.1
Plate glass	206.7	283.6	284.3	292.1
Petroleum products	167.6	159.8	159.8	160.2
Crude oil	..	192.0	192.0	191.6
Gasoline	138.5	126.5	126.4	127.1
Coal oil	136.2	134.1	134.1	134.1
Asphalt	184.1	192.3	198.6	197.7
Asphalt shingles	159.1	106.1	92.1	93.3
Sulphur	205.6	226.2	226.2	271.5
Plaster	131.3	144.0	147.7	149.0
Lime	206.9	223.2	227.1	236.2
Cement	154.5	169.9	172.8	177.0
Sand and gravel	144.1	143.0	143.6	143.2
Crushed stone	165.2	159.0	158.3	160.4
Building stone	200.2	199.6	211.2	221.6
Asbestos and products	288.6	304.4	319.7	326.2
General wholesale price index (all products)	225.6	245.4	250.3	259.5

TABLE 26

General Wholesale Price Index and Wholesale Price Indexes of Mineral and Nonmineral Industries
1942-1966

(1935-39 = 100)

	Mineral Products Industries			Nonmineral Products Industries					
	Iron Products	Non-ferrous Metal Products	Non-metallic Mineral Products	Vegetable Products	Animal Products	Textile Products	Wood Products	Chemical Products	General Wholesale Price Index
1942	116.0	107.2	114.5	114.9	137.1	131.2	132.3	127.9	123.0
1943	116.8	107.8	115.6	123.5	146.9	130.8	142.2	125.3	127.9
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	315.8	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	264.5r	217.6r	191.6	218.4	270.7	246.6r	334.0r	200.2r	250.4r
1966p	268.0	229.9	193.7	225.9	296.2	251.5	337.8	207.1	259.5

p Preliminary; r Revised.

TABLE 27

Industry Selling Price Indexes, Mineral Based Industries

(1956 = 100)

	1963	1964	1965	1966
Iron and Steel Products Industries				
Agricultural implements industry	117.1	116.8	117.4	121.5
Hardware, tools and cutlery industry	115.4	116.1	120.2	124.7
Heating and cooking apparatus industry	94.4	94.3	93.5	92.2
Machinery, household, office and store, industry	99.2	99.5	99.9	100.1
Castings, iron, industry	107.8	107.7	110.6	113.8
Pig iron industry	104.2	104.3	104.1	104.3
Steel ingots and castings industry	119.8	120.3	122.2	122.4
Rolled iron and steel products industry	106.4	106.1	108.8	110.2
Wire and wire goods industry	105.3	106.6	109.6	110.6
Nonferrous metal products industries				
Aluminum products industry	104.7	107.8	110.6	111.7
Brass and copper products industry	86.0	90.3	100.8	115.7
Jewellery and silverware industry	126.1	131.8	133.2	138.6
Nonferrous metal smelting and refining industry	101.2	109.7	112.9	114.9
White metal alloys industry	89.5	104.4	118.7	120.1
Nonmetallic mineral products industries				
Abrasives, artificial, industry	116.1	115.8	115.9	119.4
Cement, hydraulic industry	110.8	112.3	115.4	121.8
Clay products from imported clay industry	106.8	107.7	112.1	115.9
Glass and glass products industry	109.2	110.1	109.3	111.9
Lime industry	110.7	111.8	114.6	116.1
Gypsum products industry	106.1	107.2	107.9	109.2
Concrete products industry	98.2	102.4	105.5	110.9
Clay products from domestic clay industry	109.3	109.6	111.0	114.3
Coke and gas products industry	111.2	111.8	112.3	113.3
Petroleum refining and products industry	94.7	95.1	93.2	93.5
Lubricating oils and greases industry	116.5	117.9	118.2	120.9
Fertilizers industry	103.5	105.8	107.5	108.6

Industry selling price indexes are wholesale price indexes organized according to the Standard Industrial Classification.

TABLE 28

Principal Statistics of the Mineral Industry by Sectors, 1963

	Establishments No.	Employees No.	Salaries and Wages $000	Cost of Fuel and Electricity $000	Cost of Process Supplies, Ores, Concentrates & Containers $000	Gross Value of Production $000	Net Value of Production $000
Metallics							
Placer gold	30	210	1,222	71	121	2,202	1,950
Gold	122	15,120	63,095	6,734	19,147	126,903	99,259
Copper-gold-silver	176	11,536	58,514	7,010	19,882	229,873	150,193
Silver-cobalt	21	705	3,004	346	413	6,957	5,592
Silver-lead-zinc	61	4,636	24,886	3,721	8,689	125,778	70,253
Nickel-copper	26	12,110	68,080	4,220	17,414	112,121	85,524
Iron	48	9,993	65,647	14,150	32,621	305,372	215,044
Other	35	4,468	27,925	4,755	19,752	144,413	118,642
Total	519	58,778	312,373	41,007	118,039	1,053,619	746,457
Industrial Minerals							
Asbestos	17	6,823	35,508	7,638	16,274	141,998	118,086
Feldspar, quartz, nepheline syenite	20	381	1,564	343	686	6,332	5,302
Gypsum	9	680	2,876	449	2,268	9,846	7,130
Salt	11	955	4,567	1,199	3,256	22,441	17,985
Sand and gravel	331	2,266	9,250	3,170	487	42,537	38,881
Stone	207	3,452	14,046	3,768	5,954	48,767	39,045
Clay products	89	3,519	14,319	5,406	4,966	37,565	27,193
Cement	20	3,566	20,559	17,920	16,292	122,028	87,816
Lime	21	886	4,058	2,427	2,211	14,915	10,277
Other	92	2,934	11,252	3,047	4,919	46,950	38,631
Total	817	25,462	117,999	45,367	57,313[r]	493,379	390,346
Fuels							
Coal	97	8,903	35,624	3,731	13,011	71,295	54,553
Petroleum & natural gas*	634	5,840	36,397	10,533	10,785	811,101	789,783
Total	731	14,743	72,021	14,264	23,796	882,396	844,336
Total mining industry	2,067	98,983	502,393	100,638	199,148[r]	2,429,394	1,981,139[r]
Nonferrous smelting and refining	23	28,644	160,118	46,038	918,660	1,520,160	555,462[r]

* Includes natural gas processing; [r] Revised.

TABLE 29

Principal Statistics* of the Mining Industry** 1959-1963

	Establishments No.	Employees No.	Salaries and Wages $000	Cost of Fuel and Electricity $000	Cost of Process Supplies, Ores, Concentrates & Containers $000	Gross Value of Production $000	Net Value of Production† $000
1959	2,584	106,960	479,468	87,913	175,544	1,961,335	1,547,793
1960	2,473	103,556	480,011	89,219	180,760	1,972,796	1,560,682
1961	2,483	99,644	469,983	87,792	162,717	2,057,452	1,671,549
1962	2,221	98,959	485,984	94,515	180,319	2,279,854	1,867,920
1963	2,067	98,983	502,393	100,638	199,148	2,429,394	1,981,139[r]

* Commencing in 1960 certain changes in the industrial classification of industries were made by the Dominion Bureau of Statistics. The definition of establishment was changed to include only that establishment considered a separate accounting unit, capable of reporting employment, salaries and wages, etc., on a unit basis. This substantially reduced the number of establishments in comparison with previous years. Also, some companies formerly included in the mining industry were transferred to other industries (manufacturing, construction, etc) if their main revenue-producing activity was not mining.

** Does not include smelting and refining industries.

† Net value equals gross value of production less cost of process supplies, ores, concentrates, containers, treatment charges, freight, fuel and electricity.

r Revised.

TABLE 30

Principal Statistics of the Nonferrous Smelting and Refining Industries 1959-1963

	Establishments No.	Employees No.	Salaries and Wages $000	Cost of Fuel and Electricity $000	Cost of Process Supplies, Ores, Concentrates & Containers $000	Gross Value of Production $000	Net Value of Production $000
1959	23	28,172	139,320	47,341	788,218	1,283,938	448,380
1960	22	30,024	155,415	50,787	896,613	1,506,008	558,608
1961	24	29,527	157,475	49,000	891,951	1,471,048	530,097
1962	23	29,303	159,439	45,703	915,967	1,549,049	582,653
1963	23	28,644	160,118	46,038	918,660	1,520,160	555,462[r]

r Revised.

Note: See footnotes to Table 29 for references to changes in statistical classification and definition of net value of production.

TABLE 31

Consumption of Fuels and Electricity in the Canadian Mineral Industry, 1963

	Unit	Metal Mining	Nonferrous Smelting and Refining	Total	Production of Industrial Minerals	Production of Crude Mineral Fuels	Total Mineral Industry
Coal and coke	st	113,395	895,469	1,008,864	850,881	4,117	1,863,862
	$	1,788,706	13,495,225	15,283,931	8,907,179	33,964	24,225,074
Gasoline and kerosene	gal	4,004,419	1,026,669	5,031,088	9,865,703	7,547,855	22,444,646
	$	1,454,530	300,569	1,755,099	3,321,066	2,350,271	7,426,436
Fuel oil	gal	72,935,299[r]	60,402,546	133,337,845	103,534,915	4,414,843	241,287,603
	$	11,580,263	5,159,394	16,739,657	11,290,960	870,813	28,901,430
Liquefied petroleum gas	gal	285,845	674,247	960,092	246,149	1,068,170	2,274,411
	$	108,968	142,642	251,610	66,936	195,319	513,865
Natural gas	Mcf	651,323	14,736,545	15,387,868	23,839,128	23,088,699	62,315,695
	$	372,439	5,078,557	5,450,996	7,648,182	2,560,006	15,659,184
Other fuels	$	246,207	87,900	334,107	199,577	376,763	910,447
Total fuels	$	15,551,113	24,264,287	39,815,400	31,433,900	6,387,136	77,636,436
Electricity purchased	million Kwh	3,711	5,215	8,926	1,766	602	11,294
	$	25,456,160	21,774,100	47,230,260	13,932,584	7,877,007	69,039,851
Total value, fuels and electricity purchased	$	41,007,273	46,038,387	87,045,660	45,366,484	14,264,143	146,676,287
Electricity generated by industry for own use	million Kwh	432	13,735	14,167	36	47	14,250

[r] Revised.

TABLE 32

Cost of Fuel and Electricity Used in the Canadian Mining Industry *

1956-1963

		1956	1957	1958	1959	1960	1961	1962	1963
Fuel **	$ million	47.0	53.1	53.1	53.1	48.8	46.3	50.4	53.3
Electricity purchased	million Kwh	4,213	4,586	4,993	5,164	5,195	5,084	5,377	6,079
	$ million	32.2	35.8	38.1	39.5	42.8	41.5	44.1	47.3
Total cost of fuel and electricity	$ million	79.2	88.9	91.2	92.6	91.6	87.8	94.5	100.6
Electricity generated for own use	million Kwh	558	590	527	551	575	581	638	515
Electricity generated for sale	million Kwh	12	14	16	17	33	29	31	33

* Excludes nonferrous smelting and refining.

** Coal, coke, fuel oil, gasoline, gas, wood.

Note: Total cost of fuel and electricity for years 1958 to 1960, inclusive as shown in the above table do not agree with later revised totals for those years as shown in Table 29. The overall costs of fuel and electricity were revised for those years, but the individual components (fuel and electricity) were not. It is therefore, not possible to show the components, fuel and electricity in a revised form for the years 1958 to 1960 incl. to agree with the totals reported in Table 29.

TABLE 33

Cost of Fuel and Electricity Used in the Nonferrous Smelting and Refining Industries

1956-1963

		1956	1957	1958	1959	1960	1961	1962	1963
Fuel *	$ million	29.9	27.3	23.4	26.3	26.9	27.2	24.8	24.2
Electricity purchased	million Kwh	13,981	13,668	15,081	14,575	18,225	5,389	5,046	5,215
	$ million	35.0	32.2	40.1	36.0	36.3	21.8	20.9	21.8
Total cost of fuel and electricity purchased	$ million	64.9	59.5	63.5	62.3	63.2	49.0	45.7	46.0
Electricity generated for own use **	million Kwh	1,121	1,037	1,038	1,060	1,146	12,851	12,688	13,735
Electricity generated for sale	million Kwh	12	—	33	31	33	36	3	3

* Coal, coke, fuel oil, gasoline, gas, wood.

** Commencing in 1961 changes in statistical classifications account for decreases in electricity purchased and increases in electricity generated for own use.

Note: See footnote Table 32 for explanation of differences between total values of fuel and electricity 1958 to 1960 incl. as shown in above table and as reported in Table 30.

TABLE 34

Employment, Salaries and Wages in the Canadian Mineral Industry
1945, 1950, 1955, 1960 and 1963

	1945		1950		1955		1960		1963	
	Employees	$ million	Employees	$ million	Employees	$ million	Employees	$ million	Employees	$ million
Metal mining	32,913	68.8	47,697	142.0	53,364	211.2	61,882	308.0	58,778	312.4
Nonferrous smelting and refining	16,771	33.9	19,863	58.7	28,606	118.2	30,024	155.4	28,644	160.1
Industrial minerals	17,407	26.3	24,375	58.2	28,208	96.8	25,069	105.9	25,462	118.0
Fuels *	29,159	56.3	28,453	74.5	23,458	76.4	16,605	66.1	14,743	72.0
Total	96,250	185.3	120,388	333.4	133,636	502.6	133,580	635.4	127,627	662.5
Annual average of salaries and wages $	1,925		2,770		3,761		4,757		5,191	

* Coal, crude petroleum and natural gas (including natural gas processing after 1960).

TABLE 35

Number of Wage Earners — Surface, Underground and Mill — Canadian Mining Industry * by Sectors, 1956-1963

	1956	1957	1958	1959	1960	1961	1962	1963
Metallics **								
Surface	16,706	18,532	16,602	16,697	16,039	15,815	15,197	14,615
Underground	27,679	29,382	29,712	31,384	30,774	28,975	27,959	26,334
Mill	5,624	6,168	6,541	6,573	6,162	6,047	6,504	7,802
Total	50,009	54,082	52,855	54,654	52,975	50,837	49,660	48,751
Industrial Minerals								
Surface	12,804	14,347	14,029	13,988	10,321	9,485	9,656	9,464
Underground	1,798	1,749	1,458	1,327	1,164	995	951	879
Mill	12,163	11,573	11,216	11,639	10,741	10,511	10,770	10,561
Total	26,765	27,669	26,703	26,954	22,226	20,991	21,377	20,904
Fuels								
Surface	9,622	8,683	7,887	7,537	6,715	5,786	5,585	5,537
Underground	11,065	10,043	9,247	8,022	8,257	7,439	6,678	6,276
Mill	—	—	—	—	—	—	—	—
Total	20,687	18,726	17,134	15,559	14,972	13,225	12,263	11,813
Total								
Surface	39,132	41,562	38,518	38,222	33,075	31,086	30,438	29,616
Underground	40,542	41,174	40,417	40,733	40,195	37,409	35,588	33,489
Mill	17,787	17,741	17,757	18,212	16,903	16,558	17,274	18,363
Total	97,461	100,477	96,692	97,167	90,173	85,053	83,300	81,468

* Does not include nonferrous smelting and refining. ** Includes placer operations.

TABLE 36

Labour Costs in Relation to Tons Mined from Metal Mines
1945, 1955 and 1963

Types of Mines	Number of Wage Earners	Total of Wage	Average Annual Wage	Tons Mined	Average Annual Tons Mined per Worker	Wage Cost per Ton Mined
		$ millions	$	000 st	st	$
1963 Auriferous quartz	13,025	51.6	3,959	12,619	969	4.09
Copper-gold-silver	9,524	46.1	4,845	19,764	2,075	2.33
Nickel-copper	10,649	56.9	5,342	17,624	1,655	3.23
Silver-cobalt	585	2.4	4,034	307	525	7.69
Silver-lead-zinc	3,808	19.5	5,119	6,385	1,677	3.05
Iron ore	7,312	46.7	6,384	60,071	8,215	0.78
Miscellaneous metal mines	3,660	22.4	6,127	7,693	2,102	2.91
Total	48,563	245.6	5,056	124,463	2,563	1.97
1955 Auriferous quartz	16,168	55.0	3,403	16,405	1,015	3.35
Copper-gold-silver	7,644	29.8	3,896	9,912	1,297	3.00
Nickel-copper	9,943	42.7	4,296	17,022	1,712	2.51
Silver-cobalt	663	2.2	3,279	303	457	7.18
Silver-lead-zinc	5,485	21.5	3,912	7,526	1,372	2.85
Iron ore	4,265	15.9	3,735	17,220	4,038	0.93
Miscellaneous metal mines	2,229	9.9	4,461	801	3,592	12.42
Total	46,397	177.0	3,815	69,189	1,491	2.56
1945 Auriferous quartz	15,807	31.2	1,974	9,781	619	3.19
Copper-gold-silver	4,033	8.0	1,976	5,915	1,467	1.35
Nickel-copper	5,559	11.7	2,101	10,855	1,953	1.08
Silver-cobalt	147	0.2	1,394	30	208	6.72
Silver-lead-zinc	2,119	4.5	2,141	3,087	1,457	1.47
Miscellaneous metal mines	807	1.7	2,127	1,605	1,990	1.07
Total	28,472	57.3	2,013	31,273	1,098	1.83

TABLE 37

Man-hours Worked and Tons of Ore Mined and Rock Quarried, Metal Mines and Industrial Mineral Operations, 1956 - 1963

	1956	1957	1958	1959	1960	1961	1962	1963
Metal Mines*								
Ore mined (Millions st)	77.4	84.3	78.8	99.1	101.6	99.4	114.3	124.5[r]
Man-hours worked† (millions)	126.4	135.7	133.6	133.3	130.5	124.9	124.4	117.9[r]
Man-hours per ton mined (number)	1.63	1.61	1.70	1.35	1.28	1.26	1.09	0.95[r]
Industrial Mineral Operations**								
Ore mined and rock quarried (millions st)	62.9	70.0	66.5	78.5	86.0	94.6	100.9	119.0
Man-hours worked† (millions)	32.8	32.3	29.3	29.3	27.5	26.9	27.2	27.6
Man-hours worked per ton mined (number)	0.52	0.46	0.44	0.37	0.32	0.28	0.27	0.23

* Excludes placer mining.

** Excludes salt, cement, clay products, stone for cement manufacture and stone produced for lime manufacture.

† Includes man-hours worked by all employees both salaried and wage earners on surface, underground, mill and administration.

[r] Revised.

TABLE 38

Basic Wage Rates per Hour in Canadian Metal Mining Industry on October 1, 1965 and 1966

	Gold Mining		Iron Mining		Other Metal Mining	
	1965 $	1966 $	1965 $	1966 $	1965 $	1966 $
Underground Workers						
Cage and skiptenders	1.75	1.90	..	..	2.42	2.54
Chute blaster	1.63	1.81	..	..	2.47	2.66
Deckman	1.61	1.78	..	..	2.19	2.28
Hoistman	1.85	2.03	..	..	2.59	2.73
Labourer	1.61	1.75	..	..	2.19	2.30
Miner	1.73	1.91	2.65	2.85	2.41	2.56
Miner's helper	1.56	1.74	2.57	..	2.04	2.15
Motorman	1.67	1.81	..	..	2.34	2.54
Mucking machine operator	1.64	1.81	..	..	2.37	2.54
Mucker and trammer	1.60	1.76	..	..	2.35	2.50
Timberman	1.78	1.91	..	..	2.42	2.63
Trackman	1.69	1.87	..	..	2.38	2.56
Open-pit workers						
Blaster	..	..	2.64	2.74	..	..
Bulldozer operator	..	..	2.71	2.87	..	..
Driller, machine	..	..	2.72	2.91	..	..
Dump-truck driver	..	..	2.76	2.94	..	..
Oiler	..	..	2.51	2.64	..	..
Shovel operator (power)	..	..	3.08	3.34	..	..
Surface and mill workers						
Blacksmith	..	..	..	..	2.55	2.74
Carpenter, maintenance	1.89	1.99	2.87	3.13	2.40	2.67
Crusher operator	1.68	1.83	2.56	2.72	2.25	2.43
Electrician	1.90	2.07	2.90	3.26	2.65	2.91
Filter operator	..	..	..	..	2.30	2.43
Flotation operator	..	..	..	..	2.23	2.50
Grinding-mill operator	..	..	2.69	2.90	2.32	2.49
Hoistman	..	..	2.48	..	..	..
Labourer	1.52	1.66	2.16	2.34	1.96	2.19
Machinist, maintenance	1.90	2.13	2.98	3.26	2.70	2.96
Mechanic, diesel	..	..	3.12	3.23	2.59	2.81
Mechanic, maintenance	1.86	2.02	2.70	3.13	2.54	2.77
Millman	1.76*	1.92*	..	..	..	..
Millwright	..	..	2.98	3.10	..	..
Pipefitter, maintenance	1.79	1.97	2.79	3.09	2.43	2.60
Solution man	..	..	..	..	2.38	2.49
Steel sharpener	1.79	1.93	..	..	2.34	2.56
Tradesman's helper	1.64	1.75	2.42	2.55	2.21	2.40
Truck driver, light and heavy	1.68	1.85	2.57	2.83	2.19	2.49
Welder, maintenance	1.87	2.09	2.84	3.12	2.58	2.80

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

TABLE 39

Index Numbers of Average Wage Rates* for Certain Main Industries, 1941-1965

(1949 = 100)

	Logging	Mining		Manufacturing			Construction	Railways	Telephone	Personal Service	General Index
		Coal Mining	Metal Mining	All Manufacturing	Durable Goods	Non-Durable Goods					
1941	52.7	55.8	62.1	52.9	52.0	53.6	60.6	64.3	70.2	56.7	55.3
1942	58.2	57.7	65.7	57.6	57.7	57.5	64.4	67.5	73.9	59.7	59.9
1943	66.2	63.6	68.1	62.8	63.6	62.1	69.3	73.7	80.5	65.3	65.3
1944	67.6	74.5	69.2	64.9	65.6	64.4	70.4	73.7	80.8	66.1	67.4
1945	70.9	74.6	70.9	67.2	68.2	66.5	71.2	73.7	82.9	69.4	69.3
1946	77.4	74.8	75.1	74.1	74.5	73.8	78.1	82.0	82.6	75.6	75.9
1947	90.2	85.0	87.2	84.1	84.9	83.5	84.1	83.6	87.3	87.4	84.9
1948	101.2	98.4	95.7	94.5	94.7	94.4	95.7	100.0	92.7	92.7	95.7
1949	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1950	97.0	102.8	106.8	106.1	106.6	105.6	104.8	105.1	104.8	102.9	105.5
1951	109.6	111.1	121.6	120.3	121.7	118.8	118.6	121.9	115.7	110.6	119.1
1952	133.3	124.0	130.1	128.4	130.2	126.5	128.6	136.8	128.4	117.6	127.7
1953	135.5	124.0	132.3	134.6	136.3	132.8	136.2	137.2	136.6	123.3	133.6
1954	138.0	123.5	136.7	138.5	140.0	136.9	140.0	137.8	147.6	128.6	137.9
1955	138.2	122.8	140.3	142.2	143.7	140.7	145.4	137.8	152.8	132.3	141.7
1956	160.8	123.6	150.8	149.8	151.2	148.3	150.7	146.8	157.6	136.1	148.7
1957	168.4	137.4	156.2	158.6	160.7	156.3	160.7	153.3	165.9	138.9	156.5
1958	172.0	147.6	160.8	164.2	166.1	162.2	171.0	153.3	169.4	143.5	162.5
1959	176.2	147.3	164.3	168.9	170.8	167.0	180.7	165.7	175.3	146.1	168.8
1960	184.3	148.2	169.4	175.0	176.6	173.2	192.6	166.4	178.0	156.8	175.5
1961	190.8	154.5	173.9	179.5	180.3	178.7	196.3	176.5	188.0	158.8	180.0
1962	199.4	161.1	177.2	184.5	184.7	184.3	206.2	180.5	195.3	162.2	185.9
1963	208.2	155.6	182.0	190.5	190.6	190.4	214.1	185.9	200.2	171.1	192.5
1964	219.6	157.4	188.0	197.2	197.6	196.8	223.6	193.8	206.5	182.2	199.8
1965	239.0	166.7	195.0	207.0	207.8	206.0	235.2	201.3	212.3	195.4	210.1

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

TABLE 40

Average Weekly Wages and Hours of Hourly-Rated Employees in Canadian Mining, Manufacturing and Construction Industries, 1960-66

	1960	1961	1962	1963	1964	1965	1966P
Mining							
Average hours per week	41.7	41.8	41.7	42.0	42.2	42.5	42.3
Average weekly wage*	87.26	88.82	90.98	93.87	97.43	103.30	110.29
Metals							
Average hours per week*	41.9	41.8	41.5	41.5	41.7	41.9	41.6
Average weekly wage*	90.89	92.32	93.92	96.22	99.48	105.76	112.99
Fuels							
Average hours per week*	40.6	40.1	40.6	42.5	42.1	41.3	42.3
Average weekly wage*	80.13	77.62	80.77	85.10	86.98	89.07	95.68
Nonmetals							
Average hours per week*	42.2	41.1	41.1	41.1	41.7	42.7	42.1
Average weekly wage*	79.62	84.69	86.02	89.66	94.42	99.49	104.00
Manufacturing							
Average hours per week	40.4	40.6	40.7	40.8	41.0	41.0	40.8
Average weekly wage*	71.96	74.45	76.75	79.51	82.96	86.89	91.65
Construction							
Average hours per week*	40.4	41.4	41.1	41.2	41.4	41.4	42.0
Average weekly wage*	78.36	85.75	88.33	92.20	97.39	105.15	118.02

P Preliminary; * Revised back to 1961 inclusive.

TABLE 41

Average Weekly Wages of Hourly-Rated Employees in Canadian Mining Industry in Current and 1949 Dollars 1960 -1966

	1960	1961r	1962r	1963r	1964r	1965r	1966p
Current Dollars							
All mining	87.26	88.82	90.98	93.87	97.43	103.30	110.29
Metals	90.89	92.32	93.92	96.22	99.48	105.76	112.99
Gold	70.81	73.34	75.76	77.38	80.27	84.71	91.12
Fuels	80.13	77.62	80.77	85.10	86.98	89.07	95.68
Coal	69.36	70.65	73.86	79.25	80.84	80.68	85.53
Nonmetallics	79.62	84.69	86.02	89.66	94.42	99.49	104.00
1949 Dollars							
All mining	68.17	68.75	69.61	70.58	71.96	74.48	76.64
Metals	71.01	71.46	71.86	72.35	73.47	76.25	78.52
Gold	55.32	56.76	57.96	58.18	59.28	61.07	63.32
Fuels	62.60	60.08	61.80	63.98	64.24	54.22	66.49
Coal	54.19	54.68	56.51	59.59	59.70	58.17	59.44
Nonmetallics	62.20	65.55	65.81	67.41	69.73	71.73	72.27

The same figures for weekly wages as in Table 40 were used. "Other Metals" and oil and "gas" are not given in the 1966 monthlies. Average 1965 and 1966 figures for gold were obtained from monthly figures.

r Revised; p Preliminary.

TABLE 42

Industrial Fatalities in Canada per Thousand Paid Workers in Main Industry Groups *, 1953-1966

	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
Agriculture	1.00	0.82	0.83	1.03	0.95	1.00	0.92	0.62	0.61	0.56	0.48	0.72	0.48	0.54
Forestry	2.70	2.50	2.00	1.90	1.50	1.70	1.70	1.50	1.32	2.04	1.79	2.21	1.64	1.53
Fishing and Trapping	3.30	3.10	3.20	1.80	2.30	3.80	7.20	2.70	4.00	1.20	3.40	3.70	4.00	3.60
Mining*	2.00	2.00	1.60	2.10	1.50	2.20	2.00	1.92	1.73	1.89	2.33	1.87	1.24	1.13
Manufacturing	0.18	0.16	0.16	0.14	0.14	0.11	0.13	0.19	0.12	0.15	0.15	0.14	0.14	0.12
Construction	0.77	0.86	0.79	0.89	0.91	0.77	0.79	0.56	0.77	0.63	0.70	0.75	0.72	0.66
Transportation, Communication and other Utilities	0.46	0.53	0.56	0.56	0.50	0.40	0.44	0.37	0.36	0.38	0.42	0.43	0.49	0.41
Trade	0.09	0.08	0.07	0.08	0.09	0.05	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.05
Finance, Insurance and Real Estate	0.02	0.01	0.03	0.05	0.01	0.02	0.01	0.09	0.05	0.08	0.04	0.08	0.01	0.04
Service**	0.09	0.08	0.07	0.06	0.07	0.07	0.06	0.07	0.06	0.06	0.09	0.07	0.05	0.04
Total	0.33	0.32	0.32	0.33	0.30	0.27	0.28	0.21	0.22	0.22	0.23	0.24	0.23	0.19

*Includes quarrying and oil-well drilling.

* Data for years 1961-1965 were revised according to 1960 Standard Industrial Classification.

**Includes Public Administration.

TABLE 43

Strikes and Lockouts in Existence, 1965 and 1966

	1965			1966		
	Strikes and Lockouts	Workers Involved	Duration in Man-Days	Strikes and Lockouts	Workers Involved	Duration in Man-Days
Agriculture	—	—	—	—	—	—
Forestry	3	1,199	54,460	7	14,365	64,630
Mines	25	8,402	58,460	36	43,990	450,430
Manufacturing	244	97,017	1,470,770	297	95,616	1,971,930
Construction	127	19,357	237,240	149	45,360	296,250
Transportation and Utilities	55	32,532	331,210	56	161,973	1,664,830
Trade	25	11,183	154,600	30	1,976	32,840
Finance	—	—	—	1	12	20
Service	20	2,101	42,070	25	37,898	426,370
Public Administration	2	79	1,060	16	10,269	169,300
All industries	501	171,870	2,349,870	617	411,459	5,076,600

TABLE 44

Ore Mined and Rock Quarried in the Canadian Mining Industry, 1963 and 1964

(short tons)

	1963	1964
Metallic ores		
Gold quartz	12,618,059	12,757,577
Copper-gold-silver	19,764,023	20,201,393
Silver-cobalt	307,095	253,170
Silver-lead-zinc	6,385,357	8,923,216
Nickel-copper	17,624,435	20,419,111
Iron	60,071,192	72,795,146
Miscellaneous metals	7,693,024	5,901,375
Total	124,463,185	141,250,988
Nonmetallics		
Asbestos	45,738,901	50,032,255
Feldspar, nepheline syenite	367,664	390,336
Quartz (exclusive of sand)	743,008	1,506,574
Gypsum	6,082,297	6,420,038
Talc, soapstone	64,712	68,247
Rock salt	1,751,436	1,876,176
Other nonmetallics	3,376,053	4,693,733
Total	58,124,071	64,987,359
Structural materials		
Stone, all kinds quarried	62,655,329	69,794,358
Stone used to make cement	9,384,412	10,275,353
Stone used to make lime	2,703,709	2,710,253
Total	74,743,450	82,779,964
Total ore mined and rock quarried	257,330,706	289,018,311

TABLE 45

Ore Mined and Rock Quarried, Canadian Mining Industry, 1931–1964

(millions of short tons)

	Metal Mines	Industrial Mineral Operations	Total
1931	15.2	15.0	30.2
1932	14.0	8.2	22.2
1933	15.0	6.4	21.4
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	114.2	114.5	228.7
1963	124.5	132.8	257.3
1964	141.2	147.8	289.0

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TABLE 46

Cost of Prospecting by Metal Mining Industry, by Provinces and Types of Operations, 1963

$

	Placer Gold Operations	Gold Mines	Copper-gold silver Mines	Silver-cobalt Mines	Silver-lead-zinc Mines	Nickel-copper Mines	Iron Mines	Miscellaneous Metal Mines	Total
Newfoundland	3,304	84,625	88,601	—	483,702	—	223,576	14,294	898,102
Nova Scotia	—	12,201	117,184	—	58,142	—	—	88,881	276,408
New Brunswick	—	21,269	328,520	—	88,663	2,804	—	281,183	722,439
Quebec	3,299	2,787,178	7,925,089	1,925	493,307	2,408,984	752,551	1,419,179	15,791,512
Ontario	26,228	1,062,219	1,747,319	328,715	254,756	3,218,543	1,372,575	465,854	8,476,209
Manitoba	—	1,063	1,502,709	65,379	81,075	3,016,134	3,877	23,243	4,693,480
Saskatchewan	—	13,823	665,983	—	19,502	180,719	1,334	128,177	1,009,538
Alberta	—	18,850	55,892	—	201,204	—	—	88,433	364,379
British Columbia	174,989	285,223	4,442,302	114,572	1,928,269	659,548	253,247	672,036	8,530,186
Yukon	6,874	122,686	506,705	—	114,031	251,657	—	100,685	1,102,638
Northwest Territories	—	316,317	198,092	—	335,118	584,020	—	197,955	1,631,502
Total Canada	214,694	4,725,454	17,578,396	510,591	4,057,769	10,322,409	2,607,160	3,479,920	43,496,393

NOTE: The amounts shown are the expenditures incurred by 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 expends funds on prospecting for lead and zinc, such expenditures are included in the column headed 'Gold Mines' in this table.

TABLE 47

Cost of Prospecting by Metal-Mining Industry in Canada by Types of Operations, 1956-1963

$

	Placer Gold Operations	Gold Mines	Copper-gold-silver Mines	Silver-cobalt Mines	Silver-lead-zinc Mines	Nickel-copper Mines	Miscellaneous Metal Mines*	Total
1956	31,620	4,264,955	18,315,885	111,102	3,571,201	13,310,337	8,795,159	48,400,259
1957	75,468	3,370,252	17,545,591	9,065	2,781,917	12,220,660	18,421,466	54,424,419
1958	91,461	2,246,360	10,239,495	10,396	1,351,065	13,894,699	4,673,610	32,507,086
1959	65,139	3,649,286	22,226,933	87,883	1,559,613	8,512,264	6,916,517	43,017,635
1960	118,805	3,814,541	19,105,258	26,808	5,602,547	9,411,381	5,474,270	43,553,610
1961	99,484	3,663,420	18,367,148	95,958	7,051,755	8,827,546	5,379,760	43,485,071
1962	100,835	4,995,265	13,353,408	47,553	9,507,288	10,420,395	5,365,397	43,790,141
1963	214,694	4,725,454	17,578,396	510,591	4,057,769	10,322,409	6,087,080	43,496,393

*Includes iron, uranium, molybdenum mining, etc.

NOTE: See general footnote Table 46.

TABLE 48

Diamond Drilling on Canadian Metal Deposits by Mining Companies with Own Equipment and by Drilling Contractors 1951-1963

(footage)

	Gold-quartz deposits	Copper-gold-silver and nickel-copper deposits	Silver-lead-zinc deposits	Other metal-bearing deposits	Total metal deposits
1951	2,925,354	4,149,047	1,510,158	355,067	8,939,626
1952	2,651,722	3,894,437	1,496,542	183,833	8,226,534
1953	2,216,528	3,203,785	1,206,902	214,171	6,841,386
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

*Includes iron, chromite, titanium, uranium, molybdenum deposits.

TABLE 49

Exploration, Diamond Drilling Canadian Metal Deposits, 1951-1963

(footage)

	By Mining Companies with Own Personnel and Equipment	By Diamond Drill Contractors	Total
1951	1,207,398	3,616,338	4,823,736
1952	1,366,363	3,120,419	4,486,782
1953	1,046,490	2,863,084	3,909,574
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

TABLE 50

Contract Diamond Drilling Operations in Canada, 1955–65

	Footage Drilled	Income from Drilling	Average Number of Employees	Total of Salaries and Wages
	ft.	$ millions	number	$ millions
1955	6,443,641	21.4	2,840	9.9
1956	7,840,670	27.6	3,415	12.6
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

TABLE 51

Contract Drilling in Canada for Oil and Gas, 1955–63

	Footage Drilled (feet)				Gross Income from Drilling $ millions	Average Number of Employees number	Total Salaries and Wages $ millions
	Rotary	Cable	Diamond	Total			
1955	12,711,953	344,053	–	13,056,006	68.3	4,901	22.3
1956	15,424,310	376,663	–	15,800,973	93.3	5,793	28.8
1957	12,126,069	369,277	–	12,495,346	75.6	5,468	25.7
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

TABLE 52

Crude Minerals* Transported by Canadian Railways, 1965 and 1966

	1965 000's short tons	1966 000's short tons
Coal		
Anthracite	774	720
Bituminous	10,595	10,041
Iron ore	38,906	39,261
Aluminum ores and concentrates	2,351	2,864
Copper ores and concentrates	1,297	1,313
Copper-nickel ores and concentrates	4,102	4,034
Lead ores and concentrates	791	548
Zinc ores and concentrates	2,146	2,113
Ores and concentrates, other	822	682
Barite	27	38
Clay and bentonite	522	543
Sand	1,072	1,198
Sand and gravel	6,228	5,737
Stone, crushed and ground	6,123	6,080
Stone, fluxing and dolomite	813	689
Stone, rough	34	33
Stone, dressed	20	25
Petroleum, crude	255	295
Salt	1,452	1,282
Phosphate rock	1,425	1,799
Sulphur	2,057	1,984
Asbestos	1,175	1,253
Gypsum, crude	4,710	4,491
Products of mines, other	1,512	1,475
Total	89,209	88,498
Total revenue freight moved by Canadian railways	205,197	213,967
Crude minerals as a percentage of total revenue freight moved by Canadian railways	43.5	41.4

*Domestic and imported.

TABLE 53

Crude Minerals* Transported by Canadian Railways 1956-1966

(millions of short tons)

	Total of Revenue Freight	Total of Crude Minerals	Crude Minerals as a % of Revenue Freight
1956	189.6	75.7	39.9
1957	174.0	70.8	40.6
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	214.0	88.5	41.4

*Domestic and imported.

TABLE 54

Fabricated Mineral Products* Transported by Canadian Railways, 1965 and 1966

	1965 000's short tons	1966 000's short tons
Aluminum: bar, ingot, pig, shot	599	675
Aluminum metal, other	118	134
Copper: ingot and pig	521	522
Copper, brass and bronze, other	249	275
Lead and zinc: bar, ingot, pig	549	584
Lead and zinc, other	8	15
Alloys for manufacture of steel	148	160
Metals and alloys,other	138	129
Iron, pig	309	258
Iron and steel: billet, bloom, ingot	549	513
Iron and steel: bar rod, slab	539	492
Iron and steel, other	104	59
Matte	302	258
Furnace slag	455	274
Cement, natural and portland	1,973	2,041
Cement, other	59	70
Brick, common	98	88
Brick, other and building tile	158	150
Refractories	270	332
Artificial stone	82	97
Lime	635	654
Plaster: stucco and wall	91	87
Sewer pipe and drain tile	19	10
Broken brick and crockery	16	17
Gasoline	2,789	2,828
Fuel oil and petroleum oil	4,159	4,268
Lubricating oils and greases	360	381
Petroleum products, refined	1,469	1,908
Coke	1,941	1,979
Asphalt	331	312
Total	19,038	19,570
Total all revenue freight	205,197	213,967
Fabricated minerals as a per cent of total freight	9.3	9.1

*Domestic and imported.

TABLE 55

Crude and Fabricated Minerals* Transported Through Canadian Canals**, 1965

	1965 000's short tons
Crude Minerals	
Alumina and bauxite	228
Copper ore, concentrates, matte, precipitates	–
Iron ore, crude, concentrated, calcined	28,900
Lead ore and concentrates	3
Manganese ore	260
Nickel-copper ore, matte, concentrates	–
Titanium ore	–
Zinc ore and concentrates	–
Ores, concentrates, precipitates, n.e.s.	47
Iron and steel scrap	249
Nonferrous and precious metal scrap	26
Slags, drosses, etc.	32
Coal, bituminous, subbituminous, lignite	8,254
Coal, n.e.s.	2
Crude petroleum and natural gasoline	104
Natural gas and other crude bituminous substances	9
Asbestos, unmanufactured	7
Bentonite	210
China clay	46
Clay and other crude refractory materials, n.e.s.	113
Sand and gravel	314
Limestone	231
Crushed stone, including stone refuse, excluding limestone	763
Stone, crude n.e.s.	108
Fluorspar	251
Gypsum	239
Salt	1,055
Sulphur in ores, crude and refined	10
Crude nonmetallic minerals, n.e.s.	66
Total crude minerals	41,527
Fabricated Minerals	
Gasoline	644
Fuel oil	3,550
Lubricating oils and greases	410
Coke of petroleum and coal	383
Asphalt and road oils	9
Coal tar and coal pitch	122
Petroleum and coal products, n.e.s.	130
Ferroalloys	174
Pig iron	643
Primary iron and steel, n.e.s.	63
Castings and forgings (ex. pipes and fittings)	22
Bars and rods, steel	1,345
Plate, sheet, strip, steel	2,866
Structural shapes and sheet piling	1,490
Rails and railway track material	8
Pipes and tubes, iron and steel	73
Wire and wire rope	189
Aluminum, incl. alloys	83
Copper and alloys	15
Lead and alloys	2
Nickel and alloys	8
Zinc and alloys	2
Nonferrous metals, n.e.s.	30
Metal fabricated basic products	267
Bricks, tiles and refractories	4
Glass basic products	101
Asbestos and asbestos cement basic products	4
Cement	234
Nonmetallic basic products, n.e.s.	76
Total fabricated minerals	12,947
Total Crude and Fabricated Minerals	54,474
Total All Freight Transported	99,395
Per Cent Crude and Fabricated Minerals of Total Freight	54.8

* 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.

TABLE 56
Crude Minerals * and Fabricated Mineral Products * Transported by Motor Transport ** , 1965

	1965 Weight of Goods Carried
	000's short tons
Crude Minerals	
Ores and concentrates	1,140
Coal	2,372
Sand and gravel	55,139
Stone, crude	10,784
Other crude nonmetallic minerals	7,404
Total	76,839
Fabricated Minerals	
Gasoline	6,978
Fuel oil	8,097
Asphalt and road oil	4,681
Petroleum and coal products	7,691
Iron and steel and alloys and metal fabricated basic products	6.446
Bricks, clay, building	341
Cement and concrete basic products	8,717
Miscellaneous nonmetallic basic products	2,513
Total	45,464
Total crude and fabricated minerals	122,303
Grand total all products	238,163
Per cent crude and fabricated minerals of total freight	51.4

* Domestic and imported.
** Includes private and for-hire inter-city motor transport. Excludes freight carried by urban transport.

TABLE 57
Quantities* of Petroleum and Petroleum Products and Gas (Manufactured and Natural) Transported by Pipeline 1953-1966

	Petroleum and Petroleum Products			Gas		
	Domestic Sales millions of bbl.	Export Sales millions of bbl.	Total millions of bbl.	Domestic Sales 000 Mcf	Export Sales 000 Mcf	Total 000 Mcf
1953	144.5	2.8	147.3	84,500e	9,408	93,908
1954	156.8	15.7	172.5	102,500e	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	86,972	298,723
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	568,654	403,909	972,563
1966	406.5	129.7	536.2	636,146	426,224	1,062,370

*Both domestic and imported; eEstimated.

TABLE 58

Taxes* Paid to Federal, Provincial and Municipal Governments in Canada by Six Important Divisions of the Mineral Industry, 1964

$

	Federal Income Tax	Provincial Tax	Municipal Tax	Total
Auriferous-quartz mining	2,234,928	2,054,364	893,124	5,182,416
Copper-gold-silver mining	16,008,384	7,590,599	2,367,864	25,966,847
Silver-lead-zinc mining and smelting	..	..	..	..
Nickel-copper mining, smelting and refining	30,684,922	14,701,774	2,370,337	47,757,033
Iron mining	1,277,759	3,480,144	1,371,148	6,129,051
Asbestos mining	12,561,744	5,730,837	2,007,759	20,300,340
Total				

* 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.

The amounts paid in 1964 refer only to taxes paid by producing mines.

.. Not available.

TABLE 59

Taxes(a) Paid by Six Important Divisions of the Canadian Mineral Industry, 1959-1964

($ millions)

	1959	1960	1961	1962	1963	1964(b)
Auriferous-quartz mining	7.0	6.5	7.0	6.1	6.5	5.2
Copper-gold-silver mining	13.0	19.7	20.1	15.2	20.3	26.0
Silver-lead-zinc mining and smelting	12.2	15.3	15.7	17.7	20.5	..
Nickel-copper mining, smelting and refining	12.1	41.0	38.2	51.6	35.9	47.8
Iron mining	4.4	6.6	5.6	7.5	11.0	6.1
Asbestos mining	12.1	14.2	16.8	18.4	18.6	20.3
Total	60.8	103.3	103.4	116.5	112.8	

(a) see footnote Table 58.
(b) taxes paid by producing mines only.
.. Not available.

TABLE 60

Federal Income Tax Declared by Companies in Mining and Selected Related Manufacturing Industries in Canada, Fiscal Years Ended March 31, 1963 and 1964

($ millions)

	1963	1964
Mining, quarrying and oil wells		
Gold Mining	3.5	2.1
Other metal mining	55.4	80.0
Coal mines	0.8	0.3
Oil and natural gas	21.8[r]	10.3
Other nonmetal mines	12.5	12.2
Quarries	1.5	2.0
Mining unclassified	0.2	0.1
Prospecting and contract drilling	4.2	4.2
Total	99.9[r]	111.2
Metallurgical and metal fabricating industries		
Iron and steel mills	40.5	20.5
Iron foundries	3.6	7.1
Metal smelting and refining	8.4	20.3
Boilers and fabricated structural material	2.5	3.5
Metal stamping, pressing, coating	10.1	11.8
Wire and wire products	4.0	4.1
Miscellaneous metal fabricating	7.1	8.3
Total	76.2	75.6
Nonmetallic mineral products		
Cement, clay and stone products	19.9	21.2
Glass and nonmetallic minerals	9.7	11.0
Fertilizers and industrial chemicals	15.6	17.8
Total	45.2	50.0
Petroleum and coal products		
Petroleum refineries	30.6	32.9
Other petroleum and coal products	0.6	0.9
Total	31.2	33.8
Total mining and related industries	252.5[r]	270.6
Grand total, all industries	1,450.9[r]	1,621.3

[r] Revised.

TABLE 61

Capital and Repair Expenditure of the Canadian Mining Industry, 1965, 1966 and 1967

($ million)

	1965			1966p			1967f		
	Capital	Repair	Total	Capital	Repair	Total	Capital	Repair	Total
Metal Mines									
Gold mines	6.9	9.1	16.0	5.3	8.1	13.4	3.9	7.4	11.3
Silver-lead-zinc mines	40.5	6.9	47.4	31.4	8.6	40.0	22.8	8.2	31.0
Iron mines	66.2	61.9	128.1	131.0	70.8	201.8	109.8	69.0	178.8
Other metal mines*	87.2	44.4	131.6	170.0	46.7	216.7	139.0	49.2	188.2
Total metal mines	200.8	122.3	323.1	337.7	134.2	471.9	275.5	133.8	409.3
Nonmetal Mines									
Quarries and sandpits	13.7	15.5	29.2	12.8	14.6	27.4	11.1	13.3	24.4
Other nonmetallic minerals	79.0	35.5	114.5	156.9	37.8	194.7	205.0	39.3	244.3
Total nonmetal mines	92.7	51.0	143.7	169.7	52.4	222.1	216.1	52.6	268.7
Mineral Fuels									
Coal mines	3.7	7.2	10.9	3.1	8.5	11.6	2.0	8.8	10.8
Petroleum & gas wells**	437.6	42.2	479.8	483.4	52.2	535.6	507.7	56.1	563.8
Total mineral fuels	441.3	49.4	490.7	486.5	60.7	547.2	509.7	64.9	574.6
Total mining	734.8	222.7	957.5	993.9	247.3	1,241.2	1,001.3	251.3	1,252.6

p Preliminary; f Forecast.
* Includes copper-gold-silver, nickel-copper, silver-cobalt, uranium and other metal mines. ** Includes Natural Gas Processing Plants and Contract Drilling for Petroleum and Gas.

TABLE 62

Capital Investment in the Canadian Petroleum and Natural Gas Industries[a] 1948-1967

($ millions)

	Exploration	Development and Production	Oil[e] Pipelines	Gas Transmission Pipelines	Gas Processing	Petroleum Refining	Marketing		Capital Investment in Canada	
							Oil[c]	Gas[d]	Petroleum and Natural Gas Industry	All Industries
1948	(b)	37.3	4.3	–	–	32.6	9.7	3.8	87.7	3,087
1949	(b)	45.0	7.7	–	–	21.6	11.3	4.3	89.9	3,539
1950	(b)	53.9	55.0	–	–	24.1	16.7	6.6	156.3	3,936
1951	(b)	72.1	10.7	–	–	50.9	18.1	6.8	158.6	4,739
1952	59.8	101.6	91.9	2.7	1.3	60.5	25.0	6.3	349.1	5,491
1953	59.1	107.2	75.7	3.8	0.7	66.1	36.7	11.2	360.5	5,976
1954	55.1	126.8	63.5	1.6	8.5	83.9	46.3	9.7	395.4	5,721
1955	67.4	201.6	28.5	17.5	2.9	102.9	56.5	9.4	486.7	6,244
1956	73.7	252.4	43.5	133.6	10.5	79.1	68.5	46.6	707.9	8,034
1957	77.3	237.8	68.0	242.1	34.5	81.5	74.9	69.8	885.9	8,717
1958	62.4	181.5	23.6	214.8	40.1	94.9	63.6	79.4	760.3	8,364
1959	51.0	191.9	10.7	48.5	24.4	95.0	73.1	89.8	584.4	8,417
1960	50.4	209.1	18.3	80.6	19.4	59.2	68.1	62.9	568.0	8,262
1961	47.7	182.4	49.3	115.5	76.6	31.2	56.0	59.3	618.0	8,172
1962	53.9	182.7	20.8	51.4	21.8	64.8	47.7	69.3	512.4	8,715
1963	58.9	216.2	26.0	81.9	53.6	44.2	53.0	84.1	617.9	9,393
1964	59.7	262.7	29.0	135.1	40.6	23.9	48.3	68.3	667.6	10,944
1965	70.2	388.1	52.5	59.6	41.5	39.8	55.2	72.5	779.4	12,865
1966[p]	80.6	424.3	79.4	74.7	50.1	64.9	69.5	85.0	928.5	14,897
1967[f]	97.6	390.7	57.0	112.1	107.8	66.6	103.6	83.8	1,019.2	15,103

(a) The petroleum and natural gas industries in this table include all companies engaged in whole or in part in oil and gas industry activities. The investment data under "Petroleum and Natural Gas" in Tables 63, 64 and 65 apply only to companies whose main revenues are derived from oil and gas activities.

(b) Capital investment in exploration prior to 1952 is included in the Development and Production Column.

(c) Capital investment in this item includes chiefly outlets reported by major companies.

(d) Capital expenditures in gas marketing are for gas – distribution pipelines.

(e) Capital investment in oil pipelines includes small expenditures for rail and water transport.

p Preliminary; f Forecast; – Nil.

TABLE 63

Ownership of Canadian Mining and Metallurgical Industries — Year End 1962 and 1963

($ millions)

	Estimated Total Investment	Investment Owned In			
		Canada	USA	UK	Other
1962					
Petroleum and natural gas*	6,922	2,538	3,662	355	367
Mining, other	2,595	875	1,562	95	63
Smelting and refining nonferrous ores	1,042	465	436	89	52
Iron and steel mills	938	691	151	59	37
1963					
Petroleum and natural gas*	7,295	2,592	3,945	380	378
Mining, other	2,743	949	1,639	77	78
Smelting and refining nonferrous ores	1,066	513	415	84	54
Iron and steel mills	874	696	70	65	43

* Data apply to companies whose main revenues are derived from oil and gas activities.

TABLE 64

Estimated Book Value and Ownership Capital Employed in Selected Canadian Industries 1955, 1962 and 1963

($ billions)

	1955	1962	1963
Total capital employed			
Manufacturing	8.9	13.1	13.7
Petroleum and natural gas*	3.0	6.9	7.3
Other mining and nonferrous smelting and refining	2.1	3.6	3.8
Railways	4.2	5.4	5.3
Other utilities	5.8	10.6	12.2
Merchandising and construction	6.6	9.5	9.8
Total	30.5	49.2	52.1
Resident owned capital			
Manufacturing	4.7	6.0	6.2
Petroleum and natural gas*	1.1	2.5	2.6
Other mining and nonferrous smelting and refining	1.0	1.3	1.5
Railways	2.8	4.1	4.1
Other utilities	5.0	9.2	10.6
Merchandising and construction	6.0	8.5	8.8
Total	20.6	31.8	33.8
Nonresident owned capital			
Manufacturing	4.2	7.1	7.4
Petroleum and natural gas*	1.9	4.4	4.7
Other mining and nonferrous smelting and refining	1.1	2.3	2.3
Railways	1.4	1.3	1.2
Other utilities	0.7	1.3	1.5
Merchandising and construction	0.6	1.0	1.0
Total	9.9	17.4	18.3

* The investment data under "petroleum and natural gas" apply only to companies whose main revenues are derived from oil and gas activities.

Note: Owing to rounding, figures do not add to totals in all cases.

TABLE 65

Foreign Capital Invested in the Canadian Mineral Industry
Selected Years (end of year) 1930–1964

($ millions)

	1930	1945	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964
Owned by all nonresidents												
Mining and nonferrous smelting and refining	311	356	1,121	1,330	1,570	1,657	1,783	1,977	2,094	2,297	2,347	2,473
Petroleum and natural gas*	150	160	1,854	2,275	2,849	3,187	3,455	3,727	4,029	4,384	4,703	4,786
Owned by United States residents												
Mining and nonferrous smelting and refining	234	277r	975	1,129	1,307	1,386	1,513	1,701	1,821	1,998	2,054	2,115
Petroleum and natural gas*	147	152r	1,716	2,063	2,570	2,866	3,108	3,184	3,444	3,662	3,945	3,964

* Data apply only to companies whose main revenues are derived from oil and gas activities. rRevised.

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