MINERAL REPORT 7

The Canadian Mineral Industry, 1960

Mineral Resources Division
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Foreword

This volume contains reviews of fifty-seven metallic minerals, industrial minerals and mineral fuels produced or consumed in commercial quantities in Canada during 1960. These reviews are preceded by a general article dealing with the overall economic and technical factors characteristic of the mineral industry during the year. The text is supported by sixteen maps, forty-five graphs and more than two hundred statistical tables.

The report is the continuation of a series of similar publications forming an historical record of the industry as far back as 1886. As in the past, it is based on preliminary reviews issued as separates shortly after the year concerned.

The contents were prepared by the Mineral Resources Division and the Mines Branch of the Department of Mines and Technical Surveys drawing on information obtained in field and office studies. The statistics on Canadian production, trade and consumption are final and were collected on behalf of the Department by the Dominion Bureau of Statistics, except where otherwise indicated or where company data are concerned. The statistics on company operations were supplied directly to the Department by company officials or obtained from company annual reports. Market quotations are mainly from standard marketing reports issued in Montreal, London or New York.

The Department is indebted to all who contributed information, in particular to mine operators, petroleum and gas producers and others connected with the mineral industry.

W. Keith Buck,
Chief,
Mineral Resources Division

Summary

PART I

A REVIEW OF THE MINERAL ECONOMY

Introduction

This summary is designed to provide a brief survey of the progress made and the problems faced by the Canadian mineral industry in 1960, to point to trends, and to indicate the importance of the industry in the national economy. Part I consists of descriptive analyses of developments; Part II consists of statistical analyses set out in 58 tables. Within Part I an introductory section on the year's progress and problems is followed by brief surveys of each of the principal mineral commodities. Then attention is directed toward the trends of the industry and its importance in the Canadian economy. At the same time, reference is made to the statistical tabulations in Part II, which are arranged in 11 sections covering each of the several sectors of the mineral economy.

It is intended that this summary form part of the mineral-industry review series for 1960, which includes individual reviews of each of 57 mineral commodities.

Progress and Problems

The year 1960 started out well for the Canadian mineral industry. The demand for minerals in most markets of the world was good, and Canadian producers of such major metals as iron, nickel, copper, lead, zinc, and aluminum increased their production and shipments during the first few months. Subsequently, mixed trends in demand developed as buyers changed their purchasing programs, and the result was a falling-off in the demand for iron ore and aluminum and a slight slackening in lead and zinc sales. The nickel and asbestos markets, however, continued to improve. For the year as a whole, Canadian mineral production registered a 3.5-per-cent increase, its value advancing from the 1959 total of $2,409 million to $2,492.5 million. This gain was moderate compared with that of 1959, which amounted to 14.6 per cent. Table 1 shows that metallic-mineral output rose slightly and accounted for 56 per cent of the value of all mineral production. The output of industrial minerals, including nonmetallics and structural materials, was very little above the 1959 level. It accounted for 21 per cent.

Fuels accounted for 23 per cent and showed a 5.6-per-cent increase over their 1959 total.

Canada's mineral industry depends greatly on export markets. The United States in recent years has taken about two thirds of the minerals exported. In 1960, however, this market accounted for little more than half the export total, while Canadian mineral products found greater outlets in the buoyant economies of western Europe. As the United States demand for Canadian minerals slackened, there were compensating increases in the European demand for aluminum, nickel, copper, zinc, and asbestos. These gains were one of the industry's 1960 highlights.

Canadian losses in United States mineral markets became more noticeable as the year progressed. Lead and zinc continued to face the quota restrictions in effect since October 1958. Uranium, nickel, and aluminum suffered as a result of changes in buyers' contracts. Copper sales declined because of oversupply and an import tax. Iron-ore shipments dropped sharply in September with the onset of a recession in the United States steel industry. The most significant market losses were those that affected iron ore and uranium. Canadian iron-ore producers had become so dependent on United States markets that the cutback could not be offset by market expansion overseas. Furthermore, Canadian suppliers suffered more severe cutbacks than suppliers in other countries. The full impact on the uranium industry of the decision made by the United States Atomic Energy Commission in November 1959 began to be felt by mid-1960. Because of this decision, options on the purchase of additional quantities of Canadian uranium after the expiry of sales contracts will not be renewed. Uranium output dropped 20 per cent in 1960, and the industry passed through an intensive period of consolidation. At the end of the year it had only 10 mines in operation instead of 23, as in 1959, when operations were at their height.

In the fuels sector, the approval given by government agencies in both Canada and the United States to large-scale exports of natural gas to the growing markets of the United States west coast and mid-western areas was another of the year's highlights. The declaration of a National Oil Policy in the face of increasing difficulties in the marketing of crude oil indicated the beginning of a new era in oil-marketing. The most serious difficulties were those faced by the coal industry as it prepared for further mine closures. The Royal Commission on Coal completed its hearings during the year and recommended that the present transportation subventions be replaced by financial assistance in the form of direct subsidies.

In the industrial-minerals sector, asbestos shipments, which account for about 60 per cent of nonmetallics production, increased in value by 13 per cent; but there is a threat of major competition from the Union of Soviet Socialist Republics, which now has a comparable output. Progress in potash-mining development gives promise of new mineral production based on the large resources of Saskatchewan. Sand and gravel and cement, which account for two thirds of the structural-materials output, were kept close to their 1959 levels despite a cutback in construction activity that occurred in the latter part of the year.

Developments in individual mineral commodities, as reviewed briefly in the following section and at greater length in the 1960 mineral-review series, take on added significance in a world context. The swing in market emphasis from the United States to western Europe is of particular importance; and the forces behind it, including those due to the decline in North American economic activity and the continuation of buoyancy in western Europe, indicate future trends. Throughout the world during 1960 the expansion of mineral capacity continued despite the decline in the mineral requirements of the United States and a levelling-off in growth elsewhere. Surpluses developed and resulted in major increases in stocks and downward pressures on mineral prices. As the demand within its borders decreased, the United States began to move more of its mineral products into world markets. Furthermore, the rising demand in areas outside the United States, which had been much in evidence in 1959 and had continued into the first half of 1960, stimulated mineral production in Africa and South America. Copper and aluminum, in particular, were made available in increasing quantities, while lead and zinc in overseas areas showed a moderate increase. The world increase in the mineral supply began to make itself felt in the latter half of the year as the United States' demand declined and its surplus capacity increased. Competition in the world's markets intensified as the United States and other surplus-capacity countries began to seek new outlets. Later in the year, a levelling-off in United Kingdom industrial activity added further supply pressure on the world market while capacity continued to increase. By the end of the year, inevitable price reductions affecting the principal nonferrous metals began to occur in the United States. The year ended with world oversupply in the ferrous, nonferrous, and petroleum sectors.

World supply has considerably outstripped demand because of the extensive investment made in mineral development in recent years. World oversupply now requires that Canadian producers cut production costs in every way possible and apply the most efficient and progressive methods in production and marketing. Notwithstanding the situation, the Canadian mineral industry has a stability that will stand it in good stead amid rapid and unforeseen changes in the pattern of supply and demand.

As 1960 drew to a close, a major problem was that of maintaining and extending the trade diversification achieved during the year through an increase in exports to Europe. Of the year's exports of raw and semiprocessed minerals, the United Kingdom received 21 per cent and the countries of the European Common Market 11 per cent instead of 17 and 7 per cent respectively as in 1959. At the same time, however, there was some concern in Canada about the possible short-term effect of European Common Market developments on the marketing prospects for Canadian minerals. On the other hand, the economic growth expected of a more unified Europe held promise of greater long-term markets for the Canadian mineral producer.

Mineral-commodity Highlights of 1960

Metals

The value of metallic-mineral production for 1960 was $1,407 million. Six minerals - nickel, uranium, copper, iron ore, gold, and zinc, in that descending order of value - accounted for 90 per cent of the total. Although these six minerals dominate metallics, there is growing diversification of mineral output. The only significant reversal in growth trends among the minor metals in 1960 was the one that concerned cobalt.

Nickel

In 1960, nickel output was greater by 27,951 tons, or 15 per cent, than in 1959. Nickel production in Canada thus made an all-time record, and its value was second only to that of petroleum. Although demand in the United States was lower than normal, it was extremely high throughout the world and particularly so in Europe. For the first time in history, Canada exported more nickel to Europe than to the United States. A $31.5-million increase in the value of all nickel exports despite a $25.4-million decline in United States sales exemplified the marked change that had occurred in the direction of export trade. The Canadian price of electrolytic nickel at Port Colborne, Ontario, remained at 70 cents a pound throughout the year but increased to 72.75 cents on January 1, 1961.

Because of the high world demand, all nickel-producing mines in Canada operated at maximum capacity. The International Nickel Company of Canada, Limited, produced from its five mines in the Sudbury area of Ontario. Development work continued at the Crean Hill mine and was started at the Clarabelle open pit and the Copper Cliff north property. Construction work at the Thompson property in northern Manitoba continued and initial production of electrolytic nickel was planned for early 1961. The rated annual capacity at Thompson is 75 million pounds of nickel, though ultimate production may exceed this considerably. Falconbridge Nickel Mines, Limited operated its six Sudbury-area mines and treated custom ore from Norduna Mines Limited. Shaft and development work began on the large Strathcona deposit. Work is continuing on Falconbridge's iron-recovery plant and on the refinement of plant operations. Sherritt Gordon Mines, Limited operated at capacity and started to produce strip, rod, and wire in its powder-rolling plant at Fort Saskatchewan, near Edmonton, Alberta. North Rankin Nickel Mines Limited continued to ship nickel-copper concentrates to Sherritt Gordon's Fort Saskatchewan refinery. Giant Nickel Mines Limited maintained its shipments of nickel-copper concentrates to Japan. Although Cuban nickel production was lost to the Free World in 1960, Canada's nickel-producing capacity assures an ample and continuing supply for growing Free World needs.

Copper

Copper production reached an all-time high of 439,262 tons in 1960, or 43,993 tons more than the 1959 total. Its value, $264.8 million, was $31.7 $31.7 million, or 13.6 per cent, higher than in 1959.

World supplies of copper were reduced late in 1959 by the work stoppages at copper mines in the United States. Early in 1960, after settlement of the strikes, production was accelerated and by mid-year had outstripped demand. Production was high in other major copper-producing countries, as was copper consumption in Europe. A 44-per-cent increase in Canadian copper exports to western Europe, combined with moderate increases to other export markets for copper, raised Canada's exports of this metal by $53.8 million to $206.7 million. Prices were well maintained until mid-year, when the increasing world inventory of copper put pressure on the speculative prices. Prices fell initially in Europe and Canada but not until October in the United States. The price of copper in Canada fluctuated between a high of 31 cents a pound and a low of 28.5 cents and averaged 30.24 cents a pound for the year.

Activity increased in all segments of Canada's copper industry except the domestic consumption of refined copper, which decreased by 12,336 tons. The smelting and refining segments of the domestic industry operated at capacity for the year. Six smelters treated copper and copper-nickel ores and concentrates, and two refineries treated blister copper.

Exploration for new properties and development of known deposits kept pace with expanding production. Four companies started production from new mines in Quebec - Copper Rand Chibougamau Mines Ltd. (Copper Rand mine), Chibougamau Jaculet Mines Limited, Portage Island (Chibougamau) Mines Limited, and Campbell Chibougamau Mines Ltd. Hudson Bay Mining and Smelting Co., Limited, started production from the Coronation mine in Saskatchewan and the Chisel Lake mine in Manitoba. Mine-development work done in 1960 led to plans for production in 1961 or early 1962 as follows: in Newfoundland, at the mine of Atlantic Coast Copper Corporation Limited; in New Brunswick, at the Wedge property of The Consolidated Mining and Smelting Company of Canada Limited; in Quebec's Eastern Townships, at the property of Solbec Copper Mines, Ltd.; in northwestern Ontario, at Kam-Kotia Porcupine Mines, Limited; on the northern part of Vancouver Island, at the Benson Lake mine of Coast Copper Company Limited; and on the southern part of Vancouver Island, at the Sunro property of Cowichan Copper Co. Ltd.

Selenium and Tellurium

The production of selenium increased by 154,000 pounds over the 1959 total to 522,000 pounds, and the value of output rose by $1,075,000 to over $3.6 million. Selenium is produced at Canada's two copper refineries, where it is recovered from the tankhouse slimes resulting from the electrolytic refining of copper anodes. Domestic consumption of selenium decreased to 14,461 pounds from the 22,156 pounds used in 1959. Exports increased, being 78,698 pounds higher in 1960 than in 1959. Originally employed in the glass, rubber, and alloy-steel industries, selenium has been used increasingly for the manufacture of dry-plate rectifiers.

Tellurium, like selenium, is obtained as a by-product of the electrolytic refining of copper. Increased interest in the use of tellurium in the manufacture of thermoelectric units brought about a sharp boost in tellurium production.

Tellurium is also used in the rubber, alloy-iron, and nonferrous-alloy industries. Production in all forms in 1960 totalled 45,000 pounds valued at $156,000, or 32,000 pounds and $128,000 more than in 1959. The price of commercial-grade tellurium rose from $2.50 a pound in January to $4 a pound in September.

Uranium

In 1960, because of declining markets, the uranium industry underwent considerable readjustment. Production was 25 per cent less than in the previous year. After being first in value among the metallic-mineral commodities in 1959, uranium dropped in 1960 to second place, having fallen behind nickel.

Nine mines were closed in 1960 in consequence of company amalgamations and the transfer of contracts permitted under the stretch-out plan announced late in 1959. By the end of the year only 11 mines were in operation. Mine closures reduced the number of employees from 11,792 at the beginning of 1960 to a year-end total of about 6,000.

Canada's uranium-ore reserves of all types were estimated at 296,175,000 tons grading 0.12 per cent U_3O_8. Equivalent to about 320,000 tons of recoverable uranium oxide, these reserves are considered the world's largest. Ninety-six per cent of them are in Ontario's Elliot Lake district.

Ninety per cent of Canada's 1960 uranium production was sold to the United States Atomic Energy Commission, and slightly less than 10 per cent was shipped to the United Kingdom. The balance was made up of small shipments to India, West Germany, Japan, Switzerland, and other countries.

The year 1960 saw an intensification of research into the lowering of production costs and the development of new industrial uses for uranium. Laboratory experiments have shown that the addition of small amounts of uranium improves the quality of certain types of steel. Industrial research into this and other nonnuclear uses of uranium will be continued to help close the gap between Canada's uranium-production capacity and the reduced demand that has resulted from the termination of contracts with the United States Atomic Energy Commission. The Commission decided late in 1959 not to renew Canadian sales contracts expiring in 1962 and 1963, and the developments that occurred within the uranium industry in 1960 reflected that decision.

The year's activities in nuclear energy included the continuation of construction work on the 20,000-kilowatt experimental nuclear power plant, NPD-2, near Rolphton, Ontario, and the start of work on the CANDU plant at Douglas Point, on Lake Huron. CANDU will be Canada's first full-scale nuclear power station.

Iron Ore

The 19.2 million long tons of iron ore shipped by producers in 1960 were 12.0 per cent lower than the total shipped in the record year 1959. The main reason for this decrease was the recession in the steel industry of the

United States, Canada's principal iron-ore customer. Production value declined 9.1 per cent to $175.1 million. Prices remained constant, but the grade of ore shipped rose slightly. Thus the value declined proportionally less than the volume. Reaching an all-time high, exports to western Europe and Japan helped to offset the decrease in shipments to the United States. The result was that the total value of exports declined by only $2.3 million to $155.5 million. Exports to western Europe were valued at $44.1 million, or 28.4 per cent of the export total. In 1959 they amounted to 22.1 per cent.

Twelve mines produced iron ore in 1960. During the year, one new producer in Ontario commenced shipments and one small mine in British Columbia ceased operation. Two companies in Ontario and one in Quebec produce iron by-products that are not included in iron-ore-production statistics.

The opening of the St. Lawrence Seaway in 1959 brought a major change in the iron-ore shipping pattern, which has resulted in lower transportation costs to some market areas. By 1970, as much as 25 million tons of iron ore from Labrador-Quebec is expected to be shipped through the Seaway annually.

Within the last decade, particularly since 1954, Canadian iron-ore-production capacity has increased rapidly. In spite of this, Canada dropped from fourth place in 1959 to sixth place in 1960 among the iron-ore-producing nations. By 1965, Canada's annual production capacity will be more than 40 million tons, or nearly twice the record amount produced in 1959. Three projects actively developed in Labrador-Quebec during 1960 will contribute most of the expected increase. Plant capacities of these projects are planned as follows: Quebec Cartier Mining Company, 8 million tons by 1961; Iron Ore Company of Canada at Carol Lake, 7 million tons by 1962; and Wabush Iron Co. Limited, almost 6 million tons by 1965.

Cobalt

In 1960, cobalt production amounted to 3,569,000 pounds valued at $6,763,000; in 1959, it totalled 3,150,000 pounds valued at $5,955,000. The decrease in value reflects a reduction of 25 cents a pound that occurred in March in the price of cobalt metal. The price remained at $1.50 a pound for the rest of the year.

No cobalt ores have been produced in Canada since 1957, but cobalt has been obtained as a by-product from the silver ores of the Cobalt and Gowganda areas of Ontario and from the smelting and refining of nickel-copper ores from the vicinity of Sudbury, Ontario, and Lynn Lake, Manitoba. Deloro Smelting & Refining Company, Limited, announced that it would close its smelter at Deloro, Ontario, after a final clean-up run, to be completed early in 1961. Since 1957, when ore shipments began to decline, the company has kept the smelter operating by augmenting the silver ores with cobalt ore from the Canadian Government's small stockpile and with low-grade residues accumulated over the years.

The steps taken in 1960 to terminate the Deloro operation marked the end of a historic Canadian smelting enterprise. The Deloro smelter began operations about 1868, when gold was discovered in Hastings county. The gold ores, which were arsenical, were milled and refined at Deloro from that year until 1903. The rich silver ores from Cobalt, Ontario, which also contained arsenic and were recognized as suitable raw material, were then used for the continued operation of the refinery. The Deloro smelter began to produce cobalt metal on a commercial scale in 1914 and remained the leading world producer until 1925, when Belgian refineries began to produce cobalt from the copper-cobalt deposits of Katanga, Belgian Congo. The smelter of Deloro Smelting & Refining Company, Limited, handled most of the 175,525 pounds of cobalt contained in the silver ores shipped from the Cobalt and Gowganda areas. Sherritt Gordon Mines, Limited produced 310,410 pounds of cobalt in 1960, 6,067 pounds less than in 1959. The company's powder-rolling plant at Fort Saskatchewan, Alberta, which is designed to produce metal strips, rod, and wire direct from power, was virtually completed by the end of the year and was in production on a limited scale. The International Nickel Company of Canada, Limited, and Falconbridge Nickel Mines, Limited accounted for more than four fifths of Canadian cobalt production, recovering the metal from Sudbury nickel-copper ores.

Chromium

Some chromite was produced in Quebec in the period 1940-50, but Canada has no known deposits of commercial-grade chrome ore and relies on imports. Imports of chrome ore (chromite) increased in 1960 for the second consecutive year, amounting to 59,023 tons valued at $1,521,812. The consumption of ferrochrome, which is used mainly in stainless-steel manufacture, was slightly higher than in 1959, but exports of this material, at 4,611 tons, were the lowest in many years.

Manganese

No manganese ore is produced in Canada, although in past years small amounts have been mined from bog deposits in New Brunswick, Nova Scotia, and British Columbia. Manganese ore imports decreased in 1960 to 56,350 tons from the 1959 total of 118,454. This decline was due to an increase in the imports of ferromanganese from 2,334 tons in 1959 to 15,495 tons in 1960, a decrease in manganese-ore inventories, and a slight decrease in steel production. In addition, technical developments in the production of pig iron and steel have tended to reduce the ratio of manganese ore used per ton of steel produced.

Large low-grade deposits of manganese have been found in Canada, and technological advances may, in time, give some of them economic importance. The most notable of these large-tonnage low-grade deposits is near Woodstock, New Brunswick. This deposit had been estimated to contain more than 50 million tons grading 11 per cent manganese and 14 per cent iron.

Molybdenum

Shipments in 1960 of contained molybdenum and molybdic oxide (MoO_3) and molybdenite (MoS_2) concentrates amounted to 768,000 pounds valued at $1 million, or slightly more than in 1959. Molybdenite Corporation of Canada Limited was the principal Canadian producer of molybdenite and the only

Canadian producer of molybdic oxide. At the end of 1960, the price of molybdenum contained in MoS_2 was $1.25 a pound; that of molybdenum in MoO_3 was $1.46 a pound.

Molybdenite Corporation's property is at the junction of La Motte, Lacorne, Vassan, and Malartic townships, 23 miles north of Val d'Or, Quebec. On October 1, ore reserves totalled 243,931 tons blocked out or broken in stopes and assaying 0.36 per cent MoS_2, plus indicated reserves of 800,000 tons. Preissac Molybdenite Mines Limited, in which Molybdenite Corporation of Canada Limited holds a substantial interest, owns 3,550 acres in Preissac township, Quebec. In 1960 electric power was brought to the property, a head-frame for a new three-compartment shaft was erected, and shaft-sinking operations were started. The company expects that a 1,200-ton mill and a roaster plant will be in operation by 1963. Indicated ore reserves amount to about 1,250,000 tons averaging 0.53 per cent MoS_2.

Niobium (Columbium) and Tantalum

There has been no commercial production of columbium ore in Canada since 1955. Columbium Mining Products Ltd., Quebec Columbium Limited, and St. Lawrence Columbium and Metals Corporation, all with properties near Oka, Quebec, about 20 miles northwest of Montreal, conducted exploration work, beneficiation tests, and market surveys during 1960 to prepare their properties for eventual production. Columbium Mining Products Ltd. announced plans to build a 250-ton-a-day pilot plant on its property to recover columbium pentoxide. In November, St. Lawrence Columbium and Metals Corporation began the construction of a 500-ton pyrochlore concentrator. About one quarter of the overburden removed from the proposed open-pit site consists of an altered material containing a high percentage of ore assaying 0.60 per cent Cb_2O_5. This material was stockpiled and will be used as mill feed. Metallurgical Products Company Limited, Montreal, produced ferrocolumbium from imported pyrochlore concentrate, using an aluminothermic reduction process. The company expects to use domestic pyrochlore concentrates from Oka when they are available. Dominion Gulf Company continued research on extraction of columbium from its deposit in Chewett township, Ontario.

Titanium

The value of titanium shipped in 1960 in ore, titanium-bearing slag and Sorel flux was $12,963,265. This is $4,326,551 above the 1959 value and represents an all-time high for Canadian production. The Canadian titanium industry is based mainly on the mining of ilmenite for the production of titanium-dioxide slag used in making pigments. Ilmenite is mined in the Allard Lake and St. Urbain areas of Quebec. Most of the Allard Lake ore is smelted at Sorel, Quebec, to produce slag containing 72 per cent titanium dioxide (TiO_2), a high-quality pig iron, and a complex calcium-magnesium-aluminum silicate used as a slag-thinner in smelting. Most of the slag is exported, mainly to the United States, for use as raw material in the manufacture of titanium-base pigments. Some is shipped to Canadian Titanium Pigments Limited, at Varennes, Quebec. In recent years most of the shipments from the St. Urbain area has been used as heavy aggregate.

Two mines in the Flin Flon area of northern Manitoba - the Chisel Lake zinc-lead mine at Snow Lake and the Coronation copper-zinc mine near Flin Flon - were brought into production during the year. Both are operated by Hudson Bay Mining and Smelting Co., Limited. Exploration continued in the Mattagami Lake district of western Quebec, and shaft-sinking was started at the Watson Lake zinc-copper property. In New Brunswick, Heath Steele Mines Limited began to dewater its zinc-lead-copper mine 32 miles northwest of Newcastle in preparation for the resumption of operations on improvement of the market outlook.

Lead

The production of lead in 1960 totalled 205,650 tons. The most important producers were The Consolidated Mining and Smelting Company of Canada Limited, which operates three large lead-zinc mines in southeastern British Columbia; the Buchans zinc-lead-copper mine in Newfoundland; and the lead-zinc mine of United Keno Hill Mines Limited, in Yukon Territory. The refined lead produced at Trail, British Columbia, amounted to 158,510 tons. The Canadian price of lead in 1960 was 10.75 cents a pound until April 12, when it increased to 11 cents. It subsequently declined to a year-end level of 10 cents.

In 1960, under the restriction of import quotas, exports of lead in ore and concentrates and as refined lead to the United States declined by 19,400 tons from the 1959 total, but an increase in shipments abroad compensated for this decline, making the total value of exports, including scrap, $573,000 greater than in the previous year.

The International Lead and Zinc Study Group met twice - in January and in September. The meetings were concerned mainly with the imbalance between the production and the consumption of lead and the consequent increase in producers' stocks.

In New Brunswick, exploration was carried out on several properties in the Bathurst district. The Royal Commission on the Great Slave Lake Railway reported in June 1960 on the respective merits of the western and eastern routes to Pine Point, on Great Slave Lake, the site of important lead-zinc deposits. Subsequently, the federal government announced that a detailed survey of the western route would be undertaken.

Silver

Silver production in 1960 reached a record total of 34,016,829 ounces. Refined output from six refineries totalled 21,933,000 ounces. The leading mine producer was United Keno Hill Mines Limited, Yukon Territory, which had an output of 7,249,101 ounces in the fiscal year ended September 30, 1960.

Canada was the second-ranking world producer of silver, the first being Mexico, whose output in 1960 was 44 million ounces. The chief market for Canada's output continued to be the United States. The New York price remained constant throughout 1960 at 91.38 cents an ounce.

About 80 per cent of Canada's silver is derived from base-metal ores, principally from lead-zinc, copper, copper-zinc, and nickel-copper ores. Silver-cobalt ores provide from 15 to 20 per cent of the output, and gold ores about 2 per cent. A considerable proportion of the silver obtained from base-metal ores is recovered from silver-lead-zinc ores treated at Trail, British Columbia. Other refining centres are in Montreal East and the Sudbury area and at Deloro, Ontario. It was announced in May that the Deloro smelting-and-refining plant, the only one in Canada treating arsenical silver-cobalt ores for the recovery of both silver and cobalt, would close by the end of 1960 or shortly after.

Aluminum

Although it has no bauxite, Canada is a major refiner of aluminum because it has cheap electrical power and favorable transportation facilities. Canadian production in 1960 amounted to 762,012 tons, of which 105,708 tons were consumed in the domestic market and 552,155 tons were exported. Production and exports set new records, gains over the 1959 production and exports amounting to 168,382 tons and 46,813 tons, respectively. The total value of exports, exclusive of manufactures, was $268.2 million, or 16.2 per cent more than in 1959. This was achieved through increases in shipments abroad, notwithstanding a $26.3-million decline in exports to the United States.

World production for 1960, excluding that of Communist countries, is estimated at 4 million tons. Consumption amounted to 3.5 million tons and annual capacity to 4.7 million. In view of this capacity surplus, the spate of new smelter projects announced during the year implies an expectation of very rapid growth in consumption. Aluminum plants in Canada at the end of 1960 had a production capacity of 871,600 short tons. When completed, construction that was in progress during the year for Aluminum Company of Canada, Limited, will increase capacity by 6,000 to 8,000 tons. The new facilities will employ a process of subhalide distillation.

Magnesium

Highly competitive conditions in magnesium export markets are expected to continue for some years. Canada's 1960 production, at 7,289 tons, represented 92 per cent of capacity and 7 per cent of world output. Canadian consumption rose to 2,200 tons in 1960 from 1,668 tons in 1959. A major change in the export pattern raised Canada's shipments to the United Kingdom, on a value basis, to more than 70.8 per cent of the export total. In 1959, the proportion had been 45.9 per cent. Canada's main competitors are Norway, Italy, France, and the United States. The single reduction plant at Haley, Ontario, uses the ferrosilicon process to produce high-purity magnesium for world markets. A plant at Arvida, Quebec, was closed in October 1959. During 1960, magnesium ingot was priced at 30 cents a pound f.o.b. Haley.

Fuels

The value of the fuels produced in 1960 was $565.9 million. Crude petroleum made up 74.8 per cent of this total, coal 13.2 per cent, natural gas 9.2 per cent, and liquid hydrocarbons 2.8 per cent. Natural-gas output continued its rapid rate of increase. Crude petroleum gained, but the gain -

with allowance for 1958, when production declined - was the smallest since 1950. Coal production was slightly above the 1959 level, which was the lowest for any year in the last half century.

Petroleum

Crude-petroleum production in 1960 amounted to 189.5 million barrels, exceeding the record of 1959 by 2.6 per cent. The value of this output reached an all-time high of $422.9 million, surpassing the 1959 value by 0.2 per cent. Output increased in Alberta, Saskatchewan, Ontario, British Columbia and the Northwest Territories but decreased in Manitoba and New Brunswick. Alberta accounted for 68.9 per cent of Canada's production, Saskatchewan for 27.4 per cent, Manitoba for 2.5 per cent, and Ontario, British Columbia, the Northwest Territories, and New Brunswick for the remaining 1.2 per cent. In western Canada at the end of 1960 there were 15,370 oil wells capable of production. Of these, 13,156 were producing. Lack of markets kept 2,214 wells inoperative, and many of those producing were operating much below capacity.

Exploratory drilling throughout Canada resulted in 101 oil wells, three quarters the number of previous years. A major increase in the number of development oil wells, however, brought the number of exploratory and development oil wells drilled during the year to 1,577. The total for 1959 had been 1,464. This exploratory and development work raised crude-oil reserves by 181.4 million barrels to a year-end total of 3,678.5 million barrels, of which Alberta had 83 per cent.

By the end of 1960, there were 8,435 miles of oil pipelines in Canada, of which 490 miles were constructed during the year. About 65 per cent of this new mileage was built in Alberta, and most of the rest was shared nearly equally between Saskatchewan and northeastern British Columbia.

The completion during the year of four new refineries brought the total to 44 and increased the country's petroleum-refining capacity to 950,260 barrels per calendar day. The largest of the new refineries, situated in Saint John, New Brunswick, has a capacity of 47,500 barrels a day. A 26,000-barrel-a-day refinery was completed near Montreal and, like the Saint John refinery, went on stream in May. Construction of a 4,500-barrel-a-day refinery near Innisfail, Alberta, designed to treat natural-gas condensate as well as crude oil, was finished. At Taylor, in northeastern British Columbia, a 2,000-barrel-a-day distillation unit was added to the existing condensate-treating plant.

The quantity of domestic crude oil received at Canadian refineries amounted to 149.3 million barrels, 1.5 per cent less than in 1959. Receipts of foreign crude at Canadian refineries increased by 9.0 per cent to 126.8 million barrels. Exports of crude oil, which went entirely to the United States, increased by 26.6 per cent to 42.2 million barrels. Sales of refined-petroleum products increased by 9.7 million barrels to 291.7 million while imports of these commodities decreased by 3.6 million barrels to 35.2 million. The imported products consisted mainly of heavy and light fuel oils. Imports of motor and aviation gasoline decreased notably.

Thus the two new refineries in eastern Canada caused a reduction in product imports but a significant increase in crude-oil imports. After they went on stream, refinery output increased in Quebec and the Maritimes, while in Ontario, where refineries operate on Canadian crude, it decreased slightly. The net effect of the operation of these two plants on the export-import pattern was a decline of about 5 per cent in the over-all value of petroleum imports.

Natural Gas

For the natural-gas industry, the most important development of 1960 was the approval by government agencies in Canada and the United States of large-scale exports of natural gas to the growing markets of the United States west coast and Middle West. The National Energy Board granted permission to five pipeline companies to export an average of slightly more than 1,000 million cubic feet of natural gas a day in addition to amounts previously authorized by the Board of Transport Commissioners. By the end of the year, the Federal Power Commission of the United States had approved about three quarters of this amount for import into that country. As a result, new gas-pipeline projects were started, and Canadian field facilities were being expanded to meet the increase in demand.

The record net quantity of natural gas produced in 1959 was exceeded by over 25 per cent in 1960. Net production, which excludes the output of flared gas and waste, was 522,972 million cubic feet, of which Alberta produced 73.4 per cent. British Columbia produced 16.4 per cent, Saskatchewan 7.0 per cent, and Ontario 3.2 per cent. Minor quantities were produced in New Brunswick and the Northwest Territories. The total value of net production was $52.2 million.

Exploratory drilling resulted in 163 new gas discoveries in 1960. Eleven were made in Ontario and 152 in the western provinces and northern territories. Most of the new gas finds were in or near the Foothills of the Rocky Mountains. In northeastern British Columbia, many gas wells remained capped because of a lack of pipeline connections to market areas. Drilling in the Maritime Provinces was abandoned because the results were disappointing.

By the end of the year, there were nearly 32,000 miles of natural-gas pipeline in Canada. Clearing of the right-of-way for the Alberta-California pipeline was started late in the year. This line will carry more than 400 million cubic feet a day. Trans-Canada Pipe Lines Limited began delivery of gas to the United States in August through a new 51-mile line from the Winnipeg area to the Manitoba-Minnesota boundary.

The rapid rate of construction of natural-gas-processing plants continued. Much of western Canada's natural gas is marketable only after components such as propane, butane, natural gasoline, and hydrogen sulphide are removed. Fifteen new natural-gas-processing plants went on stream in Alberta and two in Saskatchewan. This brought the number of plants in western Canada to 58, with a total raw-gas capacity of 2,294 million cubic feet a day.

Domestic sales of natural gas totalled 324,791 million cubic feet, one sixth more than in 1959. Alberta and Ontario were the major consumers, accounting for 43.6 and 32.1 per cent, respectively, of domestic sales. Exports totalled 109,855 million cubic feet, one third more than in 1959. The small amount of gas imported into Ontario from the United States continued to diminish. Plans made during the year for the continuation of large-scale investment in gas-processing plants and pipeline facilities in support of export projects give promise that the near future will bring further marked increases in the value of gas exports.

Coal

Coal production was slightly higher in 1960 than in 1959. Other fuels, however, continued to offer severe competition, largely owing to the high operating costs prevailing at coal mines in eastern Canada and high transportation costs resulting from the geographical location of the mines with respect to markets. To realize the severity of the depression affecting the industry, it is necessary only to compare the 19.1 million tons that made 1950 the peak production year and the 11.0 million tons valued at $75 million that made up the output of 1960. In 1959 and 1960, production was lower than in any other year since 1909. In 1960, Canada imported 13,292,369 tons, mainly from the United States. Exports, which went mainly to Japan and New England, totalled 852,921 tons, or almost twice as much as in 1959.

The daily average of workers directly employed during the year in the coal-mining industry totalled 11,587. The all-time high was reached in 1921, when the number slightly exceeded 31,000. Since 1948, when the average was 24,319, employment in the industry has been decreasing steadily.

As 1959 ended, the Government of Canada appointed a Royal Commission on Coal to investigate conditions in the industry. The Commission submitted its report the following September and by the end of 1960 federal authorities were studying it to determine the character and amount of assistance needed for the long-term interests of the industry and its dependent communities. Transportation subventions paid by the federal government have increased considerably in recent years. They rose from $8.3 million for the fiscal year ended March 31, 1958, to $17.2 million for the one ended March 31, 1961.

Nonmetallics and Structural Materials

In 1960, a total of 25 types of nonmetallic minerals worth $197.5 million and five structural materials valued at $322.6 million were produced in Canada. Asbestos accounted for 61 per cent of the value of the nonmetallics, and salt, titanium dioxide, gypsum, and sulphur for a further 25 per cent. Sand and gravel and cement contributed two thirds of the value of the structural materials. Some of the more important developments affecting industrial minerals follow.

Asbestos

The Canadian asbestos industry had a record year in 1960, producing 1,118,000 tons of asbestos valued at $121.4 million. The year's output was

5 per cent above the previous record, set in 1955, and 6.5 per cent above the 1959 level. The increase came about largely as a result of a 28-per-cent increase in Group 4 asbestos shipments, although Groups 5 and 6 also registered increases to meet export-market demands. Asbestos-cement products are now being used extensively in nonresidential building, which increased in 1960 despite a slight general decline in North American building construction. This important market accounted in large part for the increase in the year's asbestos production.

In October, Advocate Mines Limited announced its decision to bring its Newfoundland deposit into production by 1963. The property, situated at Baie Verte on the Burlington Peninsula, is a potential source of fibre for asbestos-cement. Its operation will bring another producing province into the Canadian asbestos industry, which in 1960 derived 94.3 per cent of its output from Quebec, 3.6 per cent from British Columbia, and 2.1 per cent from Ontario.

Activity continued in exploration, development, and marketing. Important for marketing was the possible use of Group 7 asbestos in asphalt paving mixtures to improve the wearing qualities of road surfaces under variations in loading conditions and temperature.

Gypsum

A decline in building construction resulted in an 11-per-cent drop in output, but a higher unit price for Nova Scotian crude gypsum resulted in a 13-per-cent increase in the total value. The 5,206,000 tons produced in 1960 were worth $9.5 million.

Mining rights to a large gypsum deposit near Flat Bay, Newfoundland, were acquired by Flintkote Company, of the United States, from Atlantic Gypsum Limited; and plans were made to quarry gypsum for export to plants along the United States eastern seaboard. Two plants were completed - one in Vancouver for the production of plaster and wallboard, the other in Calgary for the manufacture of wallboard. The first shipments for these two plants came from a deposit at Windermere, British Columbia. Heavy-media beneficiation of gypsum was introduced into Canada with the completion of a plant at Windsor, Nova Scotia.

Potash

Developments that occurred in 1960 gave promise that the production of potash would be a major industry in a very few years. A large high-grade deposit, possibly the world's largest, underlies part of southern Saskatchewan at minable depths varying from 2,550 to 3,400 feet and contains reserves estimated at more than 6,400 million tons of recoverable potash grading at least 25 per cent K_2O. During the year, satisfactory progress was made in overcoming the technical difficulties of penetrating the wet and largely unconsolidated strata known as the Blairmore formation, which overlies the potash-bearing formations. International Minerals & Chemical Corporation (Canada) Limited estimates that the cost of bringing its deposit at Esterhazy, Saskatchewan, into production will be $25 million, and Potash Company of

America, Ltd., is investing large amounts in the development of its holdings near Saskatoon. The year's progress indicated that potash production, which started late in 1958 but stopped in 1959 because of technical difficulties, will again get under way by 1962.

Sulphur

The production of elemental sulphur, which in 1959 amounted to 146,000 tons, increased in 1960 to 274,000 tons valued at $4.3 million. Recent and current investment in natural-gas-processing facilities in western Canada should raise capacity considerably above its 1960 year-end level of 654,450 tons per annum. Plants planned or under construction at the end of 1960 will increase the annual capacity by an additional 858,500 tons to a production potential of 1 1/2 million tons of elemental sulphur a year, or six times the quantity marketed by all producers in 1960. The consumption of elemental sulphur in 1960 amounted to 463,000 tons. Sulphur produced as a by-product of natural gas could become a major export commodity.

Sulphur recovered from smelter gases at metallurgical works in Canada is used in the manufacture of sulphuric acid. The relatively constant quantity recovered in this form totalled 290,000 tons in 1960. The third source of sulphur is the pyrite and pyrrhotite obtained in base-metal operations.

Barite

The value of barite production declined by one third to $1.5 million because of increased competition in the export market. Canada's main competitors are Mexico, Peru, and Greece. The domestic market has depended on exports for 90 per cent of its market outlets.

A new barite- and bentonite-processing plant was completed in 1960 at Onoway, Alberta. Its market will be provided by the western Canada oil industry, which uses large quantities of these materials in the preparation of drilling muds.

Cement and Construction Materials

In 1960, construction expenditures were 2.7 per cent less than in 1959. Thus cement, which is used almost exclusively for construction, also dropped in output. This was the first year since 1947 in which the Canadian cement industry did not establish a production record. A new plant and plant enlargements increased production capacity in the cement industry by 16 per cent to 8.7 million short tons. A highly automated plant using the dry process and employing a 550- by 15-foot kiln, the largest of its type in the western hemisphere, was completed in Montreal. Plants at Edmonton and Regina were enlarged. The Canadian industry produced 5.8 million tons of cement in 1960 and now has approximately 50 per cent spare capacity. A small export market has been developed in the United States. In 1960 the United States Tariff Commission ruled that Canadian cement exports did not violate the International Antidumping Act.

The demand for mineral materials in the construction and road-building industry fell only slightly below 1959 levels. Applications for precast shapes and prestressed structures as well as for ready-mixed concrete, which now provides a market for 27 per cent of all the cement used in Canada, are steadily growing. New facilities for their preparation were established in 1960. Development work was carried out in preparation for the use of natural pozzolan as an additive to concrete for engineering works. Lightweight aggregates were taken into greater use in major building-construction projects. At the end of 1960 there were 32 plants in Canada in the lightweight-aggregate industry.

Mineral-Industry Trends

The tables in Part II, Sections I to III inclusive, concern supply and demand. The succeeding sections cover prices, costs, employment, exploration, mine output, transportation, taxes, and capital investment. The general observations about to be made will indicate the trends and present condition of the mineral industry.

Production

Metals, industrial minerals, and fuels, which immediately after World War II made up respectively 57, 23, and 20 per cent of Canada's mineral output, now contribute respectively 56, 21, and 23 per cent. Since the immediate postwar period, the value of production has increased fourfold and the per capita value threefold. (See Tables 1 and 2.) While the volume index for the whole industrial output has doubled since 1946, the mining volume index has increased almost 3 1/2 times, the fuels outstripping the metals and industrial minerals (Table 3). Interesting changes have taken place in the relative values of the minerals produced, petroleum, uranium, and iron ore making marked gains while gold and coal declined considerably and zinc and lead moderately (Table 4).

More than half of Canada's mineral supply, in terms of output value, comes from the Canadian Shield (Table 5). On the same basis, the supply is most heavily concentrated in Ontario (39 per cent), Quebec (18 per cent), and Alberta (16 per cent). Mineral activity is nevertheless well distributed throughout the country. (See Table 6.) Growth in the industry during the past decade has been geographically diversified (Tables 7 and 8). Today each province has a diversified mineral supply (Table 9), and as the mineral economy grows, the variety can be expected to increase. This will make for greater stability.

In proportion to the total of primary industry, mineral production has been growing since the war; in the late 1950's, in terms of net value, it was equivalent to about 30 per cent of all primary output (Table 10).

As a world producer, Canada leads in nickel, asbestos, and platinum metals and is second in uranium, cadmium, gypsum, silver, aluminum, and titanium concentrates, third in zinc, gold, bismuth, and cobalt, fourth in magnesium, and fifth in barite, lead and copper (Table 11).

Mineral Trade

Analyses of mineral supply and demand (Tables 12 and 13) show that exports of raw materials are more than 50 per cent above imports and that semiprocessed exports are 11 times greater than imports of the same kind. Nonferrous metals make up considerably more than half the raw materials exported, while nonmetallic minerals and their products, including fuels, constitute four fifths of raw-material imports. Nonferrous metals account for 80 per cent of semiprocessed exports; imports of this kind are small and have no predominant class.

Exports of fully manufactured mineral products are surprisingly small, being slightly more than one fifth of the mineral-export total and less than one fifth of all fully manufactured mineral imports. In fact, fully manufactured mineral-product imports account for four fifths of the total of mineral imports and are much greater than all types of mineral exports combined.

The excess of exports over imports in the field of raw and semi-processed minerals gives Canada a balance-of-payments gain of about $1,000 million. If, however, fully manufactured products based on minerals are included, imports exceed exports by about the same amount. Since three quarters of the fully manufactured mineral imports are products of iron, hope for general mineral self-sufficiency lies in an increase in iron and steel manufacturing.

Raw and semiprocessed mineral materials make up almost one third of all Canadian exports. In 1950, they accounted for less than one fifth (Table 20). If fully manufactured products are included, the proportion contributed in 1960 by mineral exports is two fifths (Table 14). Raw and semi-processed materials, however, constitute only one tenth of all the goods and commodities imported into Canada, and there has been a general decline since 1950 (Table 21). If, however, fully manufactured mineral products are included, the proportion for 1960 rises almost to 60 per cent. This is further evidence of Canada's great reliance on imports of iron and steel products (Table 15).

The United States in 1960 took half of Canada's exports of minerals and mineral products and was the source of two thirds of this country's mineral imports (Tables 16 and 17). A significant development in trade diversification took place in 1960, however, when raw and semiprocessed mineral exports to the United States declined by $100 million. The decline was almost balanced by a gain in exports to the United Kingdom and was more than balanced by an increase in exports to the United Kingdom, western Europe, and Japan combined (Tables 18 and 19). Copper, nickel, and aluminum made significant gains in markets outside of the United States. For Canada's mineral industry this was an important development in trade diversification.

Domestic Consumption

Canada's position as a major exporter of primary minerals, as just explained in the sections on production and trade, is further clarified by comparing domestic consumption with production (Tables 22 and 23). The comparison shows that, after domestic needs are met, large surpluses remain for export. A few notable exceptions wherein a strong dependence on foreign supply is apparent are provided by molybdenum, tin, and mica. Elemental sulphur, which as late as 1959 was a major import item, will shortly be available in large quantities for export. The degree of dependence on imports of petroleum shown for 1959 under 'fuels' will also decline considerably in the coming decade. The progress made in increasing the export surplus for the major metals in spite of large increases in domestic demand is well illustrated in Table 24. This table also emphasizes the vital importance of the export market to Canada's mineral industry.

Prices

The price average for most of the nonferrous metals was higher in 1960 than in 1959, but toward the end of the year lower prices were developing in world markets for some metals. The rate of decline exceeded that which was subsequently experienced in the United States. These price changes, combined with a shift from United States to overseas markets, resulted in a certain volume-value disparity in exports. Because base-metal prices in other countries were lower than in the United States, the gain in export volume was not accompanied by a proportionate increase in the total export value. There was compensation, however, in the iron-trade with the United States in that, despite a 24.7-per-cent drop in volume, the export value fell by only 16.7 per cent. The reason for this was the higher grade of the iron ore shipped.

A favorable price development took place when the premium on the Canadian dollar, in United States funds, dropped in mid-1960 from the mid-1959 high of 5 per cent to about 1 per cent. This downward trend, which continued on into 1961, has improved Canada's position in mineral markets abroad.

A comparison of the United States mineral price averages for 1959 and 1960 (Table 25) shows only a small number of significant changes. In the 1950's, the price indexes of the nonferrous-metals products and the nonmetallic-mineral products paralleled the general wholesale price index, while the iron-products index increased at a higher rate. For the past three years, however, the iron-products sector has been stable. (See Tables 26 and 27.)

Principal Industry Statistics

Table 28 provides a basis for studying the relationship between employment, the cost of fuel and electricity, and the cost of process supplies on the one hand and the gross and net values of production on the other. The 10-year trend shown for these production factors in Table 29 indicates that labor in the Canadian mineral industry is growing in productivity. Tables 30 and 31 illustrate the great dependence of the industry on large supplies of cheap fuel and electricity.

Employment

Employment in the mining industry declined in 1960, largely owing to the cutback in uranium production. It was higher in copper-zinc and nickel-copper mining and increased moderately in nonmetallics. Recent changes may be measured against the long-term trends of the principal sectors as shown in Table 32. During the past decade, employment rose in every sector except in that of fuels, where it fell off because of the marked decline that occurred in coal-mining. This decline also explains the decrease indicated in Table 33 in the number of underground workers. The result of all these factors was that during the 1950's employment throughout the industry increased by only 7 per cent.

In the metal-mining sector, however, employment made marked gains. These were accompanied by large wage increases, with the result that the wage cost per ton mined did not drop appreciably during the 10-year period (Table 34). The extent of the wage increases is further magnified by the improvement that took place in worker productivity in terms of man-hours per ton mined (Table 35), a development that wages seem to have kept pace with. Wages in the mining industry compare favorably with those paid in manufacturing and construction and have increased at a higher rate than those earned in manufacturing (Table 37).

Prospecting and Exploration

Statistics on prospecting costs for 1958 and 1959 indicate that companies engaged in copper-gold-silver mining and nickel-copper mining have been the most active, Manitoba and Ontario being the regions of their greatest investment (Table 40). During the past decade, emphasis in prospecting has swung from gold to base-metal exploration, and nickel-copper mining companies have generally led in exploratory expenditures (Table 41).

Contract diamond-drilling, as carried out for mining companies, has remained at a relatively stable level during the past decade (Table 42), while contract rotary drilling for the oil industry has increased fourfold (Table 43). These trends in the field activity of recent years, together with emphasis on capital investment, account for the predominance of nickel, copper, and petroleum in the mineral economy of today. This is further illustrated in Table 54, which includes statistics on iron, the leading metallic mineral from the point of view of capital investment.

Ore Mined and Rock Quarried

Iron-ore-mining has become in recent years the main tonnage operation in Canadian metal-mining. Structural materials still account for the largest commodity tonnage handled in the mineral industry as a whole. (See Table 44.) The approximately equal division of material mined that has prevailed during the past decade between metallic ores and industrial minerals continues (Table 45).

Transportation of Minerals

Crude minerals account for two fifths of all the tonnage moved by Canadian railways (Table 46). During the past 10 years, crude-mineral shipments have accounted for a consistently large proportion of all revenue freight, the proportion having increased from about one third in the early 1950's (Table 47). The primary products of smelters and refineries constitute only a small percentage of the revenue freight carried by Canadian railways (Table 48); ores and concentrates and coal are the large tonnage commodities. Most of the 1,326 miles of new railway construction completed in Canada since the end of World War II has been the direct result of mineral development in northern areas. The mineral industry has thereby played a key role in providing means of access to Canada's hinterland.

The mineral industry provides more than half of the inland-waterways traffic (Table 49). As with railway traffic, iron ore and concentrates and bituminous coal provide the largest of the mineral-commodity tonnages. In water transport, they account for more than three quarters of the mineral tonnage and in railway transport for about half.

During the past decade, the petroleum industry of Canada has built up a major system of transportation by pipeline. Table 50 shows the year-by-year increase in the pipeline transportation of petroleum and its products and of gas. The petroleum shipped by pipeline in 1960 amounted to 46.7 million tons. This equals all the mineral shipments by inland waterways and about three quarters of those made by rail. Between 1950 and 1960 pipeline transportation became a major component of Canadian transportation.

Taxation

About 60 per cent of the taxes paid by five major divisions of the mineral industry are in the form of federal income taxes; provincial and municipal taxes account for the remainder (Tables 51 and 52). Complete information on the taxes paid by the entire industry is not available.

Capital Investment, Ownership, and Control

In 1960, capital investment and repair expenditure in the mineral industry increased slightly to an estimated $464 million, half of which was in the petroleum and natural-gas sectors. The total included amounts spent on new capital construction, new machinery and equipment, and the repair of structures, machinery, and equipment. Table 54 sets out these capital and repair expenditures, but the amounts shown do not include expenditures in the non-ferrous smelting and refining industries, the petroleum-refining industry, or the pipeline-transportation industry. Mining-company expenditures on railways and electric-power plants are also omitted.

In metallics, iron ore predominates, accounting for about half the expenditures in this sector. In nonmetallics, asbestos continues to attract most of the capital. Expenditures in all parts of the petroleum and natural-gas industries, including transportation, processing, and marketing, amounted in 1960 to 8.1 per cent of all capital invested in Canada and are continuing at a high level (Table 55). The forecast for 1961 is that capital expenditure in the mineral industry will be about the same as in 1960.

The latest available statistics show that 57 per cent of the mining sector of Canada's mineral industry is foreign-owned. In the petroleum and natural gas, foreign ownership amounts to 64 per cent, and in nonferrous smelting to 55 per cent (Table 56). Comparison with other industries reveals that foreign ownership is greater in the mineral industry than in some other parts of the Canadian economy (Table 57). Finally, statistics for the past 30 years illustrate the dominant position the United States has maintained among foreign countries investing in the Canadian mineral industry.

PART II

- STATISTICAL SERIES -

THE CANADIAN MINERAL INDUSTRY

IN 1960 - A SUMMARY

A Guide to the Use of the Tables

Abbreviations

lb	-	pound
s.t.	-	short ton (2,000 lb)
oz	-	ounce
l.t.	-	long ton (2,240 lb)
gal	-	gallon
bbl	-	barrel (35 imperial gal)
kwh	-	kilowatt hour
M	-	unit of 1,000
f.o.b.	-	free on board
Mcf	-	1,000 cubic feet
p	-	preliminary
f	-	forecast
billion	-	1,000 million
(e)	-	estimated

Symbols

...	-	not available for publication
..	-	not available
-	-	zero

Sources

Recognized statistical sources have been used throughout: Canada - Dominion Bureau of Statistics, Department of Labour, and Department of National Revenue; United States - United States Bureau of Mines, American Bureau of Metal Statistics, and Engineering and Mining Journal's "Metal and Mineral Markets."

SECTION 1 - PRODUCTION

Mineral Production of Canada, 1959 and 1960

	Unit of Measure	1960 Quantity	1960 $'000	1959 Quantity	1959 $'000
Metallics					
Antimony	'000 lb	1,652	539	1,658	540
Bismuth	'000 lb	424	762	335	590
Cadmium	'000 lb	2,357	3,348	2,160	2,765
Calcium	'000 lb	135	159	67	76
Cobalt	'000 lb	3,569	6,763	3,150	5,955
Copper	'000 s.t.	439	264,847	395	233,103
Gold	'000 troy oz	4,629	157,152	4,483	150,508
Indium	'000 oz	...	...	...	...
Iron ore	'000 l.t.	19,242	175,083	21,865	192,666
Iron (remelt)	'000 s.t.	...	10,973	...	7,187
Lead	'000 s.t.	206	43,927	187	39,617
Magnesium	'000 lb	14,577	4,314	12,204	3,180
Molybdenum (Mo content)	'000 lb	768	1,015	749	941
Nickel	'000 s.t.	215	295,640	187	257,009
Platinum metals	'000 troy oz	*	*	178	5,917
Platinum	'000 troy oz	484	28,874	150	11,015
Selenium	'000 lb	522	3,651	368	2,577
Silver	'000 troy oz	34,017	30,244	31,924	28,023
Tellurium	'000 lb	45	156	27	28
Thorium	'000 lb	...	...	47	106
Tin	'000 lb	622	522	747	630
Titanium ore	'000 s.t.	3	16	27	130
Tungsten (WO_3)	'000 lb	-	-	-	-
Uranium (U_3O_8)	'000 lb	25,495	269,938	31,784	331,143
Zinc	'000 s.t.	407	108,635	396	96,943
Total, metallics			1,406,558		1,370,649
Nonmetallics					
Arsenious oxide	'000 lb	1,724	70	1,578	64
Asbestos	'000 s.t.	1,118	121,400	1,050	107,433
Barite	'000 s.t.	154	1,462	239	2,255
Diatomite	s.t.	44	1	5	0.1
Feldspar	'000 s.t.	14	239	18	301
Fluorspar	'000 s.t.	...	1,922	...	1,851
Garnet	s.t.	32	5	-	-
Grindstone	s.t.	10	2	60	9
Gypsum	'000 s.t.	5,206	9,499	5,879	8,394
Iron oxide	'000 s.t.	1	77	1	108
Lithia	'000 lb	205	84	2,756	1,422

*Platinum metals included with platinum

(Continued)

Mineral Production of Canada, 1959 and 1960 (cont'd)

	Unit of Measure	1960 Quantity	1960 $'000	1959 Quantity	1959 $'000
Nonmetallics (cont'd)					
Magnesite, dolomite, and brucite	'000 lb	...	3,279	...	3,051
Mica	'000 lb	1,703	94	814	63
Mineral water	'000 gal	375	202	369	203
Nepheline syenite	'000 s.t.	241	2,891	229	2,931
Peat moss	'000 s.t.	186	6,088	184	6,227
Potash (K_2O)	'000 s.t.	...	179	...	1,408
Pyrite, pyrrhotite	'000 s.t.	1,032	3,316	1,100	3,433
Quartz and silica sand	'000 s.t.	2,261	3,267	2,164	3,437
Salt	'000 s.t.	3,315	19,356	3,290	18,035
Silica brick	'000 bricks	-	-	1,926	354
Soapstone, talc and pyrophyllite	'000 s.t.	42	523	39	512
Sodium sulphate	'000 s.t.	214	3,449	180	2,882
Sulphur in smelter gas	'000 s.t.	290	2,855	277	2,716
Sulphur, elemental	'000 s.t.	274	4,299	146	2,621
Titanium-dioxide slag, etc.	'000 s.t.	...	12,947	...	8,507
Total, nonmetallics			197,506		178,217
Fuels					
Coal	'000 s.t.	11,011	74,676	10,627	73,876
Liquid hydrocarbons	'000 bbl	...	16,052	...	...
Natural gas	'000 Mcf	522,972	52,197	417,335	39,609
Petroleum, crude	'000 bbl	189,534	422,927	184,778	422,093
Total, fuels			565,852		535,578
Structural materials					
Clay products	$	..	38,226	..	42,515
Cement	'000 s.t.	5,787	93,261	6,284	95,148
Lime	'000 s.t.	1,530	19,302	1,686	21,304
Sand and gravel	'000 s.t.	192,074	111,164	185,124	104,651
Stone	'000 s.t.	45,359	60,641	46,440	60,959
Total, structural materials			322,594		324,577
Total, all minerals			2,492,510		2,409,021

Summary
Table 2

Value of Mineral Production of Canada and Its Per Capita Value, Selected Years, 1922-60

	Production				Per Capita Value
	Metallics ($ millions)	Industrial Minerals ($ millions)	Fuels ($ millions)	Total ($ millions)	($)
1922	62	50	72	184	20.55
1927	113	63	71	247	25.67
1932	112	30	49	191	18.20
1937	335	57	66	458	41.13
1942	392	83	92	567	48.63
1947	395	139	111	645	51.25
1952	728	293	264	1,285	89.07
1957	1,159	466	565	2,190	132.03
1958	1,130	460	511	2,101	123.22
1959	1,371	503	535	2,409	138.12
1960	1,407	520	566	2,493	139.92

Table 3

Indexes of Physical Volume of Industrial and Mineral Production in Canada, 1946-60, Unadjusted (1949 = 100)

	Total Industrial Production	Total Mining	Metals							Fuels				Nonmetals			
			Total	Gold	Nickel	Lead	Zinc	Copper	Iron Ore	Total	Coal	Natural Gas	Petroleum	Total	Asbestos	Other Nonmetals	Quarrying and Sand Pits
1946	83.8	74.3	73.2	66.4	74.6	110.8	81.7	69.8	45.9	72.2	93.4	83.5	35.3	96.6	101.1	85.9	60.6
1947	91.5	78.5	79.6	75.7	92.1	101.3	72.1	85.7	50.7	66.0	82.1	91.5	36.0	109.2	114.9	95.8	85.6
1948	96.4	90.0	88.4	86.3	102.4	104.7	81.2	91.4	40.0	83.2	97.2	100.9	57.6	118.8	124.5	105.3	101.9
1949	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1950	106.9	109.5	103.5	107.9	96.2	103.7	108.6	100.4	96.0	112.1	98.5	107.3	135.5	139.1	151.8	109.0	119.3
1951	116.6	123.4	107.9	103.9	107.1	99.0	118.4	102.5	115.9	143.5	95.6	120.5	226.9	156.3	170.7	122.0	142.9
1952	120.9	131.0	110.3	106.9	109.2	105.5	128.9	98.0	126.5	163.9	90.5	128.9	291.8	155.5	171.5	117.2	153.5
1953	129.1	142.1	115.7	97.9	111.7	121.4	139.5	96.1	170.6	192.7	81.5	147.8	385.5	152.9	162.3	130.5	154.3
1954	128.5	158.7	129.0	104.5	125.3	136.8	130.5	114.8	185.4	215.6	75.2	169.6	457.8	161.4	167.8	146.3	189.6
1955	142.3	185.2	142.7	107.7	135.9	126.9	150.3	123.7	316.5	273.2	74.1	204.5	616.8	180.2	191.9	152.4	204.3
1956	154.9	212.3	151.0	107.9	139.0	118.2	145.5	135.2	410.6	344.7	74.6	235.0	812.7	187.6	188.4	184.3	237.7
1957	155.4	227.8	170.0	106.7	146.8	113.9	142.0	137.1	462.6	358.2	65.4	295.1	859.5	179.0	184.3	158.2	264.2
1958	154.4	227.0	180.3	109.7	110.2	116.0	147.2	131.8	321.5	329.5	56.7	401.6	782.6	170.9	178.3	142.1	308.2
1959	166.1	251.1	201.3	108.4	144.8	113.7	137.4	151.6	448.9	363.1	51.9	503.9	873.7	191.4	193.5	183.3	317.7
1960	167.4	253.3	197.9	111.2	166.9	128.3	142.1	168.7	406.3	380.2	53.3	589.2	909.9	192.6	201.4	157.7	301.2

Table 4

Percentage Contribution of Leading Minerals
to Total Value of Mineral Production in Canada, 1950-60

	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
Petroleum	8.1	9.4	11.1	15.0	16.4	17.0	19.5	20.7	19.0	17.5	17.0
Nickel	10.7	12.1	11.8	12.0	12.1	12.0	10.7	11.8	9.2	10.7	11.9
Copper	11.8	12.0	11.4	11.3	11.8	13.4	14.1	9.4	8.3	9.7	10.6
Uranium	...	...	...	...	1.8	1.4	2.2	6.2	13.3	13.7	10.8
Iron ore	2.2	2.5	2.6	3.3	3.3	6.2	7.7	7.6	6.0	8.0	7.0
Gold	16.2	13.0	11.9	10.4	10.0	8.7	7.2	6.8	7.4	6.2	6.3
Asbestos	6.3	6.5	6.9	6.4	5.8	5.4	4.8	4.8	4.4	4.5	4.9
Sand and gravel	3.5	3.6	4.0	4.0	4.0	3.8	3.9	4.1	4.6	4.3	4.6
Zinc	9.4	10.9	10.1	7.2	6.1	6.6	6.0	4.6	4.4	4.0	4.4
Cement	3.4	3.2	3.7	4.4	4.0	3.7	3.6	4.3	4.6	3.9	3.7
Coal	10.5	8.8	8.6	7.7	6.5	5.2	4.6	4.1	3.8	3.1	3.0
Stone	2.5	2.3	2.4	2.3	2.7	2.4	2.3	2.7	2.6	2.5	2.4
Natural gas	0.6	0.6	0.7	0.8	0.8	0.8	0.8	1.0	1.5	1.6	2.1
Lead	4.6	4.7	4.3	3.7	3.9	3.2	2.8	2.3	2.0	1.6	1.8
Clay products	2.1	1.9	1.9	2.2	2.2	2.0	1.8	1.6	2.0	1.8	1.5
Silver	1.8	1.8	1.6	1.8	1.7	1.4	1.2	1.1	1.3	1.2	1.2
Platinum metals	1.7	1.8	1.4	1.5	1.4	1.3	1.1	1.2	0.7	0.7	1.2
Salt	0.7	0.6	0.6	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.8
Lime	1.2	1.1	1.1	1.1	1.0	0.9	0.8	0.8	0.9	0.9	0.8
Titanium dioxide	0.01	0.06	0.1	0.3	0.3	0.3	0.4	0.4	0.3	0.4	0.5
Gypsum	0.6	0.5	0.5	0.6	0.5	0.4	0.3	0.4	0.2	0.3	0.4
Other minerals	2.1	2.6	3.3	3.5	3.1	3.3	3.6	3.5	2.8	2.7	3.1
Total	100.00	100.00	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 5

Value of Mineral Production in Canada, by Main Geological Regions, 1960

	Canadian Shield	Appalachian Region	St. Lawrence Lowlands	Interior Plains	Cordilleran Region	Total, Canada
Metals						
$ millions	1,159.8	101.8	-	-	145.0	1,406.6
Percentage	82.5	7.2	-	-	10.3	100.0
Industrial minerals						
$ millions	28.5	146.9	239.8	66.3	38.6	520.1
Percentage	5.5	28.3	46.1	12.7	7.4	100.0
Fuels						
$ millions	-	53.8	9.7	491.8	10.5	565.8
Percentage	-	9.5	1.7	86.9	1.9	100.0
Total, all minerals						
$ millions	1,188.3	302.5	249.5	558.1	194.1	2,492.5
Percentage	47.7	12.1	10.0	22.4	7.8	100.0

Table 6

Value of Mineral Production in Canada, by Provinces and Mineral Classes, 1960

	Metallics		Industrial Minerals		Fuels		Totals	
	$'000	% of Total	$'000	% of Total	$'000	% of Total	$'000	% of Total
Ontario	817,803	58.1	155,577	29.9	9,724	1.7	983,104	39.4
Quebec	224,294	16.0	221,909	42.7	-	-	446,203	17.9
Alberta	6	-	32,809	6.3	362,529	64.1	395,344	15.9
Saskatchewan	84,187	6.0	14,956	2.9	112,950	20.0	212,093	8.5
British Columbia	131,722	9.4	39,148	7.5	15,392	2.7	186,262	7.5
Newfoundland	78,926	5.6	7,711	1.5	-	-	86,637	3.5
Nova Scotia	-	-	20,472	3.9	44,981	7.9	65,453	2.6
Manitoba	29,905	2.1	18,107	3.5	10,691	1.9	58,703	2.4
Northwest Territories	26,482	1.9	-	-	653	0.1	27,135	1.1
New Brunswick	-	-	8,238	1.6	8,835	1.6	17,073	0.7
Yukon Territory	13,233	0.9	-	-	97	-	13,330	0.5
Prince Edward Island	-	-	1,173	0.2	-	-	1,173	-
Canada	1,406,558	100.0	520,100	100.0	565,852	100.0	2,492,510	100.0

Table 7

Value of Mineral Production in Canada, by Provinces, 1950-60
($ millions)

	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
Ontario	367	445	445	466	497	584	651	749	790	971	983
Quebec	220	255	270	252	279	357	423	406	366	441	446
Alberta	136	168	197	249	279	326	411	410	346	376	396
Saskatchewan	36	51	49	48	68	85	123	173	210	210	212
British Columbia	139	176	170	158	159	189	203	179	151	159	186
Newfoundland	26	32	33	34	43	68	84	83	65	72	87
Nova Scotia	59	60	65	67	73	67	66	68	63	63	66
Manitoba	32	30	25	25	35	62	68	64	57	55	59
Northwest Territories	8	8	9	10	26	26	22	21	25	26	27
New Brunswick	13	10	11	12	12	16	18	23	16	18	17
Yukon Territory	9	10	11	15	17	15	16	14	12	13	13
Prince Edward Island	-	-	-	-	-	-	-	-	-	5	1
Canada	1,045	1,245	1,285	1,336	1,488	1,795	2,085	2,190	2,101	2,409	2,493

Table 8

Percentage Contribution of Provinces to Total Value of Mineral Production in Canada, 1950-60

	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
Ontario	35.1	35.7	34.6	34.9	33.4	32.5	31.2	34.2	37.5	40.3	39.4
Quebec	21.1	20.6	21.0	18.9	18.8	19.9	20.2	18.5	17.4	18.3	17.9
Alberta	13.0	13.5	15.3	18.6	18.8	18.2	19.7	18.7	16.5	15.6	15.9
Saskatchewan	3.4	4.1	3.8	3.6	4.6	4.7	5.9	7.9	10.0	8.7	8.5
British Columbia	13.3	14.1	13.2	11.8	10.7	10.5	9.7	8.2	7.2	6.6	7.5
Newfoundland	2.5	2.6	2.6	2.5	2.9	3.8	4.0	3.8	3.1	3.0	3.5
Nova Scotia	5.6	4.8	5.1	5.0	4.8	3.7	3.2	3.1	3.0	2.6	2.6
Manitoba	3.1	2.4	1.9	1.9	2.4	3.5	3.3	2.9	2.7	2.3	2.4
Northwest Territories	0.8	0.6	0.7	0.8	1.7	1.5	1.1	1.0	1.2	1.1	1.1
New Brunswick	1.2	0.8	0.9	0.9	0.8	0.9	0.9	1.1	0.8	0.8	0.7
Yukon Territory	0.9	0.8	0.9	1.1	1.1	0.8	0.8	0.6	0.6	0.5	0.5
Prince Edward Island	-	-	-	-	-	-	-	-	-	0.2	-
Canada	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 9

Production of Leading Minerals in Canada, by Province, 1960

		Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	N.W.T.	Y.T.	Canada
Petroleum, crude	bbl	-	-	-	14,148	-	1,005,030	4,764,045	51,908,428	130,506,968	867,057	468,545	-	189,534,221
	$	-	-	-	19,807	-	3,150,065	10,690,384	103,957,009	302,841,423	1,626,590	641,219	-	422,926,497
Nickel	s.t.	-	-	-	-	-	201,650	9,059	-	-	1,890	1,907	-	214,506
	$	-	-	-	-	-	277,924,234	12,400,485	-	-	2,645,915	2,669,645	-	295,640,279
Copper	s.t.	13,863	-	-	-	157,470	206,272	12,793	31,785	-	16,559	520	-	439,262
	$	8,398,362	-	-	-	95,395,158	123,750,235	7,749,877	19,255,437	-	9,982,552	815,016	-	264,846,637
Uranium (U_3O_8)	lb	-	-	-	-	-	19,793,727	-	4,624,431	-	-	1,077,211	-	25,495,369
	$	-	-	-	-	-	211,983,533	-	48,722,961	-	-	9,231,698	-	269,938,192
Iron ore	s.t.	7,611,365	-	-	-	7,457,971	5,325,197	-	-	-	1,156,297	-	-	21,550,830
	$	54,673,717	-	-	-	61,752,485	48,399,442	-	-	-	10,256,879	-	-	175,082,523
Gold	oz	13,515	-	3	-	1,035,914	2,732,673	52,762	84,775	191	212,859	418,104	78,115	4,628,911
	$	458,834	-	102	-	35,169,280	92,774,248	1,791,270	2,878,111	6,484	7,226,563	14,194,631	2,652,004	157,151,527
Asbestos	s.t.	-	-	-	-	1,054,424	23,284	-	-	-	40,748	-	-	1,118,456
	$	-	-	-	-	107,788,172	4,128,920	-	-	-	9,482,923	-	-	121,400,015
Sand and gravel	s.t.	3,912,533	474,184	8,717,693	6,184,924	46,255,963	77,660,833	10,860,566	8,952,539	13,385,970	15,669,293	-	-	192,074,498
	$	3,069,395	422,587	6,020,239	2,091,227	22,620,093	43,929,708	5,907,596	4,717,271	11,858,520	10,527,250	-	-	111,163,886
Zinc	s.t.	34,208	-	-	-	49,808	45,230	24,390	42,703	-	203,833	-	6,701	406,873
	$	9,133,517	-	-	-	13,298,602	12,076,326	6,512,255	11,401,580	-	54,423,436	-	1,789,287	108,635,003
Cement	s.t.	93,160	-	-	163,245	1,875,997	2,007,044	429,788	169,282	663,856	384,853	-	-	5,787,225
	$	1,688,664	-	-	2,546,622	28,315,159	30,699,800	8,105,802	3,997,809	11,474,865	6,432,752	-	-	93,261,473
Coal	s.t.	-	-	4,570,240	1,028,064	-	-	-	2,170,797	2,391,699	843,868	-	6,470	11,011,138
	$	-	-	44,981,257	8,663,339	-	-	-	3,833,629	11,516,842	5,584,017	-	97,156	74,676,240
Stone	s.t.	380,843	750,000	914,937	1,883,867	20,394,509	17,938,583	673,598	-	167,201	2,255,911	-	-	45,359,449
	$	644,588	750,000	1,643,427	1,413,795	28.458,115	23,220,659	1,050,535	-	310,427	3,149,075	-	-	60,640,621
Natural gas	Mcf	-	-	-	98,701	-	16,987,056	-	36,571,633	383,682,986	85,592,166	39,785	-	522,972,327
	$	-	-	-	151,603	-	6,573,990	-	3,722,992	34,148,675	7,587,403	12,219	-	52,196,882
Lead	s.t.	24,022	-	-	-	2,670	831	1,037	-	-	166,947	-	10,143	205,650
	$	5,131,091	-	-	-	570,195	177,490	221,574	-	-	35,659,900	-	2,166,638	43,926,888
Clay products	$	83,435	-	1,673,618	705,366	8,093,038	20,191,325	813,135	1,130,332	3,551,682	1,984,607	-	-	38,226,538
Silver	oz	1,271,126	-	-	-	4,115,105	11,220,823	501,637	1,163,845	19	8,447,440	79,473	7,217,361	34,016,829
	$	1,130,158	-	-	-	3,658,740	9,976,434	446,005	1,034,775	17	7,510,619	70.659	6,416,956	30,244,363
Platinum metals	oz	-	-	-	-	-	483,585	-	-	-	-	-	19	483,604
	$	-	-	-	-	-	28,871,955	-	-	-	-	-	1,553	28,873,508
Salt	s.t.	-	-	163,901	-	-	3,007,599	21,925	49,064	72,431	-	-	-	3,314,920
	$	-	-	2,256,423	-	-	13,994,545	561,161	1,337,096	1,206,433	-	-	-	19,355,658
Lime	s.t.	-	-	-	16,727	399,874	990,088	48,383	-	43,731	30,765	-	-	1,529,568
	$	-	-	-	379,258	4,449,164	12,278,630	834,698	-	756,499	603,541	-	-	19,301,790
Titanium-dioxide slag	s.t.	-	-	-	-	...	-	-	-	-	-	-	-	...
	$	-	-	-	-	12,947,000	-	-	-	-	-	-	-	12,947,000
Total, leading minerals	$	84,411,761	1,172,587	56,575,066	15,971,017	422,515,201	964,101,539	57,084,777	205,989,002	377,671,867	174,684,022	27,135,087	13,123,594	2,400,435,520
Grand total	$	86,637,123	1,172,587	65,453,531	17,072,739	446.202,726	983,104,412	58,702,697	212,093,225	395,344,010	186,261,646	27,135,087	13,330,198	2,492,509,981
% of grand total		97.4	100.0	86.4	93.5	94.7	98.1	97.2	97.1	95.5	93.8	100.0	98.5	96.3

Summary
Table 10

Net Values of Production in Canada
by Commodity-producing Industries,
1954-58

($ millions)

	1954	1955	1956	1957	1958
Primary industries					
Agriculture*	1,575	1,949	2,143	1,676	1,927
Forestry	584	664	761	663	515
Fisheries	97	91	106	94	117
Trapping	10	17	12	11	11
Mining	901	1,062	1,224	1,308	1,311
Electric power	489	543	594	633	685
Total	3,656	4,326	4,840	4,385	4,566
Secondary industries					
Manufacturing	7,902	8,754	9,605	9,822	9,792
Construction	2,608	2,770	3,344	3,714	3,720
Total	10,510	11,524	12,949	13,536	13,512
Grand total	14,166	15,850	17,789	17,921	18,078

*This series is revised for certain purchased services.

Table 11

World Role of Canada as Producer of Certain Important Minerals - 1960

Metal or Nonmetal		World Production	Rank of the Six Leading Countries 1	2	3	4	5	6
Nickel			Canada	U.S.S.R.	New Caledonia	Cuba	U.S.A.	Union of S. Africa
	s.t.	353,200	214,506	64,000	42,300	14,147	12,530	3,200
	% of world total		61	18	12	4	4	1
Asbestos			Canada	U.S.S.R.	Union of S. Africa	S. Rhodesia	China	Italy
	s.t.	2,700,000	1,118,456	660,000	175,867	133,963	88,000	56,654
	% of world total		41	24	7	5	3	2
Platinum and platinum metals			Canada	Union of S. Africa	U.S.S.R.	Colombia	U.S.A.	Japan
	troy oz	1,243,000	483,604	435,000	275,000	28,855	23,609	1,960
	% of world total		39	35	22	2	2	-
Uranium (Free World)			U.S.A.	Canada	Union of S. Africa	France	Congo	Australia
	s.t.	41,170	17,760	12,748	6,409	1,600	1,200	1,000
	% of world total		43	31	16	4	3	2
Cadmium			U.S.A.	Canada	Belgium	Japan	Congo	U.S.S.R.
	'000 lb	21,700	10,180	2,357	1,500	1,180	1,050	1,035
	% of world total		47	11	7	5	5	5
Gypsum			U.S.A.	Canada	France	U.K.	U.S.S.R.	Spain
	'000 s.t.	41,940	9,825	5,206	4,134	4,016	3,860	2,360
	% of world total		23	12	10	10	9	6
Silver			Mexico	Canada	U.S.A.	Peru	U.S.S.R.	Australia
	troy oz	239,800,000	44,525,563	34,016,829	30,766,327	30,308,665	25,000,000	15,250,000
	% of world total		19	14	13	13	10	6
Aluminum			U.S.A.	Canada	U.S.S.R.	France	W. Germany	Norway
	s.t.	4,986,318	2,014,497	762,012	750,000	259,261	186,291	182,303
	% of world total		40	15	15	5	4	4
Titanium concentrates (ilmenite)			U.S.A.	Canada	India	Norway	Australia	Malaya
	s.t.	2,225,800	786,372	388,339	275,575	258,283	137,800	132,432
	% of world total		35	17	12	12	6	6

Table 11

World Role of Canada as Producer of Certain Important Minerals - 1960 (Continued)

Metal or Nonmetal		World Production	Rank of the Six Leading Countries 1	2	3	4	5	6
Zinc			U.S.S.R.	U.S.A.	Canada	Mexico	Australia	Japan
	s.t.	3,425,183	450,000	432,442	406.873	299,192	273,393	172,524
	% of world total		13	13	12	9	8	5
Gold			Union of S. Africa	U.S.S.R.	Canada	U.S.A.	Australia	Ghana
	troy oz	45,000,000	21,383,019	10,000,000	4,628,911	1,679,800	1,082,784	878,800
	% of world total		48	24	10	4	2	2
Cobalt			Belgian Congo	N. Rhodesia	Canada	Morocco	Australia	
	s.t.	16,800	9,083	2,036	1,784	1,401	16	
	% of world total		54	12	11	8	-	
Bismuth			Peru	Mexico	Canada	Bolivia	S. Korea	Japan
	s.t.	2,600	461	220	212	202	175	122
	% of world total		18	8	8	8	7	5
Magnesium			U.S.A.	U.S.S.R.	Norway	Canada	Italy	U.K.
	s.t.	104,000	40,070	27,600	14,311	7,289	6.003	4,119
	% of world total		39	27	14	7	6	4
Barite			U.S.A.	W. Germany	Mexico	Greece	Canada	U.S.S.R.
	s.t.	3,100,000	770,968	517,657	315,627	165,000	154,292	140,000
	% of world total		25	17	10	5	5	5
Lead			U.S.S.R.	Australia	U.S.A.	Mexico	Canada	Peru
	s.t.	2,374,881	360,000	325,377	243,942	210,176	205,650	139,022
	% of world total		15	14	10	9	9	6
Copper			U.S.A.	N. Rhodesia	Chile	U.S.S.R.	Canada	State of Katanga
	s.t.	4,498,187	1,092,500	635,326	586,856	510,000	439.262	332,900
	% of world total		24	14	13	11	10	7
Iron ore			U.S.S.R.	U.S.A.	France	China	Sweden	Canada
	l.t.	465,670,578	105,407,143	87,296,429	65,854,464	21,428,571	20,980,357	19,241,813
	% of world total		23	19	14	5	4	4
Molybdenum			U.S.A.	U.S.S.R.	Chile	China	Japan	Canada
	s.t.	44,700	34,119	5,500	2,220	1,650	421	384
	% of world total		76	12	5	4	1	1
Arsenic trioxide			Mexico	Sweden	France	Japan	Italy	Canada
	s.t.	62,000	16,500	15,114	8,800	1,200	1,100	862
	% of world total		27	24	14	2	2	1

SECTION II - TRADE

Summary
Table 12

Value of Exports of Minerals and Their Products
from Canada, by Main Groups and Degree
of Manufacture, 1959 and 1960

($ millions)

	1960	1959	Increase or Decrease	
			$ Millions	%
Iron and its products				
Raw material	155.5	157.8	- 2.3	- 1.5
Semiprocessed	73.2	51.1	+ 22.1	+43.2
Fully manufactured	376.5	354.5	+ 22.0	+ 6.2
Total	605.2	563.4	+ 41.8	+ 7.4
Nonferrous metals and their products				
Raw material	428.0	459.8	- 31.8	- 6.9
Semiprocessed	715.3	597.6	+117.7	+19.7
Fully manufactured	79.2	57.1	+ 22.1	+38.7
Total	1,222.5	1,114.5	+108.0	+ 9.7
Nonmetallic minerals and their products (including fuels)				
Raw material	190.4	160.2	+ 30.2	+18.9
Semiprocessed	117.6	104.1	+ 13.5	+13.0
Fully manufactured	31.5	29.9	+ 1.6	+ 5.4
Total	339.5	294.2	+ 45.3	+15.4
All minerals and their products				
Raw material	773.9	777.8	- 3.9	- 0.5
Semiprocessed	906.1	752.8	+153.3	+20.4
Fully manufactured	487.2	441.5	+ 45.7	+10.4
Total	2,167.2	1,972.1	+195.1	+ 9.9

Table 13

Value of Imports of Minerals and Their Products into Canada, by Main Groups and Degree of Manufacture, 1959 and 1960

($ millions)

	1960	1959	Increase or Decrease $ Millions	%
Iron and its products				
Raw material	48.4	27.1	+ 21.3	+78.6
Semiprocessed	32.0	34.4	- 2.4	- 7.0
Fully manufactured	1,965.9	2,030.6	- 64.7	- 3.2
Total	2,046.3	2,092.1	- 45.8	- 2.2
Nonferrous metals and their products				
Raw material	55.4	46.8	+ 8.6	+18.4
Semiprocessed	34.9	29.0	+ 5.9	+20.3
Fully manufactured	380.8	395.5	- 14.7	- 3.7
Total	471.1	471.3	- 0.2	- 0.04
Nonmetallic minerals and their products (including fuels)				
Raw material	396.1	396.2	- 0.1	- 0.03
Semiprocessed	16.0	18.1	- 2.1	-11.6
Fully manufactured	260.1	291.3	- 31.2	-10.7
Total	672.2	705.6	- 33.4	- 4.7
All minerals and their products				
Raw material	499.9	470.1	+ 29.8	+ 6.3
Semiprocessed	82.9	81.5	+ 1.4	+ 1.7
Fully manufactured	2,606.8	2,717.4	-110.6	- 4.1
Total	3,189.6	3,269.0	- 79.4	- 2.4

Summary
Table 14

Value of Exports of Minerals and Their Products from Canada, by Degree of Manufacture and in Relation to Total Export Trade, 1959 and 1960

	1960		1959	
	$ Millions	% of Total	$ Millions	% of Total
Raw material	773.9	14.7	777.8	15.4
Semiprocessed	906.1	17.2	752.8	14.9
Fully manufactured	487.2	9.3	441.5	8.7
Total, minerals and products	2,167.2	41.2	1,972.1	39.0
Total, all products	5,266.4	100.0	5,060.9	100.0

Table 15

Value of Imports of Minerals and Their Products into Canada, by Degree of Manufacture and in Relation to Total Import Trade, 1959 and 1960

	1960		1959	
	$ Millions	% of Total	$ Millions	% of Total
Raw material	499.9	9.1	470.1	8.3
Semiprocessed	82.9	1.5	81.5	1.4
Fully manufactured	2,606.8	47.5	2,717.4	48.1
Total, minerals and products	3,189.6	58.1	3,269.0	57.8
Total, all products	5,492.3	100.0	5,654.2	100.0

Table 16

Value of Exports of Minerals and Their Products from Canada, by Main Groups and Destinations, 1960

($ millions)

	United Kingdom	United States	Other Countries	Total
Iron and its products	72.8	325.4	207.0	605.2
Nonferrous metals and their products	297.3	564.9	360.3	1,222.5
Nonmetallic minerals and their products	16.6	248.2	74.7	339.5
Total, minerals and their products	386.7	1,138.5	642.0	2,167.2
Percentage	17.9	52.5	29.6	100.0

Table 17

Value of Imports of Minerals and Their Products into Canada, by Main Groups and Sources, 1960

($ millions)

	United Kingdom	United States	Other Countries	Total
Iron and its products	271.3	1,610.2	164.8	2,046.3
Nonferrous metals and their products	69.7	296.0	105.4	471.1
Nonmetallic minerals and their products	29.2	268.2	374.8	672.2
Total, minerals and their products	370.2	2,174.4	645.0	3,189.6
Percentage	11.6	68.2	20.2	100.0

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Table 18

Value of Exports of Raw and Semiprocessed Minerals
from Canada, by Commodity and Destination, 1960
($'000)

Minerals	U.S.A.	U.K.	Other E.F.T.A.[1] Countries	E.E.C.[2] Countries	Japan	Other Countries	Total
Iron ore	101,903	27,722	-	16,423	9,424	-	155,472
Primary ferrous metals	29,107	21,602	1,143	13,539	5,345	2,451	73,187
Aluminum	53,742	79,676	6,895	53,287	8,481	66,073	268,154
Copper	75,400	68,697	12,611	27,759	11,684	10,533	206,684[3]
Lead	11,188	8,521	4	4,160	1,761	409	26,043
Nickel	88,597	67,896	53,542	32,683	-	15,613	258,331
Zinc	31,837	20,456	997	3,134	2,242	4,869	63,535
Uranium	236,594	25,905	29	295	147	571	263,541
Asbestos	53,903	9,386	3,581	25,498	8,499	19,247	120,114
Fuels	114,743	-	-	-	4,464	83	119,290
All other minerals[4]	82,971	28,437	1,634	8,317	5,353	2,353	129,065
Total	879,985	358,298	80,436	185,095	57,400	122,202	1,683,416

(1) Other European Free Trade Area countries: Norway, Sweden, Denmark, Switzerland, Austria, and Portugal.

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

(3) Brass scrap included.

(4) Includes salt, which is under 'fully manufactured' in Tables 12, 13, 14, and 15.

Table 19

Value of Exports of Raw and Semiprocessed Minerals from Canada, by Commodity and Destination, 1959
($'000)

Minerals	U.S.A.	U.K.	Other E.F.T.A.[1] Countries	E.E.C.[2] Countries	Japan	Other Countries	Total
Iron ore	117,810	22,428	-	12,522	5,054	-	157,814
Primary ferrous metals	41,892	2,439	158	1,494	4,562	574	51,119
Aluminum	80,014	68,645	6,308	32,360	5,150	38,206	230,683
Copper	66,391	48,781	9,323	17,747	4,570	6,067	152,879[3]
Lead	15,145	6,260	170	3,640	6	249	25,470
Nickel	114,019	46,219	46,476	12,836	22	7,285	226,857
Zinc	35,847	16,084	617	1,574	153	822	55,097
Uranium	278,913	32,603	132	129	107	20	311,904
Asbestos	54,638	9,129	3,452	21,268	6,737	15,207	110,431
Fuels	93,991	-	-	-	971	115	95,077
All other minerals[4]	84,104	21,323	3,250	5,764	1,766	1,696	117,903
Total	982,764	273,911	69,886	109,334	29,098	70,241	1,535,234

(1) Other European Free Trade Area countries: Norway, Sweden, Denmark, Switzerland, Austria, and Portugal.
(2) European Economic Community (Common Market) countries: France, West Germany, Italy, Belgium, Luxembourg, and the Netherlands.
(3) Brass scrap included.
(4) Includes salt, which is under 'fully manufactured' in Tables 12, 13, 14, and 15.

Summary Table 20

Value of Exports of Raw and Semiprocessed Minerals from Canada in Relation to Total Export Trade, 1950-60

($ millions)

	Raw	Semi-processed	Total Minerals*	Exports, All Products	Mineral Exports as % of Export Trade
1950	134	435	569	3,118	18
1951	177	532	709	3,914	18
1952	205	609	814	4,301	19
1953	235	613	848	4,117	21
1954	241	630	871	3,881	22
1955	352	772	1,124	4,282	26
1956	530	857	1,387	4,790	29
1957	655	854	1,509	4,839	31
1958	676	685	1,361	4,826	28
1959	778	753	1,531	5,061	30
1960	774	906	1,680	5,266	32

*Salt excluded.

Table 21

Value of Imports of Raw and Semiprocessed Minerals into Canada in Relation to Total Import Trade, 1950-60

($ millions)

	Raw	Semi-processed	Total Minerals	Imports, All Products	Mineral Imports as % of Import Trade
1950	445	60	505	3,174	16
1951	492	78	570	4,085	14
1952	459	82	541	4,030	13
1953	435	63	498	4,383	11
1954	390	53	443	4,093	11
1955	432	73	505	4,712	11
1956	521	115	636	5,705	11
1957	561	90	651	5,623	12
1958	468	62	530	5,192	10
1959	470	82	552	5,654	10
1960	500	83	583	5,492	11

SECTION III - CONSUMPTION

Summary
Table 22

Reported Consumption of Minerals in Canada
and its Relationship to Production, 1959

Mineral	Unit	Consumption	Production[1]	Consumption as % of Production
Metallics				
Aluminum	s.t.	114,344	593,630	19.3
Antimony	lb	1,134,719	1,657,797	68.4
Bismuth	lb	39,722	334,736	11.9
Cadmium	lb	226,288	2,160,363	10.5
Chromium (chromite)	s.t.	58,532	-	-
Cobalt	lb	250,046	3,150,027	7.9
Copper	s.t.	129,973[2]	395,269	32.9
Iron ore[3]	l.t.	6,770,233	22,104,863	30.6
Lead	s.t.	46,165[4]	186,696	24.7
Magnesium	s.t.	1,668	6,102	27.3
Manganese ore	s.t.	90,311	-	-
Mercury	lb	161,987	-	-
Molybenum (Mo content)	lb	928,505	748,566	124.0
Nickel	s.t.	3,689	186,555	2.0
Selenium	lb	22,156	368,107	6.0
Silver	oz	10,202,769	31,923,969	32.0
Tellurium	lb	9,677	13,023	74.3
Tin	l.t.	4,223	334	
Tungsten (W content)	lb	659,991	-	-
Zinc	s.t.	64,788[4]	396,008	16.4
Nonmetallics				
Feldspar	s.t.	6,916	17,953	38.5
Fluorspar	s.t.	96,016	...	...
Mica	lb	3,622,000	813,834	445.1
Quartz (silica)	s.t.	2,535,059	2,163,546	117.2
Talc etc.	s.t.	33,703[6]	39,176[5]	86.0
Sodium sulphate	s.t.	151,829	179,535	84.6
Sulphur, elemental	s.t.	450,007	145,656	309.0
Fuels				
Coal	s.t.	24,548,259	10,626,722	231.0
Natural gas	Mcf	283,230,089	417,334,527	67.9
Petroleum, crude	bbl	267,850,044	184,778,497	145.0

(1) Production, so far as it applies to metals, means, in most instances, production in all forms. This includes the recoverable metal content of ores, concentrates, matte, etc. exported and the metal content of primary products that is recoverable at domestic smelters and refineries. Production of nonmetals means producers' shipments.

(2) Producers' domestic shipments of refined copper. (3) Includes by-product sinter, pellets, etc., which in the production total amounted to 240,287 long tons. (4) Consumption of primary refined metal only. (5) Ground talc. (6) Includes soapstone and pyrophyllite. (7) Domestic and imported crude oil.

Table 23

Apparent Consumption of Minerals in Canada
and its Relationship to Production, 1959

(short tons)

	Apparent Consumption(1)	Production(2)	Consumption as % of Production
Asbestos	36,507	1,050,429	3.5
Barite	18,908	238,967	7.9
Gypsum	1,147,884	5,878,630	19.5
Nepheline syenite	50,602	228,722	22.1
Salt	2,385,866	3,289,976	72.5
Cement	6,010,616	6,284,486	95.6
Lime	1,692,507	1,685,725	100.4

(1) Production plus imports less exports. Statistics on the consumption of these commodities as reported by the consumers were not readily available.

(2) Producers' shipments.

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Table 24

Domestic Consumption of Principal Refined Base Metals(1) in Relation to Their Production(2) in Canada, 1950-60

	Unit	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
Copper												
Domestic consumption	s.t.	106,876	134,174	130,347	105,482	102,432	138,559	145,286	118,225	122,893	129,973	117,636
Production	s.t.	238,204	245,466	196,320	236,966	253,365	288,997	328,458	323,540	329,239	365,366	417,029
% consumption of production		44.9	54.7	66.4	44.5	40.4	47.9	44.2	36.5	37.3	35.6	28.2
Nickel												
Domestic consumption	s.t.	2,226	2,744	2,223	2,275	2,595	5,020	5,545	4,532	4,099	3,689	4,996
Production	s.t.	68,434	78,132	76,825	82,684	92,702	108,712	109,453	123.718	75,707	111,711	122,443
% consumption of production		3.3	3.5	2.9	2.8	2.8	4.6	5.1	3.7	5.4	3.3	4.1
Zinc												
Domestic consumption	s.t.	54,370	61,023	51,581	50,717	46,735	58,062	61,173	52,713	56,097	64,788	55,803
Production	s.t.	204,367	218,578	222,200	250,961	213,775	256,542	255,564	247,316	252,093	255,306	260,968
% consumption of production		26.6	27.9	23.2	20.2	21.9	22.6	23.9	21.3	22.3	25.4	21.4
Lead												
Domestic consumption	s.t.	54,723	60,348	62,466	67,718	67,947	76,351	75,882	71,583	69,769	65,935	72,087
Production	s.t.	170,023	162,000	182,943	165,752	166,005	148,811	147,865	142,935	132,987	135,296	158,510
% consumption of production		32.2	37.3	34.1	40.9	40.9	51.3	51.3	50.1	52.5	48.7	45.5
Aluminum												
Domestic consumption	s.t.	65,185	86,241	90,287	88,548	80,355	91,522	91,869	77,984	101,886	89,000	106,708
Production	s.t.	396,882	447,095	499,758	548,445	557,897	612,543	620,321	556,715	634,102	593,630	762,012
% consumption of production		16.4	19.3	18.1	16.1	14.4	14.9	14.8	14.0	16.1	15.0	13.9

(1) Refined, comprising both primary and secondary metal.

(2) Refined metal from all sources, including metal derived from secondary materials at primary refineries.

SECTION IV - PRICES

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Table 25

Annual Average Prices of Main Minerals,* 1959 and 1960

	1960	1959	Increase or Decrease	
			Cents or Dollars	Percentage
Aluminum ingot, cents per lb	27.225	26.838	+ 0.387	+ 1.4
Antimony, N.Y., boxed, cents per lb	32.590	32.590	-	-
Bismuth, dollars per lb	2.25	2.25	-	-
Cadmium, cents per lb	152.494	133.750	+18.744	+14.0
Calcium, dollars per lb	2.05	2.05	-	-
Chromium metal, dollars per lb	1.17	1.17	-	-
Cobalt metal, dollars per lb	1.56	1.77	- 0.21	-11.9
Cobalt ore 10% Co, free market, f.o.b. shipping point, cents per lb Co contained	60.00	60.00	-	-
Copper, U.S. domestic, cents per lb	32.053	31.182	+ 0.871	+ 2.8
Gold, Canadian dollars per troy oz	33.95	33.57	+ 0.38	+ 1.1
Iron ore 51.5% Fe, dollars per l.t. Lower Lakes ports				
Mesabi, non-Bessemer	11.45	11.45	-	-
Mesabi, Bessemer	11.60	11.60	-	-
Old Range, non-Bessemer	11.70	11.70	-	-
Old Range, Bessemer	11.85	11.85	-	-
Lead, Common, N.Y., cents per lb	11.948	12.211	- 0.263	- 2.2
Magnesium ingot, cents per lb	35.250	35.250	-	-
Mercury, dollars per flask (76 lb)	210.760	227.484	-16.724	- 7.4
Molybdenum metal, dollars per lb	3.35	3.35	-	-
Molybdenite 90-95% MoS_2, dollars per lb Mo contained	1.25	1.25	-	-
Nickel, f.o.b. Port Colborne (duty included), cents per lb	74.000	74.000	-	-
Platinum, dollars per troy oz	81.729	73.250	+ 8.479	+11.6
Selenium, dollars per lb	7.000	7.000	-	-
Silver, N.Y., cents per troy oz	91.375	91.202	+ 0.173	+ 1.7
Sulphur, dollars per l.t.	23.00	23.50	- 0.50	- 2.1
Tin, Straits, N.Y., cents per lb	101.438	102.053	- 0.615	- 0.6
Titanium metal, dollars per lb	1.52	1.67	- 0.15	- 9.0
Titanium ore (ilmenite) 59.5% TiO_2, f.o.b. Atlantic ports, dollars per l.t.	23 to 26	23 to 26	-	-
Tungsten metal, dollars per lb	2.85	2.85	-	-
Zinc, Prime Western, East St. Louis, cents per lb	12.946	11.448	+ 1.498	+13.1

*These prices, except those for gold, are in United States currency and are from E & M J Metal and Mineral Markets. The Canadian prices follow closely.

Summary Table 26

Wholesale Price Indexes of Minerals and Mineral Products and General Wholesale Price Index of all Commodities, Canada, 1950 and 1958-60

(1935-39 = 100)

	1950	1958	1959	1960
Iron and its products	183.6	252.6	255.7	256.2
Pig iron	218.1	295.3	295.3	295.3
Rolling-mill products	170.6	246.6	249.2	251.8
Pipe and tubing	213.4	263.1	265.0	268.3
Wire	205.1	292.2	293.7	294.2
Scrap iron and steel	244.4	276.1	307.4	288.5
Tinplate and galvanized sheet	178.2	239.3	240.7	238.4
Nonferrous metals and their products				
Total (including gold)	159.5	167.3	174.6	177.8
Total (excluding gold)	200.8	224.1	238.0	242.9
Antimony	206.3	160.1	163.9	167.5
Copper and its products	222.0	246.5	285.0	291.4
Lead and its products	299.6	237.3	222.6	224.0
Silver	208.3	223.2	225.8	228.9
Tin	196.9	179.6	196.0	196.8
Zinc and its products	334.9	238.3	266.0	291.1
Solder	207.4	196.4	199.3	200.6
Nonmetallic minerals and their products	164.8	188.5	186.5	185.6
Clays and clay products	172.6	248.4	253.2	255.8
Pottery	146.8	180.7	185.8	185.8
Coal	167.9	193.2	193.0	191.9
Coal tar	154.4	237.9	242.8	214.5
Coke	204.1	242.1	241.3	241.6
Window glass	172.5	270.2	272.1	272.7
Plate glass	135.4	217.0	218.4	218.8
Petroleum products	167.7	169.7	164.2	162.2
Crude oil	204.5	203.6	190.1	187.1
Gasoline	142.3	139.6	138.0	135.8
Coal oil	128.8	135.4	134.4	134.4
Asphalt	179.9	215.1	203.7	199.5
Asphalt shingles	133.6	148.4	127.2	116.3
Sulphur	170.5	201.8	199.6	201.8
Plaster	111.1	136.3	137.5	138.1
Lime	168.7	211.2	211.2	212.0
Cement	128.2	163.5	160.6	162.6
Sand and gravel	132.9	151.2	145.4	145.2
Crushed stone	139.6	165.0	171.4	171.4
Building stone	166.2	207.6	208.8	208.8
Asbestos and products	211.3	304.3	304.3	302.2
General wholesale price index (all products)	211.2	227.8	230.6	230.9

Table 27

Canadian General Wholesale Price Index and Component Products for Selected Years, 1939-60

(1935-39 = 100)

	1939	1946	1950	1952	1954	1956	1958	1960
General wholesale price index	99.2	138.9	211.2	226.0	217.0	225.6	227.8	230.9
Mineral products								
Iron products	104.8	127.4	183.6	219.0	213.4	239.8	252.6	256.2
Nonferrous-metal products	100.0	108.0	159.5	172.9	167.5	199.2	167.3	177.8
Nonmetallic-mineral products	99.7	114.5	164.8	173.9	177.0	180.8	188.5	185.6
Other products								
Vegetable	89.1	134.2	202.0	210.3	196.8	197.3	198.1	203.0
Animal	100.6	160.2	251.3	248.2	236.0	227.7	250.7	247.6
Textile	98.9	137.9	246.7	251.5	231.1	230.2	229.0	229.8
Wood products	107.5	172.1	258.3	291.0	286.8	303.7	298.5	303.8
Chemical	100.3	120.3	157.8	180.1	176.4	180.1	183.0	188.2

SECTION V - PRINCIPAL INDUSTRY STATISTICS

Table 28

Principal Statistics of Mineral Industry in Canada, by Sectors, 1959

	Establish-ments	Employees	Salaries and Wages	Cost of Fuel and Electricity	Cost of Process Supplies	Value of Production Gross	Value of Production Net*
			($'000)	($'000)	($'000)	($'000)	($'000)
Metallics							
Placer gold	112	239	1,195	75	356	2,463	1,990
Gold quartz	139	16,777	65,519	7,161	20,901	130,098	100,519
Copper-gold-silver	310	9,682	43,460	4,948	12,949	147,753	90,660
Silver-cobalt	11	486	1,648	186	229	5,007	4,119
Silver-lead-zinc	52	4,241	19,844	1,992	6,244	101,873	53,554
Nickel-copper	55	11,025	57,210	3,457	15,235	110,332	84,746
Iron	59	7,776	41,451	7,708	10,044	192.666	125,208
Other	84	13,645	76,604	9,024	57,983	333,770	265,835
Total	822	63,871	306,931	34,551	123,941	1,023,962	726,631
Industrial minerals							
Asbestos	23	6,653	31,449	5,952	13,730	110,997	91,315
Feldspar, quartz, nepheline syenite	37	509	2,079	422	753	6,798	5,397
Gypsum	15	874	3,229	488	711	8,394	7,195
Salt	15	844	3,484	1,194	3,420	20,224	15,844
Sand and gravel	8,101	6,316	19,522	4,229	828	104,651	99,594
Stone	613	3,873	13,937	3,090	5,129	60,959	52,739
Clay products	116	4,250	15,973	6,447	1,372	42,515	35,592
Cement	19	3,421	16,436	17,309	13,270	98,778	67,613
Lime	40	1,245	4,779	5,056	1,455	22,131	15,602
Other	96	2,839	8,639	2,159	3,380	22,516	16,909
Total	9,075	30,824	119,527	46,346	44,048	497,963	407,800
Fuels							
Coal	133	11,485	37,123	4,282	10,706	73,876	58,888
Petroleum and natural gas	21,557	6,721	33,702	7,420	9,662	455,517	438,435
Total	21,690	18,206	70,825	11,702	20,368	529,393	497,323
Total, mining industry	31,587	112,901	497,283	92,599	188,357	2,051,318	1,631,754
Nonferrous smelting and refining	24	27,746	137,227	62,320	815,788	1,307,997	429,889

*Net value equals the gross value of production less the cost of process supplies, fuel and electricity, and transportation.

Table 29

Principal Statistics of Mining Industry (1) in Canada, 1950-59

	Establish-ments	Employees	Salaries and Wages	Cost of Fuel and Electricity	Cost of Process Supplies	Value of Production	
						Gross	Net(2)
			($'000)	($'000)	($'000)	($'000)	($'000)
1950	17,078	100,525	274,696	44,619	84,698	903,818	712,249
1951	18,140	106,057	321,687	49,360	99,959	1,049,806	832,116
1952	19,939	109,508	365,012	54,418	110,027	1,085,831	845,733
1953	20,490	104,923	358,520	58,504	110,257	1,111,401	871,340
1954	21,882	103,397	362,710	60,686	115,483	1,239,726	987,861
1955	24,091	105,030	384,406	66,228	124,844	1,456,825	1,156,309
1956	26,914	111,772	435,908	79,195	139,893	1,672,830	1,326,719
1957	29,430	116,256	476,397	88,886	167,145	1,807,562	1,386,948
1958	29,546	112,581	479,418	91,132	177,944	1,823,432	1,438,748
1959	31,587	112,901	497,283	92,599	188,357	2,051,318	1,631,754

(1) Does not include the nonferrous-smelting and -refining industries.

(2) Net value equals the gross value of production less the cost of process supplies, fuel and electricity, and transportation.

Table 30

Consumption of Fuels and Electricity in Canadian Mineral Industry, 1959

	Unit	Metal-mining	Nonferrous Smelting and Refining	Total	Production of Industrial Minerals	Production of Crude Mineral Fuels	Total, Mineral Industry
Coal and coke	s.t.	226,078	1,215,781	1,441,859	1,470,301	94,989	3,007,149
	$	3,336,868	18,643,287	21,980,155	16,190,476	578,347	38,748,978
Gasoline and kerosene	gal	3,122,285	721,787	3,844,072	13,047,404	6,802,302	23,693,778
	$	1,273,444	244,191	1,517,635	4,673,598	2,577,971	8,769,204
Fuel oil	gal	48,669,428	64,144,687	112,814,115	66,143,082	5,322,113	184,279,310
	$	8,733,277	5,772,787	14,506,064	8,300,723	1,169,431	23,976,218
Liquefied petroleum gas	gal	444,535	49,203	493,738	578,956	1,439,586	2,512,280
	$	127,611	18,357	145,968	118,252	489,868	754,088
Manufactured gas	Mcf	4,860	117,541	122,401	868,884	-	991,285
	$	2,085	66,320	68,405	213,071	-	281,476
Natural gas	Mcf	59,814	6,364,943	6,424,757	15,154,216	3,498,468	25,077,441
	$	32,190	1,473,376	1,505,566	4,043,329	456,871	6,005,766
Other fuels	$	379,761	62,444	442,205	359,406	5,185	806,796
Total, fuels	$	13,885,236	26,280,762	40,165,998	33,898,855	5,277,673	79,342,526
Electricity purchased	million kwh	3,300	14,575	17,875	1,511	352	19,738
	$	20,666,212	36,039,614	56,705,826	12,447,312	6,424,502	75,577,640
Total value, fuels and electricity purchased	$	34,551,448	62,320,376	96,871,824	46,346,167	11,702,175	154,920,166
Electricity generated by industry for own use	million kwh	505	1,060	1,565	34	12	1,611

Table 31

Cost of Fuel and Electricity Used in Canadian Mineral Industry,[1] 1950-59

	Fuel[2]	Electricity Purchased		Total Cost of Fuel and Electricity	Electricity Generated for Own Use	Electricity Generated for Sale
	$ Millions	Millions kwh	$ Millions	$ Millions	Millions kwh	Millions kwh
1950	27.8	2,624.5	16.8	44.6	280.9	32.6
1951	30.3	2,990.3	19.0	49.3	228.9	26.7
1952	33.1	3,026.4	21.3	54.4	248.8	21.0
1953	35.2	3,091.7	23.3	58.5	240.3	9.7
1954	37.0	3,243.3	23.7	60.7	426.2	18.8
1955	39.9	3,540.2	26.5	66.4	486.9	47.1
1956	47.0	4,213.5	32.2	79.2	557.7	12.0
1957	53.1	4,585.9	35.8	88.9	590.0	14.2
1958	53.1	6,292.9	38.1	91.1	526.7	15.8
1959	53.1	5,163.7	39.5	92.6	550.9	17.0

(1) Excludes nonferrous smelting and refining.
(2) Coal, coke, fuel oil, gasoline, gas, wood, etc.

Table 31A

Cost of Fuel and Electricity Used in Nonferrous Smelting and Refining, 1950-59

	Fuel*	Electricity Purchased		Total Cost of Fuel and Electricity	Electricity Generated for Own Use	Electricity Generated for Sale
	$ Millions	Millions kwh	$ Millions	$ Millions	Millions kwh	Millions kwh
1950	19.0	9,044.6	19.5	38.5	700.0	9.1
1951	21.4	9,993.9	23.3	44.7	624.5	7.2
1952	23.9	11,176.8	26.7	50.6	639.5	7.3
1953	23.0	12,296.9	29.6	52.6	796.2	4.3
1954	24.8	12,690.2	30.4	55.2	753.9	13.4
1955	24.3	13,803.7	32.6	56.9	1,131.9	9.2
1956	29.9	13,981.4	35.0	64.9	1,121.4	12.2
1957	27.3	13,668.2	32.2	59.5	1,036.6	-
1958	23.4	15,081.2	40.1	63.5	1,038.5	33.2
1959	26.3	14,574.6	36.0	62.3	1,060.0	30.7

*Coal, coke, fuel oil, gasoline, gas, wood, etc.

SECTION VI - EMPLOYMENT, SALARIES, AND WAGES

Table 32

Employment, Salaries, and Wages in Canadian Mineral Industry, by Sectors, at Five-year Intervals, 1939-59

	1939		1944		1949		1954		1959	
	Employees	$ Millions	Employees	$ Millions	Employees	$ Millions	Employees	$ Millions	Employees	$ Millions
Metal-mining	45,594	79.2	34,559	71.9	46,181	132.3	51,599	195.2	63,871	307.0
Nonferrous smelting and refining	12,449	19.4	23,927	44.5	19,150	55.1	26,048	102.6	27,746	137.2
Industrial minerals	19,474	18.0	16,439	24.7	22,581	50.0	26,991	89.2	30,824	119.5
Fuels*	30,242	35.8	29,953	63.7	28,595	72.2	24,807	78.3	18,206	70.8
Total	107,759	152.4	104,878	204.8	116,507	309.6	129,445	465.3	140,647	634.5
Annual average of salaries and wages		$1,414		$1,953		$2,657		$3,595		$4,511

*Coal, crude petroleum, and natural gas.

Table 33

Numbers of Wage Earners - Surface, Underground, and Mill - in Canadian Mining Industry,[1] by Sectors, 1950-59

	Metallics[2]				Industrial Minerals				Fuels				Total			
	Surface	Under-ground	Mill	Total	Surface	Under-ground	Mill	Total	Surface	Under-ground	Mill	Total	Surface	Under-ground	Mill	Total
1950	12,622	26,168	4,154	42,944	11,283	1,486	9,545	22,314	9,420	16,089	-	25,509	33,325	43,743	13,699	90,767
1951	13,862	27,869	4,365	46,096	11,484	1,680	9,925	23,089	9,985	15,482	-	25,467	35,331	45,031	14,290	94,652
1952	15,689	28,941	4,643	49,273	11,882	1,794	10,079	23,755	9,990	14,897	-	24,887	37,561	45,632	14,722	97,915
1953	13,959	27,580	4,320	45,859	11,574	1,718	10,658	23,950	9,838	13,587	-	23,425	35,371	42,885	14,978	93,234
1954	14,098	26,821	4,761	45,680	11,826	1,659	10,825	24,310	9,082	12,422	-	21,504	35,006	40,902	15,586	91,494
1955	15,540	26,522	4,664	46,726	12,204	1,632	11,445	25,281	8,886	11,439	-	20,325	36,630	39,593	16,109	92,332
1956	16,706	27,679	5,624	50,009	12,804	1,798	12,163	26,765	9,622	11,065	-	20,687	39,132	40,542	17,787	97,461
1957	18,532	29,382	6,168	54,082	14,347	1,749	11,573	27,669	8,683	10,043	-	18,726	41,562	41,174	17,741	100,477
1958	16,602	29,712	6,541	52,855	14,029	1,458	11,216	26,703	7,887	9,247	-	17,134	38,518	40,417	17,757	96,692
1959	16,697	31,384	6,573	54,654	13,988	1,327	11,639	26,954	7,537	8,022	-	15,559	38,222	40,733	18,212	97,167

(1) Does not include nonferrous smelting and refining.
(2) Includes placer operations.

Summary Table 34

Labor Costs in Relation to Tons Mined from Metal Mines[1] in Canada, 1939, 1949, and 1959

Types of Mines	Number of Wage Earners	Total of Wages	Average Annual Wage	Tonnage Mined	Average Annual Tonnage Mined per Worker	Wage Cost per Ton Mined
(1959)		($ millions)	($)	('000 s.t.)	(s.t.)	($)
Auriferous-quartz	14,967	55.7	3,722	14,247	952	3.91
Copper-gold-silver	8,156	35.6	4,365	12,436	1,525	2.86
Nickel-copper	9,969	49.6	4,975	18,964	1,902	2.62
Silver-cobalt[2]	415	1.3	3,133	197	475	6.60
Silver-lead-zinc	3,476	15.3	4,402	5,709	1,642	2.68
Iron-ore	6,169	31.6	5,122	32,398	5,252	0.98
Miscellaneous metal mines	11,288	63.5	5,625	15,130	1,340	4.20
Total	54,440	252.6	4,640	99,081	1,820	2.55
(1949)						
Auriferous-quartz	20,233	53.6	2,649	16,000	791	3.35
Copper-gold-silver	6,534	18.6	2,847	8,245	1,262	2.26
Nickel-copper	6,500	20.0	3,077	10,924	1,681	1.83
Silver-cobalt[2]	234	0.5	2,137	39	167	12.82
Silver-lead-zinc	4,778	13.2	2,763	3,915	819	3.37
Miscellaneous metal mines[3]	3,103	8.3	2,675	4,208	1,356	1.97
Total	41,382	114.2	2,760	43,331	1,047	2.64
(1939)						
Auriferous-quartz	27,959	46.8	1,674	17,106	612	2.74
Copper-gold-silver	5,587	8.8	1,575	8,475	1,517	1.04
Nickel-copper	5,685	10.7	1,882	7,859	1,382	1.36
Silver-cobalt[2]	278	0.3	1,079	60	216	5.00
Silver-lead-zinc	1,375	2.3	1,673	2,195	1,596	1.05
Miscellaneous metal mines[3]	291	0.4	1,375	192	660	2.08
Total	41,175	69.3	1,683	35,887	872	1.93

(1) Excludes placer-mining operations.

(2) In silver-cobalt-mining operations considerable tonnages of old tailings were used. These tonnages are not included in the foregoing tabulation.

(3) Includes iron-ore mines.

Table 35

Man-hours Worked and Tonnages Mined in Metal Mines and Industrial-mineral Operations in Canada, 1952-59

	Metal Mines			Industrial-mineral Operations		
	Tonnages of Ore Mined (millions s.t.)	Man-hours Worked (millions)	Man-hours Worked per Ton Mined	Tonnages of Ore Mined and Rock Quarried (millions s.t.)	Man-hours Worked (millions)	Man-hours Worked per Ton Mined
1952	52.3	125.7	2.40	44.2	61.9	1.40
1953	54.4	113.5	2.09	47.2	61.7	1.31
1954	59.0	112.6	1.91	61.5	62.5	1.02
1955	69.2	117.4	1.70	63.5	66.8	1.05
1956	77.3	127.1	1.64	73.1	68.5	0.94
1957	84.3	136.4	1.62	82.1	70.1	0.85
1958	78.8	134.3	1.70	78.5	66.3	0.84
1959	99.1	134.0	1.35	90.7	66.7	0.74

Summary Table 36

Basic Wage Rates per Hour in Canadian Metal-mining as at October 1, 1959

Occupation	Gold-mining	Iron-mining	Other Metal-mining
	($)	($)	($)
Underground workers			
Cage-and-skip tender	1.45	..	2.08
Chute blaster	1.38	..	2.17
Deckman	1.37	..	1.92
Hoistman	1.55	2.08	2.22
Laborer	1.33	..	1.97
Miner	1.43	2.51	2.08
Miner's helper	1.33	..	1.75
Motorman	1.38	2.08	2.05
Mucker and trammer	1.34	..	2.01
Mucking-machine operator	1.38	2.10	2.07
Timberman	1.43	..	2.18
Trackman	1.40	..	2.10
Pipe fitter	..	..	2.19
Open-pit workers			
Blaster		2.22	
Bulldozer operator		2.26	
Heavy-truck driver		2.29	
Machine driller		2.26	
Oiler		2.05	
Shovel operator		2.64	
Surface and mill workers			
Carpenter	1.56	2.41	2.15
Crusher operator	1.40	2.14	1.99
Electrician	1.58	2.58	2.37
Laborer	1.27	1.83	1.75
Machinist	1.55	2.64	2.35
Mechanic	1.56	2.47	2.29
Millman	1.45	..	2.10
Pipe fitter	1.48	..	..
Steel sharpener	1.47	..	2.09
Tradesman's helper	1.35	2.07	1.84
Truck driver	1.39	..	1.87

Table 37

Average of Weekly Wages and Hours of Hourly-rated Employees in Canadian Mining, Manufacturing, and Construction Industries, 1954-60

	1954	1955	1956	1957	1958	1959	1960
Mining							
Average hours per week	42.6	43.2	42.8	42.3	41.5	41.5	41.7
Average weekly wage	$67.14	$69.68	$73.92	$79.35	$81.30	$84.80	$87.26
Metals							
Average hours per week	44.1	44.1	43.0	42.9	41.8	41.7	41.9
Average weekly wage	$71.27	$73.07	$77.27	$83.70	$84.77	$88.73	$90.89
Fuels							
Average hours per week	39.5	41.0	42.0	40.8	40.0	39.9	40.6
Average weekly wage	$60.71	$64.00	$69.01	$72.91	$75.12	$77.11	$80.13
Nonmetals							
Average hours per week	42.9	43.3	43.1	42.5	42.3	42.2	42.2
Average weekly wage	$63.15	$66.16	$68.79	$71.57	$73.73	$76.87	$79.62
Manufacturing							
Average hours per week	40.7	41.0	41.0	40.4	40.2	40.7	40.4
Average weekly wage	$57.43	$59.45	$62.40	$64.96	$66.77	$70.16	$71.96
Construction							
Average hours per week	40.3	39.9	41.1	41.2	40.7	40.2	40.4
Average weekly wage	$59.85	$60.49	$67.77	$72.55	$72.36	$74.20	$78.41

Summary
Table 38

Average of Weekly Wages of Hourly-rated Employees in Canadian Mining Industry in Current and 1949 Dollars, 1954-60

	1954	1955	1956	1957	1958	1959	1960
Current dollars							
All mining	67.14	69.68	73.92	79.35	81.30	84.80	87.26
Metals	71.27	73.07	77.27	83.70	84.77	88.73	90.89
Gold	63.48	64.17	65.77	67.48	68.09	68.95	70.81
Other	75.55	77.89	82.26	90.13	91.59	95.92	98.52
Fuels	60.71	64.00	69.01	72.91	75.12	77.11	80.13
Coal	57.02	58.88	61.04	63.51	67.43	67.00	69.37
Oil and natural gas	73.31	77.34	85.11	90.13	89.20	92.74	96.58
Nonmetallics	63.15	66.16	68.79	71.57	73.73	76.87	79.62
1949 dollars							
All mining	57.78	59.86	62.59	65.09	64.99	67.04	68.17
Metals	61.33	62.77	65.43	68.66	67.76	70.14	71.01
Gold	54.63	55.13	55.69	55.36	54.43	54.51	55.32
Other	65.02	66.92	69.65	73.94	73.21	75.83	76.97
Fuels	52.25	54.98	58.43	59.81	60.05	60.96	62.60
Coal	49.07	50.58	51.69	52.10	53.90	52.96	54.20
Oil and natural gas	63.09	66.44	72.07	73.94	71.30	73.31	75.45
Nonmetallics	54.35	56.84	58.25	58.71	58.94	60.77	62.20

Table 39

Industrial Fatalities in Canada per Thousand Paid Workers in Main Industry Groups, 1950-60

	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
Agriculture	0.52	0.97	0.94	1.00	0.82	0.83	1.03	0.95	1.00	0.92	0.62
Logging (forestry)	2.40	2.10	2.40	2.70	2.50	2.00	1.90	1.50	1.70	1.70	1.50
Fishing and trapping	4.20	2.00	2.10	3.30	3.10	3.20	1.80	2.30	3.80	7.20	2.70
Mining*	2.30	2.40	2.30	2.00	2.00	1.60	2.10	1.50	2.20	2.00	1.92
Manufacturing	0.19	0.17	0.18	0.18	0.16	0.16	0.14	0.14	0.11	0.13	0.19
Construction	0.59	0.76	0.90	0.77	0.86	0.79	0.89	0.91	0.77	0.79	0.56
Public utilities	1.30	0.60	0.72	0.60	0.43	0.67	0.44	0.57	0.39	0.44	0.49
Transportation, storage, and communications	0.56	0.66	0.62	0.46	0.53	0.56	0.56	0.50	0.40	0.44	0.37
Trade	0.11	0.08	0.07	0.09	0.08	0.07	0.08	0.09	0.05	0.06	0.06
Finance	..	0.02	0.06	0.02	0.01	0.03	0.05	0.01	0.02	0.01	0.09
Service	0.15	0.16	0.12	0.09	0.08	0.07	0.06	0.07	0.07	0.06	0.07
Total	0.35	0.36	0.36	0.33	0.32	0.32	0.33	0.30	0.27	0.28	0.21

*Includes quarrying and oil-well-drilling.

SECTION VII - PROSPECTING AND EXPLORATION

64374-2—6

Table 40

Cost of Prospecting by Metal-mining Industry in Canada, by Provinces and Types of Operations, 1958 and 1959
($)

1958	Placer Gold Operations	Gold Mines	Copper-Gold-Silver Mines	Silver-Cobalt Mines	Silver-Lead-Zinc Mines	Nickel-Copper Mines	Miscellaneous Metal Mines*	Total
Newfoundland	-	51,330	19,786	-	321,269	-	380,039	772,424
Nova Scotia	-	24,065	33,563	-	50,430	-	3,860	111,918
New Brunswick	-	175,810	299,803	-	44,806	13,971	26,526	560,916
Quebec	-	671,523	2,140,416	-	203,955	114,873	2,957,702	6,088,469
Ontario	-	850,371	1,616,780	10,396	50,323	3,628,819	984,136	7,140,825
Manitoba	-	110,550	3,009,460	-	11,421	9,051,804	102,957	12,286,192
Saskatchewan	-	30,416	454,615	-	52,125	400,558	57,710	995,424
Alberta	-	-	52	-	30,287	-	-	30,339
British Columbia	9,004	221,837	1,965,080	-	384,890	2,060	44,433	2,627,304
Northwest Territories	-	83,929	488,649	-	65,932	673,862	116,247	1,428,619
Yukon Territory	82,457	26,529	211,291	-	135,627	8,752	-	464,656
Canada	91,461	2,246,360	10,239,495	10,396	1,351,065	13,894,699	4,673,610	32,507,086
1959								
Newfoundland	-	49,646	33,117	-	251,038	-	568,805	902,606
Nova Scotia	468	54,283	90,232	-	2,007	-	8,680	155,670
New Brunswick	17,577	275,593	310,385	-	73,112	-	9,513	686,180
Quebec	-	1,707,344	13,966,818	42,202	205,736	626,542	4,077,469	20,626,111
Ontario	-	1,203,466	3,184,028	45,281	75,738	2,146,916	1,096,012	7,751,441
Manitoba	-	126,883	2,395,300	400	8,442	5,264,027	31,445	7,826,497
Saskatchewan	-	28,211	468,794	-	17,724	188,509	143,202	846,440
Alberta	32,500	-	2,605	-	44,348	-	-	79,453
British Columbia	3,413	76,945	1,436,069	-	737,916	1,043	280,293	2,535,679
Northwest Territories	-	112,491	172,440	-	66,458	285,227	698,730	1,335,346
Yukon Territory	11,181	14,424	167,145	-	77,094	-	2,368	272,212
Canada	65,139	3,649,286	22,226,933	87,883	1,559,613	8,512,264	6,916,517	43,017,635

*Includes iron-, uranium-, and molybdenum-mining,etc.

Note: The amounts shown are the expenditures incurred by mining companies, as 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 the foregoing tabulation.

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Table 41

Cost of Prospecting by Metal-mining Industry in Canada, by Types of Operations, 1949-59

($)

	Placer Gold Operations	Gold Mines	Copper-Gold-Silver Mines	Silver-Cobalt Mines	Silver-Lead-Zinc Mines	Nickel-Copper Mines	Miscellaneous Metal Mines*	Total
1949	66,304	3,211,201	549,015	37,042	952,266	586,329	1,013,022	6,415,179
1950	60,550	2,758,669	801,388	86,010	575,322	614,377	456,951	5,353,267
1951	21,106	2,414,004	1,194,546	36,119	968,244	3,123,263	1,419,157	9,176,439
1952	11,805	2,566,981	1,740,207	105,902	2,268,355	5,124,466	1,760,458	13,578,174
1953	33,007	2,573,466	2,514,501	63,985	3,593,678	6,742,918	2,311,203	17,832,758
1954	35,240	3,399,755	3,188,890	24,733	6,843,897	6,785,804	6,536,916	26,815,235
1955	24,804	1,470,643	7,147,498	86,524	3,192,248	8,344,186	6,662,638	26,928,541
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

*Includes iron-, uranium-, and molybdenum-mining, etc.
Note: See the general footnote for Table 40.

Summary
Table 42

Contract Diamond-drilling Operations* in Canada, 1950-59

	Footage Drilled	Income from Drilling ($ millions)	Average Number of Employees	Total of Salaries and Wages ($ millions)
1950	6,006,747	9.5	1,862	4.5
1951	5,091,514	12.4	2,431	6.0
1952	5,180,783	14.7	2,345	7.1
1953	5,258,870	15.8	2,238	7.1
1954	5,639,574	15.9	2,352	7.8
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

*Drilling operations conducted by contractors who employed diamond drills only, which were used chiefly in testing metalliferous deposits.

Table 43

Contract Drilling* in Canada for Oil and Gas, 1950-59

	Footage Drilled				Gross Income from Drilling	Average Number of Employees	Total of Salaries and Wages
	Rotary	Cable	Diamond	Total	($ millions)		($ millions)
1950	3,480,315	308,008	2,132	3,790,455	23.4	2,254	7.3
1951	5,318,736	918,048	446	6,237,230	43.0	3,620	13.1
1952	8,102,599	351,670	-	8,454,269	61.2	4,679	18.1
1953	10,139,151	625,891	-	10,765,042	59.7	4,903	19.8
1954	9,609,140	457,480	-	10,066,620	58.8	4,559	18.1
1955	12,711,953	354,053	-	13,066,006	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

*Drilling done by contract-drilling companies only. Drilling by oil companies with their own equipment is not included.

SECTION VIII - ORE MINED AND ROCK QUARRIED

Summary Table 44

Tonnages of Ore Mined and Rock Quarried in Canadian Mining Industry, 1957-59

(millions of s.t.)

	1957	1958	1959
Metallic ores			
Gold-quartz	14.4	14.8	14.3
Copper-gold-silver	10.6	11.5	12.4
Silver-cobalt	0.2	0.2	0.2
Silver-lead-zinc	6.7	5.9	5.7
Nickel-copper	19.3	12.9	19.0
Iron	26.4	20.3	32.4
Miscellaneous	6.7	13.2	15.1
Total, metallic ores	84.3	78.8	99.1
Nonmetallics			
Asbestos	22.6	22.4	23.1
Feldspar and nepheline syenite	0.3	0.3	0.4
Quartz	1.3	0.7	1.0
Gypsum and anhydrite	4.7	4.0	6.0
Other	1.6	1.6	2.7
Total, nonmetallic	30.5	29.0	33.2
Structural materials			
Stone, all kinds*	40.3	38.2	46.4
Stone for manufacture of cement	8.7	8.5	8.0
Stone for manufacture of lime	2.6	2.8	3.1
Total, structural materials	51.6	49.5	57.5
Total, ore mined and rock quarried	166.4	157.3	189.8

*Exclusive of stone for the manufacture of cement and lime.

Table 45

Tonnages of Ore Mined and Rock Quarried
in Canadian Mining Industry, at Five-year Intervals,
1928-59

(millions of s.t.)

	Metal Mines	Industrial-mineral Operations	Total
1928	12.7	18.8	31.5
1933	15.0	6.4	21.4
1938	31.4	14.9	46.3
1943	38.7	20.8	59.5
1948	36.9	33.6	70.5
1953	54.4	47.2	101.6
1958	78.8	78.5	157.3
1959	99.1	90.7	189.8

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SECTION IX - TRANSPORTATION OF MINERALS

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Summary Table 46

Crude Minerals* Transported by Canadian Railways, 1959 and 1960

(millions of s.t.)

	1960	1959
Coal		
Anthracite	1.4	1.6
Bituminous	11.0	12.0
Petroleum, crude	0.6	0.7
Copper ore and concentrates	0.6	0.5
Iron ore and concentrates	18.8	22.3
Copper-nickel ore and concentrates	3.0	3.0
Aluminum ore and concentrates	2.9	2.6
All other ores and concentrates	3.6	2.7
Sand and gravel	5.8	6.4
Stone and rock	6.3	7.2
Asbestos	1.1	1.0
Gypsum, crude	3.4	4.8
Salt	1.2	1.1
All other crude minerals (chiefly industrial)	3.2	3.3
Total	62.9	69.2
All revenue freight moved by Canadian railways	157.4	166.0
Crude minerals as percentage of revenue-freight total	39.9	41.7

*Both domestic and imported.

Table 47

Crude Minerals* Transported by Canadian Railways, 1950-60

(millions of s.t.)

	Total of Revenue Freight	Total of Crude Minerals	Crude Minerals as % of Revenue Freight
1950	144.2	51.8	35.9
1951	161.3	52.5	32.5
1952	162.1	50.6	31.2
1953	156.2	49.3	31.5
1954	143.1	49.6	34.6
1955	167.8	67.5	40.2
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

*Both domestic and imported.

Table 48

Primary Mineral Products* Transported by Canadian Railways, 1959 and 1960

(millions of s.t.)

	1960	1959
Aluminum - bar, ingot, pig, and slab	0.39	0.35
Copper - ingot and pig	0.55	0.48
Lead and zinc - bar, ingot, and pig	0.43	0.42
Iron - pig	0.19	0.29
Iron and steel - billet, bloom, and ingot	0.44	0.49
Coke	1.59	1.58
Asphalt	0.38	0.43
Total, primary mineral products	3.97	4.04
Total, all revenue freight	157.4	166.0
Primary mineral products as a percentage of all freight transported	2.5	2.4

*Both domestic and imported.

Table 49

Crude Minerals* Transported on Inland Waterways in Canada, 1958 and 1959

(millions of s.t.)

	1959	1958
Coal		
Anthracite	0.19	0.07
Bituminous	11.44	10.74
Petroleum, crude	2.02	1.90
Copper ore and concentrates	0.07	0.06
Iron ore and concentrates	24.25	16.83
Aluminum ore and concentrates	1.99	2.00
Lead and zinc ore	0.03	0.03
All other metallic ores and concentrates	0.79	0.55
Sand, gravel, and crushed stone	2.14	1.72
Stone and rock	1.73	0.84
Asbestos	0.28	0.21
Gypsum, crude	0.33	0.30
Salt	0.66	0.51
Sulphur	0.34	0.39
All other crude minerals(chiefly industrial)	0.43	0.43
Total	46.69	36.58
Shipments of all types of commodities	82.56	72.12
Crude minerals as a percentage of all commodities moved on inland waterways	56.5	50.7

*Both domestic and imported.

Table 50

Quantities* of Petroleum, Petroleum Products, and Gas (Manufactured and Natural) Transported by Pipeline in Canada, 1950-60

	Petroleum and Petroleum Products		Gas
	Millions of bbl	Millions of s.t.	'000 Mcf
1950	50.6	7.5	...
1951	88.4	13.1	65,200(e)
1952	107.8	15.9	74,100(e)
1953	147.3	21.8	84,500(e)
1954	172.5	25.5	102,500(e)
1955	224.3	33.2	136,738
1956	274.9	40.7	163,764
1957	290.8	43.1	184,738
1958	274.8	40.7	211,751
1959	308.5	45.7	283,808
1960	315.2	46.7	326,212

*Both domestic and imported.

SECTION X - TAXATION

Summary
Table 51

Taxes (1) (2) Paid by Five Important Divisions of Canadian Mineral Industry, 1954-59

($ millions)

	1954	1955	1956	1957	1958	1959
Auriferous-quartz-mining	5.9	6.2	6.2	5.9	6.1	7.0
Copper-gold-silver mining	13.0	18.1	26.1	19.2	8.5	13.0
Silver-lead-zinc mining and smelting	16.6	23.0	20.8	12.7	10.8	12.2
Nickel-copper mining, smelting, and refining	27.6	24.6	48.9	46.6	22.4	12.1
Asbestos-mining	9.2	9.2	11.7	12.1	11.4	12.1
Total	72.3	81.1	113.7	96.5	59.2	56.4

(1) As the amounts reported pertain only to the payments actually made within the calendar year specified, these tax payments do not necessarily reflect the tax assessments of a calendar year.
(2) Include taxes on nonoperating revenue.

Table 52

Taxes (1) (2) Paid to Federal, Provincial, and Municipal Governments in Canada by Five Important Divisions of Mineral Industry, 1959

($)

	Federal Income Tax	Provincial Tax	Municipal Tax	Total
Auriferous-quartz-mining	3,636,741	2,610,297	768,743	7,015,781
Copper-gold-silver mining	7,121,825	4,389,509	1,462,807	12,974,141
Silver-lead-zinc mining and smelting	8,371,059	2,836,939	1,036,389	12,244,387
Nickel-copper mining, smelting, and refining	6,550,635	3,897,333	1,697,550	12,145,518
Asbestos-mining	7,141,321	3,711,814	1,213,498	12,066,633
Total	32,821,581	17,445,892	6,178,987	56,446,460

(1) As the amounts reported pertain only to the payments actually made within the calendar year specified, these tax payments do not necessarily reflect the tax assessments of a calendar year.
(2) Include taxes on nonoperating revenue.

Table 53

Federal Income Tax Declared by Companies in Mining and Related Industries in Canada, Fiscal Years Ended March 31, 1958 and 1959

($ millions)

	1959	1958
Mining, quarrying, and oil wells		
Gold-mining	3.3	3.3
Other metal-mining	43.1	20.7
Coal-mining	0.4	0.5
Oil and natural gas	4.3	4.2
Nonmetal-mining	8.6	6.9
Quarries	2.4	2.2
Mineral and oil prospecting	0.3	0.5
Total	62.4	38.3
Metallurgical and metal-fabricating industries		
Iron castings	8.0	9.9
Primary iron and steel	53.4	29.4
Agricultural implements	6.6	5.2
Boilers and fabricated structural steel	4.7	9.8
Hardware and tools	5.0	4.2
House, office, and store machinery	14.0	10.8
Machine-shop products	0.7	1.0
Machine tools	0.5	0.3
Miscellaneous machinery	11.5	10.0
Sheet-metal products	11.8	9.2
Wire and wire products	3.6	3.0
Miscellaneous iron and steel products	4.3	3.1
Aluminum products	1.8	1.3
Other nonferrous metal products	8.1	7.4
Total	134.0	104.6
Nonmetallic-mineral products		
Abrasives, asbestos, cement, and clay products	13.3	10.2
Miscellaneous nonmetallic mineral products	8.1	8.4
Fertilizers and industrial chemicals	4.9	4.4
Total	26.3	23.0
Petroleum and products		
Petroleum-refining and products	35.0	22.7
Miscellaneous petroleum and coal products	2.0	3.5
Fuel, gasoline, and other petroleum products	9.7	6.4
Total	46.7	32.6
Total, mining and related industries	269.4	198.5
Total, all industries	1,300.1	1,056.4

SECTION XI - CAPITAL EMPLOYED, OWNERSHIP AND CONTROL OF THE MINERAL INDUSTRY

Table 54

Capital and Repair Expenditures of Canadian Mining Industry, 1959-61

($'000)

	1961[f]			1960[p]			1959		
	Capital	Repair	Total	Capital	Repair	Total	Capital	Repair	Total
Metallics									
Gold	7,100	8,205	15,305	8,491	8,656	17,147	8,801	9,147	17,948
Copper-gold-silver	11,957	9,462	21,419	11,969	10,105	22,074	15,148	8,928	24,076
Iron	77,876	19,205	97,081	76,252	18,747	94,999	57,393	15,749	73,142
Nickel-copper	12,452	12,159	24,611	23,657	12,525	36,182	15,299	12,075	27,374
Silver-cobalt	903	398	1,301	872	414	1,286	370	223	593
Silver-lead-zinc	14,577	3,894	18,471	5,168	3,983	9,151	2,525	2,341	4,866
Uranium	4,082	2,538	6,620	3,236	2,597	5,833	14,348	9,433	23,781
Total, metallics	128,947	55,861	184,808	129,645	57,027	186,672	113,884	57,896	171,780
Nonmetallics									
Asbestos	9,893	12,464	22,357	8,277	12,275	20,552	7,596	10,994	18,590
Gypsum	946	1,254	2,200	1,265	1,271	2,536	2,969	1,414	4,383
Miscellaneous nonmetallics and quarrying	11,696	10,399	22,095	6,695	1,855	8,550	13,075	2,241	15,316
Total, nonmetallics	22,535	24,117	46,652	16,237	15,401	31,638	23,640	14,649	38,289
Fuels									
Coals	3,213	4,138	7,351	4,616	3,948	8,564	3,474	3,526	7,000
Petroleum and natural gas	219,812	13,294	233,106	224,229	12,988	237,217	191,914	18,885	210,799
Total, fuels	223,025	17,432	240,457	228,845	16,936	245,781	195,388	22,411	217,799
Total, mining industry	374,507	97,410	471,917	374,727	89,364	464,091	332,912	94,956	427,868

Annual Capital Investment in Canadian Petroleum and Natural-gas Industries,[1] 1947-61

($ millions)

Year	Exploration[2]	Development and Production[3]	Oil Pipelines	Gas-transmission Pipelines	Rail and Water Transport	Gas-processing	Petroleum-refining	Marketing Oil[3]	Marketing Gas[4]	Capital Investment in Canada: Petroleum and Natural-gas Industries	Capital Investment in Canada: All Industries
1947		9.5	-	-	2.6	-	25.7	14.9	2.5	56.7	2,440
1948		37.3	-	-	4.3	-	32.6	9.7	3.8	89.5	3,087
1949		45.0	7.0	-	0.7	-	21.6	11.3	4.3	92.0	3,539
1950		53.9	53.8	-	1.2	-	24.1	16.7	6.6	160.7	3,936
1951		72.1	9.8	-	0.9	-	50.9	18.1	6.8	161.8	4,739
1952	59.8	101.6	76.0	2.7	15.9	1.3	60.5	25.0	6.3	352.2	5,491
1953	59.1	107.2	71.7	3.8	4.0	0.7	66.1	36.7	11.2	363.1	5,976
1954	55.1	126.8	61.0	1.6	2.5	8.5	83.9	46.3	9.7	401.5	5,721
1955	67.4	201.6	28.5	17.5	-	2.9	102.9	56.5	9.4	497.0	6,244
1956	73.7	252.4	42.5	133.6	1.0	10.5	79.1	68.5	46.6	707.9	8,034
1957	77.3	237.8	65.8	242.1	2.2	34.5	81.5	74.9	69.8	885.9	8,717
1958	62.4	181.5	21.8	214.8	1.8	40.1	94.9	63.6	79.4	760.3	8,364
1959	51.0	191.9	10.1	48.5	0.6	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[(p)]	51.9	200.3	47.3	126.8	0.8	78.2	34.6	57.6	59.4	656.9	8,109

(1) The petroleum and natural-gas industries in this tabulation 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 56 to 58 inclusive apply only to companies whose main revenues are derived from oil and gas activities.

(2) Exploration investment from 1947 to 1951 inclusive is under 'development and production.'

(3) Does not include repair expenditures. They are included in Table 54.

(4) Capital expenditures in gas-marketing are on gas-distribution pipelines.

Table 56

Ownership and Control of Canadian Mineral Industry at End of Year, 1955-58

($ millions)

	1955		1956		1957		1958	
	At End of Year	% of Total Invest-ment	At End of Year	% of Total Invest-ment	At End of Year	% of Total Invest ment	At End of Year	% of Total Invest-ment
Mining(1)								
Estimated total investment	1,315	100.0	1,609	100.0	1,934	100.0	2,066	100.0
Owned in:								
Canada	572	43.5	693	43.1	846	43.7	892	43.2
United States	675	51.3	808	50.2	957	49.5	1,027	49.7
United Kingdom	48	3.7	75	4.7	92	4.8	103	5.0
Other countries	20	1.5	33	2.0	39	2.0	44	2.1
Petroleum and natural gas(2)								
Estimated total investment	2,961	100.0	3,500	100.0	4,483	100.0	4,980	100.0
Owned in:								
Canada	1,107	37.4	1,225	35.0	1,634	36.5	1,793	36.0
United States	1,716	58.0	2,063	58.9	2,570	57.3	2,866	57.6
United Kingdom	31	1.0	72	2.1	108	2.4	134	2.7
Other countries	107	3.6	140	4.0	171	3.8	187	3.7
Nonferrous smelting(3)								
Estimated total investment	785	100.0	844	100.0	893	100.0	880	100.0
Owned in:								
Canada	338	43.1	358	42.4	411	46.0	397	45.1
United States	326	41.5	347	41.1	350	39.2	359	40.8
United Kingdom	74	9.4	81	9.6	70	7.8	68	7.7
Other countries	47	6.0	58	6.9	62	7.0	56	6.4

(1) Excludes petroleum and natural gas.
(2) The investment data under 'petroleum and natural gas' apply only to companies whose main revenues are derived from oil and gas activities.
(3) Native ores only.

Table 57

Estimated Book Value, Ownership, and Control of Capital Employed in Selected Canadian Industries, at End of Year, 1954-58

($ billions)

	1954	1955	1956	1957	1958
Total capital employed					
Manufacturing	8.3	8.9	10.0	10.7	11.0
Petroleum and natural gas*	2.5	3.0	3.5	4.5	5.0
Other mining and smelting	1.9	2.1	2.5	2.9	2.9
Railways	4.1	4.2	4.4	4.6	4.9
Other utilities	5.3	5.8	6.4	7.4	8.2
Merchandising and construction	6.1	6.6	7.3	7.8	8.5
Total	28.2	30.5	34.1	37.6	40.5
Resident-owned capital					
Manufacturing	4.4	4.7	5.2	5.4	5.4
Petroleum and natural gas*	1.0	1.1	1.3	1.6	1.8
Other mining and smelting	0.9	1.0	1.1	1.3	1.3
Railways	2.7	2.8	2.9	3.2	3.5
Other utilities	4.6	5.0	5.5	6.3	7.0
Merchandising and construction	5.5	6.0	6.6	7.0	7.7
Total	19.1	20.6	22.7	24.8	26.7
Nonresident-owned capital					
Manufacturing	3.9	4.2	4.8	5.3	5.6
Petroleum and natural gas*	1.5	1.9	2.3	2.8	3.2
Other mining and smelting	1.0	1.1	1.3	1.6	1.7
Railways	1.4	1.4	1.4	1.4	1.4
Other utilities	0.7	0.7	0.9	1.0	1.1
Merchandising and construction	0.6	0.6	0.7	0.7	0.8
Total	9.1	9.9	11.4	12.9	13.8

*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.

Summary
Table 58

Foreign Capital Invested in Canadian Mineral Industry, Selected Years, (1) (2) 1930-58

($ millions)

	Owned by All Nonresidents		Owned by United States Residents	
	Mining and Smelting	Petroleum and Natural Gas(3)	Mining and Smelting	Petroleum and Natural Gas(3)
1930	311	150	234	147
1945	359	157	280	149
1951	586	693	497	682
1955	1,121	1,854	975	1,716
1956	1,330	2,275	1,129	2,063
1957	1,570	2,849	1,307	2,570
1958	1,657	3,187	1,386	2,866

(1) As at the end of the year.

(2) Any disagreement with Tables 56 or 57 arises from differences in corporate classification.

(3) The investment data under 'petroleum and natural gas' apply only to companies whose main revenues are derived from oil and gas activities.

ABRASIVES

J.S. Ross*

Abrasive products, which contain natural- or artificial-abrasive materials, are used in most industries for their cutting, grinding, or polishing action.

Abrasives may be classified according to quality or use. The high-grade varieties include diamonds, corundum, and some artificial products such as silicon carbide and fused alumina. Quartz and feldspar are examples of the low-grade variety. Mild abrasives, used for polishing and scouring, include lime and diatomite. The largest quantities consumed are of the high-grade variety, although the use of the materials of each class is widespread.

The value of Canada's production of natural abrasives is small and not available separately, but it is estimated to be over $100,000. Few of these materials are employed solely as abrasives. Most of them are dealt with individually in other reviews. Re-exports of industrial diamonds continued to be substantial. Exports of other natural abrasives, which included iron oxide and garnet, were minor. Imports of natural abrasives, comprising mainly industrial diamonds, were valued at $4,737,349.

Canada is by far the leading producer of crude silicon carbide and fused alumina, the most commonly used artificial abrasives. Canadian shipments of these two commodities are dependent upon export trade. More than 90 per cent normally goes to the United States, and most of the remainder to the United Kingdom. The volume of the production of crude fused alumina increased 22.8 per cent from its 1959 level to 187,105 tons valued at $19,417,568. The record year was 1953, when production amounted to 245,627 tons. Shipments of crude silicon carbide dropped 2 per cent below the record established in 1959 to 84,611 tons valued at $13,026,009.

In 1960, the value of all crude and secondary artificial abrasive materials was $48,568,969 compared to $43,243,405 in 1959. Although crude silicon carbide and fused alumina are abrasive materials, they are not used solely for abrasive purposes.

Ninety-seven per cent of the $32,605,968 worth of abrasives exported in 1960 consisted of crude artificial abrasives. They indicated Canadian production and the North American demand for these materials. In addition, the bulk of the industrial-diamond imports was re-exported, and these re-exports had a value of $3,858,667.

(text continued on page 102)

*Mineral Processing Division, Mines Branch.

Abrasives - Production, Trade and Consumption

	1960		1959	
	Short Tons	$	Short Tons	$
Production				
Artificial abrasive materials				
Crude silicon carbide(1).	84,611	13,026,009	86,248	12,660,211
Crude fused alumina(1)..	187,105	19,417 568	152,319	15,414,241
Abrasive wheels and segments	(2)	6,425,394	(2)	7,550,473
Sharpening stones and files	(2)	264,477	(2)	280,505
Other products(3).......	(2)	9,435,521	(2)	7,337,975
Total..................		48,568,969		43,243,405
Imports(4)				
Natural and artifical abrasives				
Artificial-abrasive grains		2,046,966		2,373,079
Diamond dust, and bort and black diamonds for borers		4,339,852		6,298,061
Emery in bulk(5)		202,157		240,845
Grinding wheels, bonded, with natural or artificial grains		1,948,297		2,172,854
Grinding stones or blocks manufactured by bonding together either natural or artificial abrasives, not otherwise provided.....		376,439		357,681
Grindstones not otherwise provided.....		16,441		20,434
Pumice and pumice stone, lava and calcareous tufa, not further manufactured than ground		195,340		236,190
Coated abrasive paper and cloth		1,142,682		833,371
Manufactures of abrasives, not otherwise provided .		585,366		692,680
Total..................		10,853,540		13,225,195

Abrasives - Production, Trade and Consumption (cont'd)

	1960		1959	
	Short Tons	$	Short Tons	$
Exports[4]				
Natural and artificial abrasives				
Abrasives, natural, not otherwise provided, in ore, bulk, crushed, or ground form..........	17	9,099	66	29,667
Fused alumina, crude and grains............	191,771	19,756,589	242,893	27,736,800
Silicon carbide, crude and grains	82,558	11,928,750		
Abrasives, artificial, crude, not otherwise provided............	11	50,440		
Abrasives, artificial, manufactured, not otherwise provided....		71,050		210,368
Sandpaper and emery cloth		743,723		669,040
Grindstones, manufactured		46,317		64,875
Total..................		32,605,968		28,710,750
Re-exports				
Diamonds, industrial, and diamond dust or bort..................		3,858,667		3,806,923
	1959		1958	
Consumption (incomplete)[6]				
Abrasives, natural and artificial, in the production of artificial abrasive products				
Natural-abrasive grains				
Garnet...............	232	66,481	252	78,781
Emery...............	101	16,895	43	8,938
Quartz or flint	142	9,457	145	10,004
Other................		726		1,306
Total		93,559		99,029

Note: In 1959, the 242,893 short tons and $27,736,800 are bracketed together for fused alumina, silicon carbide, and artificial crude abrasives not otherwise provided.

(table continued)

Abrasives - Production, Trade and Consumption (cont'd)

	1959		1958	
	Short Tons	$	Short Tons	$
Consumption (cont'd)				
Artificial-abrasive grains for wheels, paper, etc.				
Fused alumina	2,582	811,551	1,656	440,657
Silicon carbide	2,626	641,867	3,237	761,568
Total................	5,208	1,453,418	4,893	1,202,225

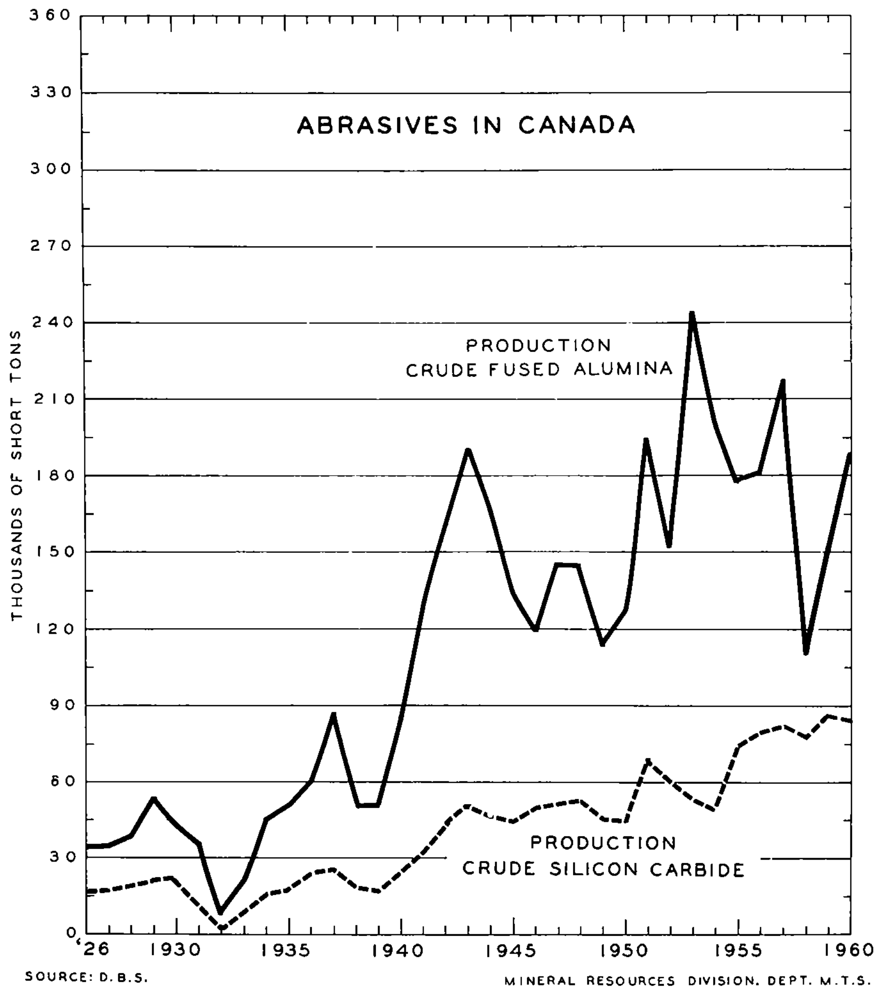
Source: Dominion Bureau of Statistics.
(1) Includes material for use in refractories and for other nonabrasive purposes.
(2) Not available.
(3) Includes abrasive cloth, abrasive paper, abrasive tile, artificial pulpstone, boron carbide, and fused magnesia.
(4) Trade of Canada.
(5) Includes also corundum and garnet. Separation is not possible.
(6) Does not include the consumption of such natural abrasives as diamonds, pumice, and calcareous tufa, nor does it include the consumption of natural and artificial grains for use as loose grains.

The imports of all types of abrasives were valued at $10,853,540 and included about $2 million worth of refined artificial-abrasive grains from the United States.

Producers

Most of the natural abrasives produced in Canada are derived from industrial minerals used mainly for other purposes. The sources of these abrasives include beach sand, sandstone, quartzite, granite, feldspar, iron oxide, and garnet.

Dominion Silica Corporation Limited markets quartzite for use in sandblasting and, with Canadian Silica Corporation Limited, produces silica flour for scouring powders and cleansers. Some feldspar from Quebec is used in the manufacture of scouring powders and cleansers. Crushed granite from British Columbia serves as a sandblasting medium. Nova Scotia Sand and Gravel Limited recovers beach sand for sandblasting at Shubenacadie, Nova Scotia. Other beach sands are used on occasion throughout Canada for the same purpose. H.C. Reid produces grindstones from sandstone recovered in the Bathurst district of New Brunswick. Token shipments of crude garnet, the



first since 1950, were made by Industrial Garnet Company Limited from near River Valley, Ontario. Bog iron ore is processed at Red Mill, Quebec, by The Sherwin-Williams Co. of Canada, Ltd. A substantial part of this output is exported for use as crocus and jeweller's rouge.

Six companies produced crude fused alumina and/or crude silicon carbide at four plants in Ontario and four in Quebec. The output from these plants normally makes up three quarters of North America's production and is exported in the crude form. In 1960, Canada's silicon-carbide plants were at 86 per cent of rated capacity and its fused-alumina plants were at 53 per cent.

Of the 14 secondary-abrasives plants, one is in British Columbia and one in Quebec, and the others are in southern Ontario. In 1959, secondary-abrasives plants produced such articles as coated abrasive paper and cloth, grinding wheels and segments, and pulpstones, valued at $15,168,953.

Canadian Producers of Crude Artificial Abrasives

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

Uses

Natural abrasives serve various purposes. They may be used for sandblasting or in scouring powders and cleansers. Both natural and synthetic industrial diamonds and diamond dust are employed for such pruposes as metal-grinding, concrete- and rock-boring, concrete- and rock-cutting, glass-polishing and -cutting,and ceramic cutting. Garnet is used in coated abrasives for abrading wood, leather, rubber, plastics, and brass. Loose grains serve for polishing glass and stone and for sandblasting. Emery is used in concrete and asphalt to provide nonslip smooth surfaces, and in grinding-wheels, other shapes, and coated papers. Corundum is consumed mainly in the manufacture of grinding-wheels.

In North America, about 5 per cent of the fused alumina and 25 per cent of the silicon carbide are put to nonabrasive use, mainly in refractories. In the form of loose grains, silicon carbide may be used in the wire-sawing of stone, in concrete floors and stairs, in lapping operations, and in sandblasting. It may be employed in coated abrasives and in the metalworking, woodworking, plastics, leather, glass, and stone industries. Silicon carbide is bonded into grinding-wheels, sticks, rubs, etc., for use in abrading metals, stone, ceramics, rubber, leather, and wood. Fused-alumina grains have uses similar to those of silicon carbide. They are used also for grinding and polishing glass and in buffing compounds. Coated abrasives containing fused alumina are employed in the metalworking, woodworking, and leather industries. Bonded abrasives containing fused alumina are used mainly to abrade metals.

Prices

The average prices per short ton for some of the abrasive grains consumed in Canada in 1959 were as follows: emery, $167; garnet, $287; quartz or flint, $67; silicon carbide, $244; and fused alumina, $314.

LIGHTWEIGHT AGGREGATES

H. S. Wilson*

The value of construction in Canada in 1960 was 2.7 per cent less than in 1959. That of residential construction, which was 28 per cent of the total, was down by nearly 11 per cent; and commercial construction, valued at 10 per cent of the total, decreased by more than 6 per cent. Industrial building and institutional construction, which respectively make up 6 and 9 per cent of the total, showed respective increases of more than 5 and nearly 8 per cent. Engineering construction, valued at 42 per cent of the total, increased by 1.4 per cent in value.

The value of the lightweight aggregates produced in 1960 was about 1 per cent over the 1959 value. Because the various aggregates are used largely in nonresidential construction, their production was not as adversely affected as was the output of some materials more dependent on residential construction.

The expanded-clay and -shale aggregates showed the greatest increase - 25 per cent in both volume and value. In output, some plants showed an increase and others a decrease. The plant on Saturna Island, British Columbia, had its first full year of production. The plant at Abbotsford, British Columbia, did not produce during the year. The plant on Salt Spring Island, British Columbia, on which construction was started in 1959, did not start to operate in 1960. At the end of the year, one plant was under construction at Regina, Saskatchewan.

The production of expanded slag increased 4 per cent in volume and 6 per cent in value over the 1959 totals.

The volume and value of the exfoliated vermiculite processed were both 9 per cent less in 1960 than in 1959. All the companies operating exfoliating plants reported a decrease in production. The plant at Cornwall, Ontario, was closed; in Quebec, a new plant at Lachine replaced the one at St. Laurent.

In 1960, the volume and value of the expanded perlite produced were respectively 18 and 17 per cent lower than in 1959. Most plants reported a decrease in production, but some reported an increase.

The value of pumice used as lightweight aggregate was 25 per cent less than in 1959.

The production and value of the individual aggregates produced in 1960 are shown in the table on the next page. The graph on page 108 shows the relative production of the principal lightweight aggregate over the past seven years

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*Mineral Processing Division, Mines Branch.

Production of Lightweight Aggregates

	1960		1959	
	Cubic Yards	$	Cubic Yards	$
From domestic raw materials				
Expanded clay and shale....	363,600	2,061,600	290,000	1,649,000
Expanded slag.............	226,046	544,846	218,300	512,688
From imported raw materials				
Exfoliated vermiculite......	312,067	2,081,317	344,430	2,298,337
Expanded perlite	104,000	832,000	127,000	999,000
Pumice..................		60,000		80,000
Total.....................		5,579,763		5,539,025

Source: Information provided directly by the producers.

Uses of Lightweight Aggregates

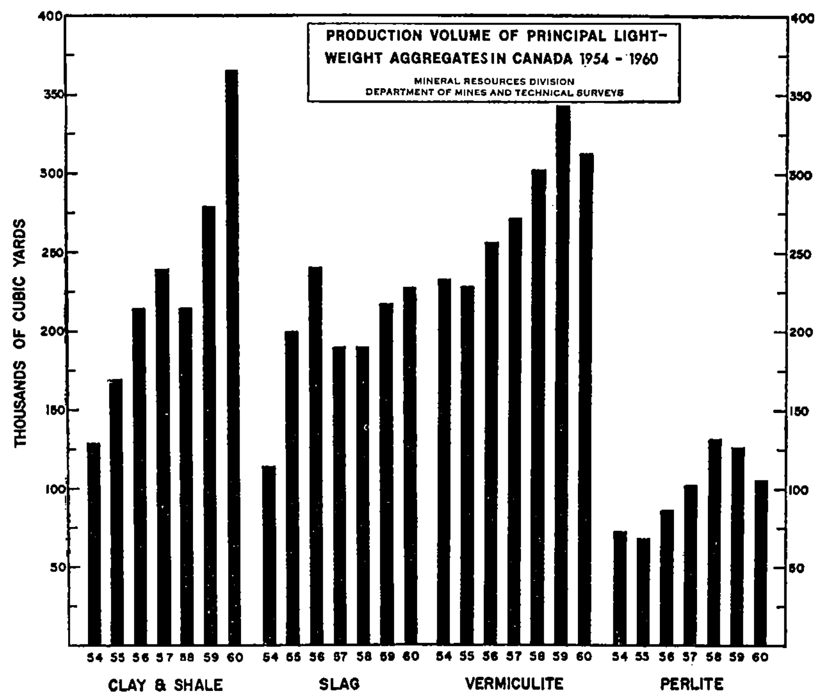
Lightweight aggregates are used in structural concrete, masonry units, and insulating concrete. Structural concrete can be made with expanded-clay, -shale, and -slag aggregates. All the lightweight aggregates can be used in masonry units, but in Canada this use of vermiculite and perlite is limited. These two, because of their insulating properties and low unit weights, are used as aggregates in insulating concrete. Vermiculite is used mainly as loose insulation, and perlite largely as plaster aggregate. Lightweight aggregates also serve as roofing gravel and oil-well concrete, in stucco, and for horticultural and acoustical purposes.

Raw Materials

The shales and common clays are the most widespread raw materials for lightweight-aggregate manufacture. Ten plants were in operation at the end of the year - at St. François du Lac, Quebec; Cooksville, Ontario; St. Boniface, Manitoba; Regina, Saskatchewan (2); Calgary (2) and Edmonton (2), Alberta; and on Saturna Island, British Columbia. One plant is under construction at Regina, Saskatchewan.

Expanded blast-furnace slag is a by-product of the iron-and-steel industry. It is produced at Hamilton and Port Colborne, Ontario, and at Sydney, Nova Scotia.

Vermiculite is a type of hydrous mica that exfoliates, when heated, to form a highly cellular material possessing good insulating properties. All the raw vermiculite exfoliated in Canada is imported from the United States and the Transvaal, Union of South Africa. Five companies produce vermiculite from imported raw materials at 10 locations - Vancouver and New Westminster,



British Columbia; Calgary, Alberta; Regina, Saskatchewan; Winnipeg, Manitoba; St. Thomas, Rexdale, and Toronto, Ontario; and Lachine and Montreal, Quebec.

Perlite is a volcanic rock which pops when heated, the result being a white, cellular product of low density. Deposits occur in central British Columbia, but they have not been developed commercially. Raw material is imported from the United States for processing. Eight plants were in operation during the year - at Caledonia and Hagersville, Ontario; Montreal, Ville St. Pierre and Beauport, Quebec; Winnipeg, Manitoba; Calgary, Alberta; and New Westminster, British Columbia.

Pumice, a highly vesicular material of volcanic origin, is used in its natural state as a lightweight aggregate. All the pumice used is imported from the United States. None is produced in Canada, as the known deposits are either too small or too far from transportation facilities.

Lightweight-aggregate Plants in Canada

	Location	Aggregate
Producing Plants		
Aggregates and Construction Products Ltd.	Regina, Sask.	Expanded clay
Atlas Light Aggregate Limited	St. Boniface, Man.	" "
Edmonton Concrete Block Company Limited	Edmonton, Alta.	" "
Featherock Inc.	St. François du Lac, Que.	" "
Hobbs Concrete Blocks Ltd.	Edmonton, Alta.	" "
Light Aggregate (Sask.) Ltd.	Regina, Sask.	" "
British Columbia Lightweight Aggregates Limited	Saturna Island, B.C.	Expanded shale
Burtex Industries Limited	Calgary, Alta.	" "
Consolidated Concrete Industries Limited	Calgary, Alta.	" "
Cooksville-Laprairie Brick Limited	Cooksville, Ont.	" "
Dominion Iron & Steel Limited	Sydney, N.S.	Expanded slag
National Slag Limited	Hamilton, Ont.	" "
	Port Colborne, Ont.	" "
F. Hyde and Company Limited	Montreal, Que.	Vermiculite
	Toronto, Ont.	"
	St. Thomas, Ont.	"
Insulation Industries (Canada) Ltd.	Vancouver, B.C.	"
	Calgary, Alta.	"
	Regina, Sask.	"
	Winnipeg, Man.	"
Perlite Industries Limited	New Westminster, B.C.	"
Siscoe Vermiculite Mines Limited	Rexdale, Ont.	"
Vermiculite Insulating Limited	Lachine, Que.	"
Canadian Gypsum Company Limited	Hagersville, Ont.	Perlite
Canadian Perlite Corporation	Montreal, Que.	"
Gypsum, Lime & Alabastine Limited	Caledonia, Ont.	"
Perlite Atlas Limited	Beauport, Que.	"
Perlite Industries Reg'd.	Ville St. Pierre, Que.	"
Perlite Industries Limited	New Westminster, B.C.	"
Perlite Products Ltd.	Winnipeg, Man.	"
Western Perlite Company Ltd.	Calgary, Alta.	"
Evans Coleman & Evans Limited	Vancouver, B.C.	Pumice

	Location	Aggregate
Nonproducing Plants		
Clayburn-Harbison Ltd.	Abbotsford, B.C.	Expanded shale
Alsam Manufacturing (B.C.) Ltd...	Salt Spring Island, B.C..	" "
Plant under Construction		
Cindercrete Products Ltd.	Regina, Sask...........	Expanded clay

Consumption

Expanded Clay and Shale

In 1960, as in 1959, masonry units and precast shapes took 87 per cent of the quantity used as aggregate in concrete, and cast-in-place structural concrete took 10 per cent, or 1 per cent more than in 1959. Concrete brick, insulation, roofing gravel, filtration beds, etc. accounted for 3 per cent of production instead of 4 per cent as in 1959.

Expanded Slag

Concrete masonry units accounted for 93 per cent of production, compared with 94 per cent in 1959. Three per cent was used in precast concrete, 2 per cent less than in 1959. Cast-in-place structural concrete took 3 per cent. This was the first year this use was reported. In both 1959 and 1960, 1 per cent was used in built-up roofing.

Exfoliated Vermiculite

Seventy-four per cent, 2 per cent more than in 1959, was used as insulation. Plaster accounted for 18 per cent, 2 per cent less than in 1959. The quantity used in 1960 in insulating concrete increased by 1 per cent to 3 per cent. Other products, such as acoustic plaster, stucco, underground-pipe insulation, refractory concrete, and vermiculite for horticultural purposes, took 5 per cent instead of 6 per cent as in 1959.

Expanded Perlite

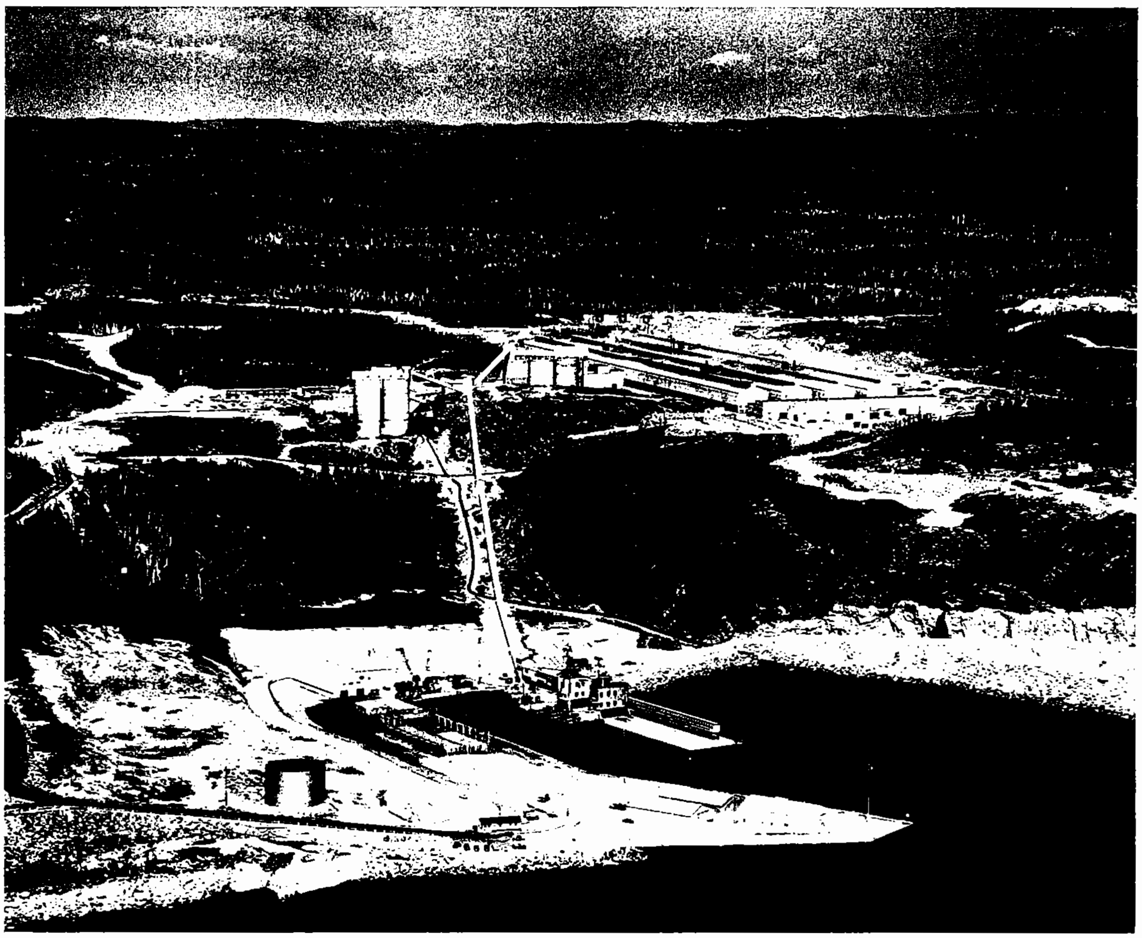
Eight-six per cent of production was used in 1960 as aggregate in plaster; the proportion so used in 1959 was 81 per cent. Aggregate in insulating concrete took 5 per cent, 8 per cent less than in 1959. Four per cent was used in acoustic tile and plaster, 1 per cent more than in 1959. Five per cent served as insulation, in stucco, for horticultural purposes, etc., 2 per cent more than in 1959.

Pumice

In 1960, as in 1959, all the pumice was imported. The pumice was used as aggregate in masonry units.

Prices

Expanded-clay and -shale aggregates sold at $5 to $6.65 a cubic yard, and expanded slag at $2.25 to $3.60 a cubic yard. Vermiculite sold at 20 to 30 cents a cubic foot, and perlite at 25 to 35 cents a cubic foot. Vermiculite and perlite were marketed in bags of 3 and 4 cubic feet. All prices shown are f.o.b. plant.



Aluminum reduction works and dock facilities of Canadian British Aluminium Company Limited at Baie Comeau, Quebec.

ALUMINUM

W.H. Jackson*

No new smelters were built in 1960, but a small experimental unit was set up at Arvida, Quebec. Although the annual capacity of 872,000 tons was not fully utilized, more aluminum was produced than in any previous year. Output amounted to 762,012 tons, or 28.4 per cent more than in 1959. This included inventories awaiting shipment, producers' domestic shipments totalling 105,708 tons, and exports of primary forms, including alloys, amounting to 552,155 tons.

On the basis of value, primary forms represent 90.20 per cent of the exports, semifabricated items 5.97 per cent, manufactured goods 0.47 per cent, and scrap 3.36 per cent. Additional detail appears in the table on pages 114 and 115.

The rate of further growth in the Canadian aluminum industry depends more on the needs of export markets than on expansion of the domestic economy. In 1960 the main markets for primary forms, in order of magnitude, were: the United Kingdom, 179,618 tons (9.0 per cent higher); the European Common Market, 112,674 tons (55.7 per cent higher); and the United States, 100,689 tons (40.7 per cent lower). The marked decline in shipments to the United States was due in part to lower consumption but mostly to the cancellation, on a basis agreeable to the contracting parties, of the last part of a 600,000-ton contract signed in 1953, which called for delivery of 60,000 tons in 1960-61. Exports to this market should improve by 1963, after the completion of a 100,000-ton hot-rolling mill at Oswego, New York. In the United Kingdom, where consumption has been rising rapidly in recent years, imports from Canada have increased. Canada's proportionate share of this market, however, has declined owing to competition from other exporting countries and changes in the corporate structure of the United Kingdom aluminum industry.

World Developments

New metallurgical processes for producing aluminum to compete economically with the Hall-Herault process were being evaluated in 1960. The 5,000-ton-a-year equipment being installed at Noguères, France, by the Pechiney and Ugine organizations operates by carbothermic reduction; the Canadian installation at Arvida utilizes the high-temperature properties of aluminum chloride. Both methods are believed to reduce capital expenditures but require about the same amount of power per unit of production as those used

*Mineral Resources Division.

Aluminum - Production, Trade and Consumption

	1960 Short Tons	1960 $	1959 Short Tons	1959 $
Production				
Ingot	762,012		593,630	
Imports				
Bauxite and alumina for refining				
British Guiana	1,613,824	8,199,211	1,253,394	6,929,208
Guinea*	499,983	2,793,869	264,892	1,542,353
Jamaica	418,182	26,500,248	301,051	19,072,234
Surinam	218,132	1,242,758	205,170	1,189,684
France	8,432	458,653	47,490	2,611,276
Australia	5,802	334,533	-	-
United States			1	90
Total	2,764,355	39,529,272	2,071,998	31,344,845
Cryolite				
Italy	3,724	652,823	112	16,529
Denmark	4,423	687,833	5,779	971,102
United States	192	46,478	123	29,813
Total	8,339	1,387,134	6,014	1,017,444
Aluminum products				
Semimanufactured		6,200,971		6,365,911
Fully manufactured		19,484,575		18,999,593
Total		25,685,546		25,365,504
Exports				
Primary forms				
United Kingdom	179,618	78,873,365	164,795	68,393,148
United States	100,689	47,358,659	169,841	73,487,906
West Germany	76,724	32,942,522	34,334	14,274,078
Australia	25,030	10,967,293	16,404	6,885,695
Hong Kong	17,207	7,227,235	10,403	4,274,265
Japan	15,168	6,421,568	10,424	4,288,589
Belgium and Luxembourg	12,753	5,597,117	9,725	4,040,749
Italy	12,398	5,268,747	7,460	3,009,583
Brazil	12,048	5,027,415	4,033	1,629,172
France	9,171	4,088,143	18,952	7,975,635
Other countries	91,349	39,161,936	58,971	24,028,883
Total	552,155	243,034,000	505,342	212,287,703

Aluminum - Production, Trade and Consumption (cont'd)

	1960 Short Tons	1960 $	1959 Short Tons	1959 $
Exports (cont'd)				
Semifabricated				
India	8,877	4,348,727	8,909	4,495,576
United States	7,480	4,712,020	5,932	4,002,806
Turkey	2,345	1,052,081	-	-
New Zealand	2,240	1,094,219	580	280,624
Pakistan	1,581	659,146	1,014	542,803
Venezuela	1,041	584,513	1,046	573,075
Other countries	6,559	3,620,025	7,677	3,620,628
Total	30,123	16,070,731	25,158	13,515,512
Manufactured				
United States		477,265		400,993
Venezuela		93,505		169,396
New Zealand		74,845		27,141
Colombia		57,756		171,212
British Guiana		50,382		9,020
Other countries		511,616		964,267
Total		1,265,369		1,742,029
Scrap				
Italy	9,758	3,557,405	2,317	736,234
United States	7,149	1,670,838	9,019	2,523,352
Japan	5,374	2,047,200	2,410	846,280
West Germany	3,316	1,075,431	1,935	649,868
United Kingdom	1,702	624,168	77	18,637
Other countries	271	74,360	420	105,894
Total	27,570	9,049,402	16,178	4,880,265
Consumption (producers' domestic shipments)	105,708		89,000	

Source: Dominion Bureau of Statistics.

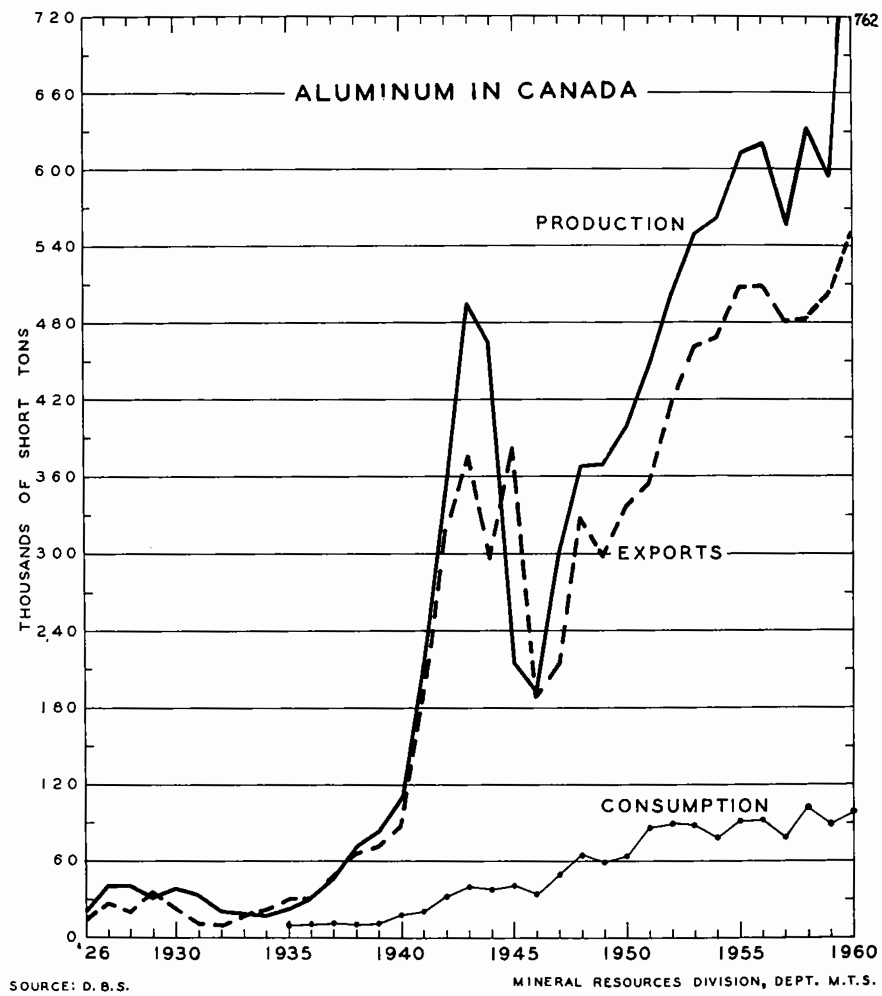
at existing plants. They can produce aluminum directly from bauxite without going through the alumina stage, although economics could still dictate the use of alumina in smelters remote from bauxite supplies.

The Business and Defense Services Administration of the United States Department of the Interior places the world output of primary aluminum for 1960 at some 5 million tons. With the Soviet Union and associated countries

Primary Aluminum - Production, Trade and Consumption, 1950-60
(short tons)

	Production	Imports	Exports	Consumption*
1950	396,882	63	335,727	65,185
1951	447,095	270	354,414	86,241
1952	499,758	13	412,590	90,287
1953	548,445	35	459,692	88,548
1954	557,897	115	468,494	80,355
1955	612,543	99	510,631	91,522
1956	620,321	1,405	508,994	91,869
1957	556,715	2,122	478,670	77,984
1958	634,102	11,257	484,438	101,886
1959	593,630	852	505,342	89,000
1960	762,012	501	552,155	105,708

Source: Dominion Bureau of Statistics.
*Producers' domestic shipments.



excluded, production amounted to 4 million tons and consumption to 3.5 million. The world's annual capacity was 4.7 million tons, but at the end of the year it was not in full operation. Most of the excess was in North America, 400,000 tons in the United States and 158,000 tons in Canada. If on all the new projects announced in many countries in 1960 construction is carried out without careful analysis of economic factors, oversupply may continue for years.

Aluminum-smelting in Canada

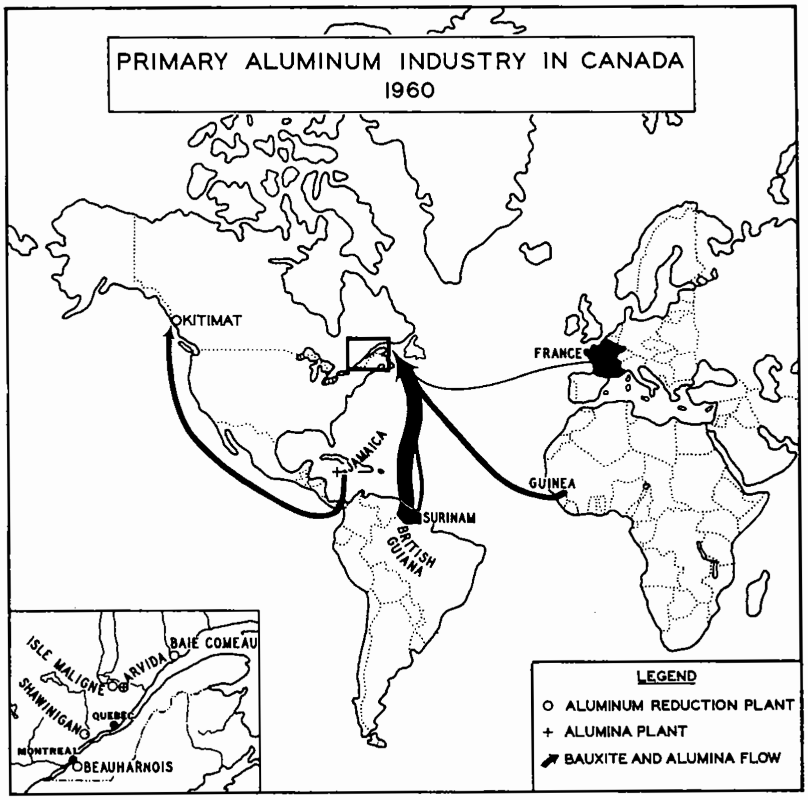
Three companies produce primary aluminum in Canada. Plant locations in relation to the flow of bauxite and alumina are shown on the accompanying map. The capacities are as follows:

Operating Company	Plant Capacities Dec. 31, 1960 (short tons)
Aluminum Company of Canada, Limited (ALCAN)	
Arvida, Que.	367,000
Beauharnois, Que.*	38,000
Shawinigan, Que.	70,000
Isle Maligne, Que.	115,000
Kitimat, B.C.	192,000
Canadian British Aluminium Company Limited (CBA)	
Baie Comeau, Que.	90,000
Total	872,000

Source: Dominion Bureau of Statistics.
*Leased to Chryslum Limited.

Aluminum Company of Canada, Limited, a subsidiary of Aluminium Limited, is the world's leading exporter of aluminum. Averaging 85 per cent of capacity, it produced 637,800 tons in 1960 and at the end of the year its operating rate was 80 per cent of capacity. Building construction at Kitimat, suspended in 1957, was resumed. The buildings will eventually house two potlines with a combined annual capacity of 80,000 tons. An 8,000-ton unit for evaluating a new method of producing aluminum was under construction at Arvida and is expected to be completed in 1962. At Arvida, Kitimat, and Isle Maligne, improved casting facilities were installed for the production of extrusion billets and sheet ingot.

As the year ended, Canadian British Aluminium Company Limited was operating slightly above its rated capacity, having overcome start-up problems. In addition to remelt ingot and hardeners, the company now produces such other primary forms as wire bar, extrusion billet, and sheet ingot, any of which may be in most of the commonly used alloys.



The Beauharnois smelter, leased to Chryslum Limited by ALCAN, produces alloys for the Chrysler Corporation of Canada, Limited, and affiliated automobile plants in the United States.

Aluminum smelters are located in Canada because of the availability of low-cost hydro power in close proximity to ocean shipping. Canada provides the electricity. During the year ALCAN completed the 1-million-horsepower Chute des Passes project on the Peribonca River. This is connected by a 385-kilovolt line to Isle Maligne and gives the company a generating capacity in the Saguenay region of 3,600,000 horsepower. In British Columbia, the Kitimat smelter is supplied with enough power from the 1,050,000-horsepower Kemano plant to support the annual production of 300,000 tons of aluminum. Power for the Baie Comeau smelter is obtained from the Bersimis development of the Quebec Hydro-Electric Commission and from the Manicouagan Power Company. The latter could raise its capacity from 292,000 to 580,000 horsepower upon completion of a new 6-million-horsepower project planned by Quebec Hydro for the headwaters of the Manicouagan and Outardes rivers.

The only possible sources of aluminum in Canada are clays, shales, nepheline syenites, and anorthosites. Much experimental work, occasionally published,* has been directed in many countries toward the recovery of alumina from these minerals, but the only production obtained has come from a segment of the Soviet Union's aluminum industry that utilizes nepheline syenite.

Bauxite from British Guiana, Guinea, and Surinam is imported into Canada to supply the alumina smelter at Arvida, Quebec (capacity, 1,200,000 tons). The Demerara Bauxite Company, Limited, of British Guiana, produced 2,499,773 dry tons, 64.5 per cent of which was imported by Canada. Early in 1961, the company began production from its new 245,000-ton alumina plant at Mackenzie. Alumina Jamaica Limited mined 2,192,126 dry tons and operated its alumina plants at near capacity (Kirkvine, 540,000; Ewarton, 270,000), to produce 745,204 tons of alumina, of which 447,952 tons were shipped to Canada. In Guinea, dried bauxite produced by Bauxites du Midi reached 573,000 tons.

This pattern is expected to change owing to the termination, on December 31, 1961, of a contract whereby ALCAN supplied CBA with part of its alumina requirements. Shipments to CBA will then come from the Fria alumina project in Guinea and from Corpus Christi, Texas.

British Guiana bauxite has a typical analysis of 59 per cent alumina, 6 per cent silica, 2.5 per cent titania, 2.5 per cent iron oxide, and 30 per cent combined water of hydration. The ore is mined by open-pit methods after the overburden has been stripped off. Upon beneficiation to remove part of the silica, the ore is dried to a uniform moisture content and shipped by sea to Port Alfred, Quebec, blended with ore from other sources, and then shipped by rail to the alumina plant at Arvida. Aluminum-smelting differs from that of most metals in that refining the ore comes before smelting and impurities in alumina will appear in the metal. A typical analysis of Arvida alumina in terms of percentage of weight is as follows: silica, 0.02-0.04; iron oxide, 0.02-0.05; titania, 0.003-0.01; soda, 0.45-0.70; loss on ignition,0.5-1.5.

To produce aluminum metal, electrolytic reduction plants need complex chemical and electrical equipment, rectifier stations, and transmission lines, the components of which are obtained from many sources. The fluorspar used in producing the electrolyte, chiefly artificial cryolite and other fluorides, comes from the St. Lawrence area of Newfoundland. Natural cryolite is imported. Petroleum coke for electrodes, consumed in quantites of about 60 per cent, by weight, of the metal produced, is partly imported along with pitch, carbon blocks, and beehive coke or anthracite, usually from the United States, but some items may come from as far away as the United Kingdom or Japan. The soda ash and lime needed for alumina plants are available domestically.

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*In 1960, Canada prepared a publication entitled The Alum-Amine Process for the Recovery of Alumina from Shale (Research Report R74, Mines Branch, Department of Mines and Technical Surveys).

Uses and Consumption

Lightness and strength, resistance to corrosion, and the mechanical properties obtainable by alloying and tempering make aluminum desirable for many structural purposes. The metal, which is readily available in a variety of alloys and shapes, can be cast, rolled, stamped, spun, drawn, extruded, or forged. Wide dissemination of technical data, continuing research on new products, and the existence of a rapidly growing fabricating industry help to promote market expansion. A relatively stable pricing system permits potential users to assess cost factors with reasonable accuracy.

Weight for weight, aluminum is a better conductor of electricity than copper. This accounts for its use in electrical cables. Such properties as heat conductivity, ease of forming, and the ability to take a good finish make it desirable in the manufacture of appliances and utensils. In some applications - the deoxidation of iron and steel or use as a reducing agent, for example - chemical properties are the determining factor.

In 1960 in Canada, 121,758 tons of aluminum were used to make semifabricated products. Of this amount, 90.9 per cent went into wrought products and 7.7 per cent into castings, and 1.2 per cent was used as deoxidizers in the iron-and-steel industry. The output of secondary aluminum totalled 9,109 tons. A detailed analysis of consumption is given in the following table.

Consumption of Aluminum, 1960
(short tons)

Castings	
Sand	1,284
Permanent-mould	2,375
Die	4,590
Other	1,105
Wrought products	
Extrusions	29,764
Sheet, plate, coil, and other, including rod, forgings, and slugs	80,928
Destructive uses	
Nonaluminum-base alloys	271
Deoxiders	1,441
Total consumed	121,758
Secondary aluminum produced	9,109

Source: Dominion Bureau of Statistics.

Receipts and Inventories at Plants, 1960*
(short tons)

	Metal Entering	On Hand Dec. 31
Primary-aluminum ingot and alloys	111,862	43,904
Secondary aluminum	11,458	1,602
Scrap originating outside plant	11,340	989

Source: Dominion Bureau of Statistics.

Main Consumers of Primary Aluminum

Use: Castings	Extrusions	Sheet	Rod	Forgings	Alloying	Deoxidizer	Company
						x	Algoma Steel Corporation, Limited, The
	x						Alsco Products of Canada, Limited
x							Alumaloy Castings, Limited
x	x	x	x	x			Aluminum Company of Canada, Limited
	x						Aluminum Extruders, Limited
		x					Aluminum Goods, Limited
						x	Atlas Steels Limited
x							Barber Die Casting Company Limited
x					x		Bay Bronze, Ltd.
x					x		Canada Metal Company, Limited, The
x					x		Canadian General Electric Company Limited
	x						Canadian Mouldings, Limited
x							Canadian Steel Improvement, Limited
	x						Chromedge (Canada) Limited
x							Dominion Die Casting
						x	Dominion Foundries and Steel, Limited
	x				x	x	Dominion Magnesium Limited
x							Dunbar Aluminum Foundry Limited
x							Electrolux (Canada) Limited
x							Eureka Foundry and Manufacturing Co., Limited
x					x		Federated Metals Canada, Limited
x							Hoover Co., Limited, The
x							McKinnon Industries, Limited
					x		Metals and Alloys, Limited
x							Monarch Fabricating Company Limited
x							Outboard Marine Corporation
x							Precision Dies & Castings, Limited
		x					Reynolds Aluminum Co. of Canada Ltd.
						x	Steel Company of Canada, Limited, The
		x					Supreme Aluminum Industries, Limited
x							Thompson Products Limited
x	x						Werner (Canada) Limited, R.D.

Prices

In Canada, the base price of primary aluminum in 50-pound ingots, purity 99.5 per cent, f.o.b. shipping point, was 23.25 cents a pound. It had been in effect since December 16, 1959. In Canada, the cost of shipment to consuming plants is paid by the producer.

Tariffs

Canada

	British Preferential	Most Favored Nation	General
Bauxite and alumina	free	free	free
Aluminum and aluminum alloys			
Pigs, ingots, blocks, notch bars, slabs, billets, blooms, and wire bars	"	1 1/4¢ per lb	5¢ per lb
Bars, rods, plates, sheets, strips, circles, squares, disks, and rectangles	"	3¢ per lb	7 1/2¢ per lb
Angles, channels, beams, tees, and other rolled, drawn, or extruded sections and shapes	"	22 1/2%	30%
Wire and cable, twisted or stranded or not, and whether reinforced with steel or not	"	22 1/2%	30%
Pipes and tubes	"	22 1/2%	30%
Leaf not otherwise provided or foil, less than 0.005" in thickness, plain or embossed, with or without backing	"	22 1/2%	30%
Aluminum powder	"	27 1/2%	30%
Aluminum leaf less than 0.005 millimetre in thickness	"	free	free
Aluminum scrap	"	"	"
Manufactures of aluminum not otherwise provided	15%	22 1/2%	30%
Kitchen or household hollow-ware of aluminum, not otherwise provided	20%	22 1/2%	30%

United States

Bauxite	free
Aluminum and aluminum alloys in which aluminum is the component material of chief value	
In crude form (not including scrap)	1 1/4¢ per lb

United States (cont'd)

In bars, blanks, circles, coils, disks, plates, rectangles, rods, sheets, squares, and strips	2 1/2¢ per lb
Aluminum scrap	free
Aluminum manufactures not otherwise provided, wholly or in chief value of aluminum	19%
Table, household, kitchen, and hospital utensils, and hollow or flat ware, whether or not containing electrical heating elements as constituent parts, wholly or in chief value of aluminum	3 1/2¢ per lb and 17% ad valorem

ANTIMONY

J. W. Patterson*

All the antimony produced in Canada is initially in antimonial lead resulting from lead-refining. The amount thus obtained in 1960 was 1,651,786 pounds, or 0.4 per cent less than the 1,657,797 pounds produced in 1959.

The Consolidated Mining and Smelting Company of Canada Limited (Cominco), Canada's only producer of antimony, started to produce this metal in 1938 in an electrolytic refinery at Trail, British Columbia. Since the closure of the refinery, in 1944, most of the company's output of antimony has been in the form of antimonial-lead alloy, which normally contains about 25 per cent antimony. The rest, consisting of small amounts of high-purity antimony, was produced for the electronics industry in the electronic-materials plant at Trail, which in 1960 completed its first full year of operation.

Most of the antimonial lead produced at Trail is derived from lead concentrates obtained from ores of the company's Sullivan mine, at Kimberley, British Columbia. The remainder is obtained from smaller company mines and from lead-silver ores and concentrates shipped by other mining companies to Trail for treatment. The lead bullion produced from the smelting of these ores and concentrates contains about 1 per cent antimony, which is recovered in anode residues and furnace drosses resulting from the electrolytic refining of the bullion. The residues and drosses are further refined to yield antimonial-lead alloy.

In 1960, world production of antimony, as shown on page 128, was 61,000 tons.

The United States, the chief consumer, used 13,267 tons of primary antimony that year, the totals for 1959 and 1958 having been 13,317 and 11,880 tons respectively. The country's mines provided 635 tons of the primary metal. Imports of antimony in ores and concentrates, in antimonial lead, and as oxide and sulphide increased to 14,515 tons, having amounted in 1959 to 13,273 tons. The chief exporters of these materials to the United States were the United Kingdom, Mexico, the Union of South Africa, and Yugoslavia. Canada was an important supplier of antimonial lead.

Between 1955 and 1960, Canada's output ranged between the 1956 high of 2,140,432 pounds and the 1958 low of 858,633 pounds. In previous

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*Mineral Resources Division.

Antimony - Production, Trade and Consumption

	1960 Pounds	1960 $	1959 Pounds	1959 $
Production				
Antimony content of antimonial-lead alloys......	1,651,786	538,482	1,657,797	540,276
Imports				
Regulus				
United Kingdom............	353,869	65,624	341,334	75,335
Belgium and Luxembourg...	232,195	50,539	89,600	18,360
China (Communist).........	229,642	36,826	57,305	12,942
U.S.S.R.	22,074	3,482	-	-
Other countries............	6,014	1,795	682,557	124,258
Total.....................	843,794	158,266	1,170,796	230,895
Antimony oxide				
United Kingdom............	253,375	56,216	300,000	64,803
United States..............	139,476	31,211	80,254	18,021
Belgium and Luxembourg...	44,000	9,221	42,714	8,657
West Germany.............	-	-	88,184	19,249
Total.....................	436,851	96,648	511,152	110,730
Antimony salts				
United States..............	37,251	17,846	38,838	19,889
Exports				
Antimony content of antimonial-lead alloys......	1,230,500		1,118,460	
Consumption				
Antimony regulus in production of:				
Antimonial-lead alloys	576,996		650,282	
Babbitt	113,311		112,090	
Solder	10,518		21,136	
Type metal................	100,849		147,012	
Other commodities*........	150,042		204,199	
Total.....................	951,716		1,134,719	

Source: Dominion Bureau of Statistics.

*Includes antimony oxide, foil, bronze, secondary metals, pipe and sheet, lead-base alloys, drop shot, and other minor commodities.

Antimony - Production, Imports and Consumption, 1950-60

	Production(1) (all forms)	Imports (regulus)	Consumption(3) (regulus)
1950	643,540	3,212,784	1,994,000
1951	6,702,164(2)	1,362,260	1,480,000
1952	2,330,900	1,721,622	1,334,000
1953	1,488,105	1,729,253	1,606,000
1954	1,302,333	2,043,544	1,610,000
1955	2,021,726	1,359,163	1,692,000
1956	2,140,432	1,803,630	1,478,000
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	951,716

Source: Dominion Bureau of Statistics.

(1) Antimony content of antimonial-lead alloys and antimony recovered from flue dust and dore slag. All derived from Canadian ores.

(2) Includes antimony in flue dust and dore slag produced in 1949 and 1950 but not previously recorded.

(3) Consumption of antimony regulus as reported by consumers.

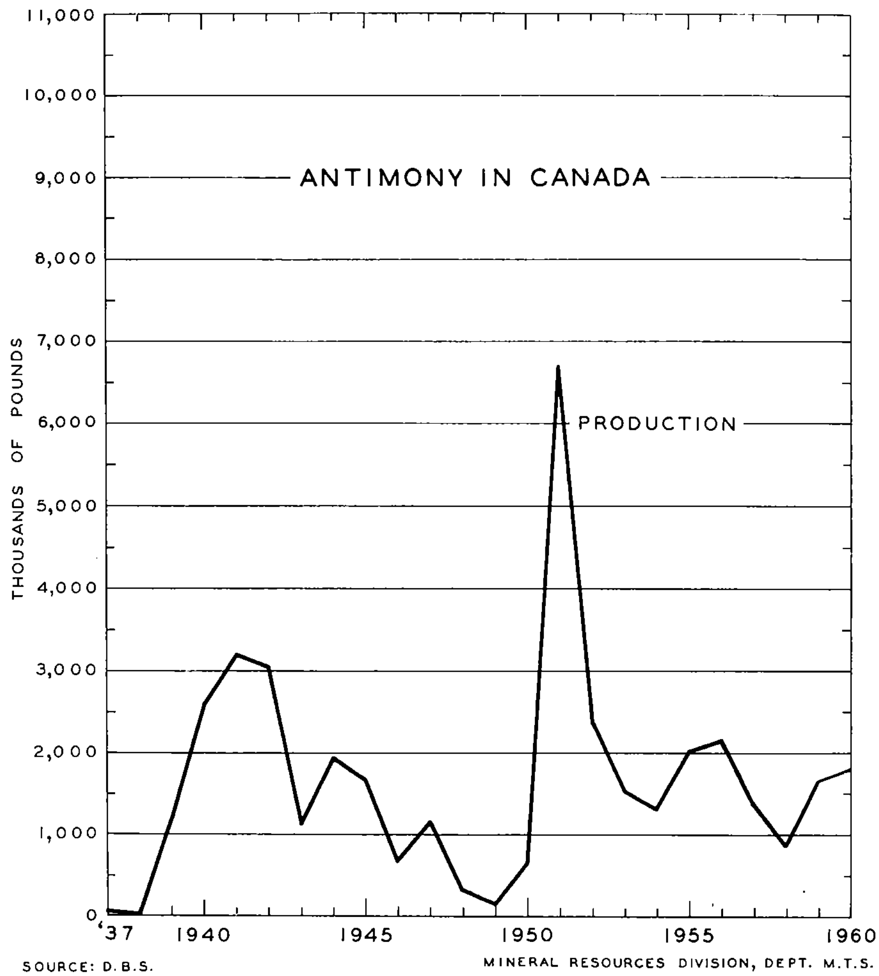
years, the variation was even greater, as the accompanying graph shows. These production changes are attributed to substantial fluctuations in demand.

Occurrences

Several Canadian occurrences or deposits of the principal antimony mineral, stibnite (Sb_2S_3), have been explored and partly developed, but results generally have not been encouraging. The better-known occurrences are: Mortons Harbour mine, New World Island, Notre Dame Bay, Newfoundland; West Gore deposits, Hants county, Nova Scotia; Lake George property, Prince William parish, York county, New Brunswick; South Ham deposit, Wolfe county, Quebec; Stuart Lake mine, near Fort St. James, British Columbia. Other deposits are situated as follows: British Columbia - near Bralorne, in the Bridge River district, and near Slocan City and Sandon, in the southeastern part of the province; Yukon Territory - south of Whitehorse, in the Wheaton River area, and near Highet Creek, in the Mayo district.

Uses and Consumption

That antimony finds its main use as an ingredient in many lead alloys is due largely to the hardening and strengthening effect it has on the alloys and, to a lesser extent, to its expansion on solidification. The alloys receive their ability to expand from the antimony.



Antimonial-lead alloys that contain from 3 to 12 per cent antimony and are employed in the manufacture of storage batteries account for most of the antimony consumed. Antimonial-lead alloys are also used in the manufacture of type metal, bearing metal, and solder and in the extrusion of cable sheathing.

The fire-retardant properties of certain compounds of antimony are increasing its use in flameproof plastics and in solutions that make fabrics fire-resistant by surface application. The oxide and pentasulphide compounds of antimony are used respectively as a white pigment and a vulcanizing agent in the paint and rubber industries.

The thermoelectric properties shown by various alloys of antimony when used with such metals as bismuth, selenium, silver, and tellurium and the use of an aluminum-antimony alloy in the manufacture of transistors and rectifiers have given high-purity antimony a wider application.

World Production of Antimony, on Mine Basis except as Otherwise Indicated

(short tons)

	1960	1959
China(e)	19,000	16,500
Union of South Africa	13,567	13,619
U.S.S.R.(e)	6,600	6,600
Bolivia (exports) (e) (1)	5,500	6,605
Mexico(1)	4,662	3,621
Yugoslavia (metal)	2,657	2,514
Czechoslovakia(e)	1,800	1,800
Turkey (exports)(e)	1,650	1,380
Algeria	785	1,135
Other countries	4,779	5,226
Total(2)	61,000	59,000

Source: U.S. Bureau of Mines, Minerals Yearbook 1960.
(e) Estimated.
(1) Includes the antimony content of smelter products derived from mixed ores.
(2) Antimony is also produced in Hungary, but production data are not available. No estimate is included in the total.

Prices and Tariffs

The price of antimony, boxed, New York, as quoted by E & M J Metal and Mineral Markets, was 32.59 cents a pound throughout 1960. The bulk price, f.o.b. shipping point, was 29 cents a pound for the whole year. These prices have been in effect since February 14, 1958.

Antimony metal and antimony salts enter Canada free of duty. Ad valorem duties of 12 1/2 per cent (most favored nation) and 15 per cent (general) are applied to imports of antimony oxide.

The United States imposes the following duties: antimony regulus, 2 cents a pound; the lead content of antimonial lead, 1 1/16 cents a pound; antimony oxide, 1 cent a pound; antimony, liquated or needle, 1/4 cent a pound; and antimony sulphides and other compounds, ad valorem rates plus fixed amounts. Antimony ores and concentrates enter the United States duty-free.

ARSENIC TROIXIDE

J.S. Ross*

The only Canadian plant producing refined arsenic trioxide ceased smelting operations in January 1961. Constructed in the 1880's at Deloro, Ontario, to roast arsenical gold ores, it was acquired in 1907 by Deloro Smelting & Refining Company, Limited, primarily to smelt and refine cobalt-silver concentrates from northern Ontario's Cobalt area. It has supplied nearly all the arsenic trioxide needed in Canada but has exported the major part of its production, chiefly to the United States. The closure was due basically to a decrease that occured in recent years in the price of cobalt and that resulted in the company's receipt of concentrates containing diminishing amounts of cobalt and increasing amounts of silver. The quantities of cobalt received fell below the level required for economic plant operation.

Refined arsenic trioxide is also known as white arsenic or arsenious oxide. When ores that are being smelted contain arsenic, the oxide is recovered in the crude form, primarily for the sake of safety from its toxic effects. For the same reason, when the amount recovered exceeds the demand, as it normally does, the excess must be disposed of in the crude state or as harmless calcium arsenate. The remainder is refined and used as the basic source of arsenic.

Shipments of refined arsenic trioxide depend mainly on a small export market and fluctuate greatly from year to year. Sixty-one per cent of the 1,724,326 pounds produced in 1960 was exported, all to the United States.

Although Canada is more than self-sufficient in arsenic trioxide, it will have to start to import as the Deloro stocks become depleted. In 1960, small quantities of such other arsenical compounds as arsenic acid, arsenate of lead, lime, and soda, and sodium biarsenate were imported at a cost of $70,071.

Canada is a minor contributor to the world output of arsenic trioxide, which is estimated to have amounted in 1960 to 62,000 short tons. Sweden and Mexico produced more than half the total.

(text continued on page 132)

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*Mineral Processing Division, Mines Branch.

Arsenic - Production, Trade and Consumption

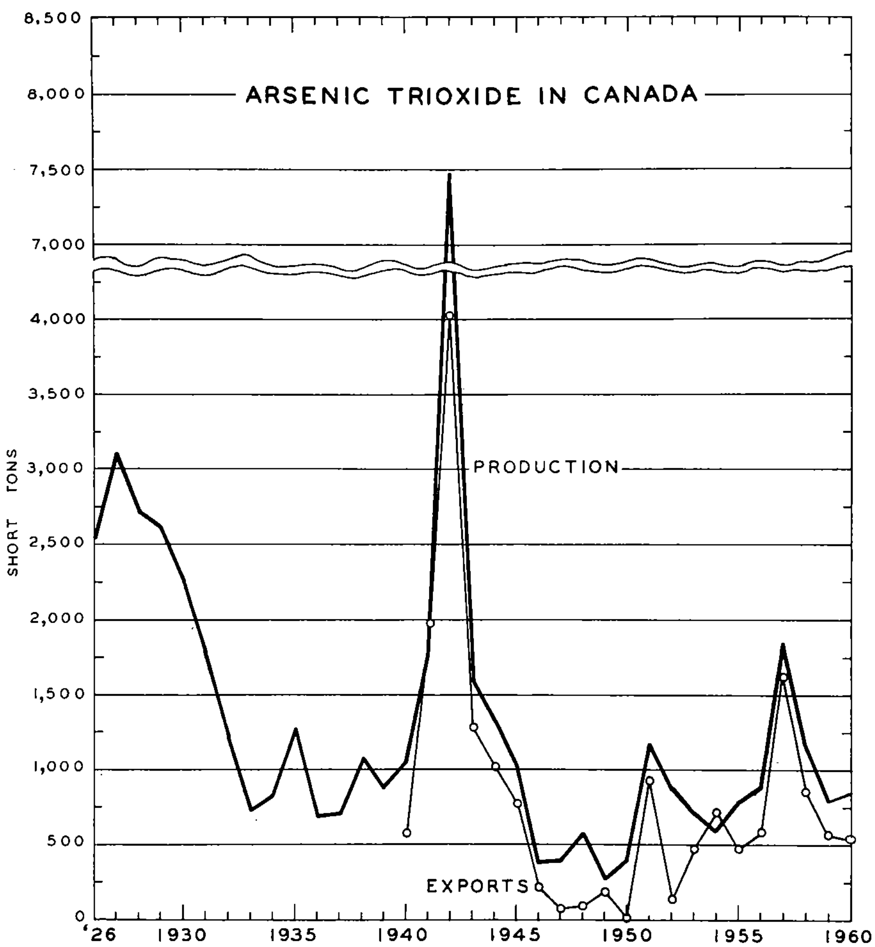
	1960		1959	
	Pounds	$	Pounds	$
Production (shipments)				
Refined arsenic trioxide...	1,724,326	70,400	1,578,307	63,786
Exports*				
United States............	1,054,200	37,908	1,108,200	45,683
Iran	-	-	22,200	777
Total..................	1,054,200	37,908	1,130,400	46,460
Imports				
Arsenic acid				
United States............	374,661	12,336	595,674	20,081
France.................	32,804	1,011	-	-
Total..................	407,465	13,347	595,674	20,081
Arsenate of lead				
United States............	56,688	12,487	73,248	16,718
France.................	8,800	1,295	-	-
United Kingdom	-	-	11,200	1,712
Total	65,488	13,782	84,448	18,430
Arsenate of lime				
Belgium and Luxem-bourg	66,000	3,193	76,446	2,268
United States............	2,000	191	11,080	1,079
Total	68,000	3,384	87,526	3,347
Arsenate and biarsenate				
United Kingdom.........	67,200	5,378	131,036	8,251
United States	61,413	34,180	76,098	32,668
Total..................	128,613	39,558	207,134	40,919
	1959		1958	
Consumption				
Refined arsenic trioxide				
Glass..................	241,022		269,344	
White-metal alloys.......	35,299		68,120	
Miscellaneous chemicals .	73,456		60,927	
Total..................	349,777		398,391	

Arsenic - Production, Trade and Consumption (cont'd)

	1959		1958	
	Pounds	$	Pounds	$
Consumption (cont'd)				
Arsenic acid (As_2O_5)				
Miscellaneous chemicals .	626,787		438,022	
Metallic arsenic				
White-metal alloys	13,297		12,582	

Source: Dominion Bureau of Statistics.

*Does not include the arsenic content of gold ores exported for treatment outside Canada.



SOURCE: D.B.S.

MINERAL RESOURCES DIVISION, DEPT. M.T.S.

Production

In Canada, the year's output of arsenic trioxide was recoved from smelter gases during the smelting of arsenical silver-cobalt custom concentrates from the Cobalt-Gowganda area. Most of it was exported to the United States. The amounts recovered varied with the arsenic content of the concentrates, and their total exceeded the demand.

Other Domestic Sources

There is no other domestic source of refined arsenic trioxide. To reduce toxic air polution, the following gold-mining companies recover it in the crude form during the roasting of arsenical gold ores: at Yellowknife, Northwest Territories - Giant Yellowknife Gold Mines Limited* and The Consolidated Mining and Smelting Company of Canada Limited; in Ontario's Red Lake area - Campbell Red Lake Mines Limited, Cochenour Willans Gold Mines, Limited, and New Dickenson Mines Limited.** This waste product is carefully disposed of in dumps or certain underground workings.

Arsenical residues were produced by Eldorado Mining and Refining Limited at Port Hope, Ontario, and were disposed of in insoluble form in a dump. Shipments of these uranium concentrates to the Port Hope refinery were discontinued during the latter part of 1960.

Arsenical gold concentrates are exported to the United States by Bralorne Pioneer Mines Limited, Bralorne, British Columbia.

Arsenic occurs in many other metalliferous deposits in Canada.

Consumption and Uses

Arsenic trioxide is the source of the arsenic used for the production of other arsenic compounds, arsenic metal, and arsenic alloys.

Arsenic compounds are used throughout the world, chiefly for their poisonous effects. Calcium and lead arsenates, constituents of insecticides rodenticides, and other pesticides, are commonly employed for this purpose. They are used intermittently in the southern United States to combat the gradual immunity of the boll weevil to other insecticides. Newer organic and inorganic poisons have, however, grown overwhelmingly popular and reduced arsenic compounds to a minor role.

In 1960, the apparent Canadian consumption of white arsenic was 670,126 pounds, or 39 per cent of the shipment total. In Canada, the glass industry is the main consumer of arsenic trioxide, which it uses as an additive to assist in the decolorization and fining of glass. Arsenic trioxide is also employed in the production of arsenic compounds, alloys, and metal. Metallic arsenic is used in small quantities in certain copper- and lead-base alloys. It has relatively new use as a semiconductor.

Arsenic compounds are also used in wood-preserving, hide-tanning, and the manufacture of paint pigments. Some pulp companies have used sodium arsenate to kill and debark trees and have thus, under certain conditions, reduced peeling, drying, and the cost of transportation.

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*On June 30, 1960, amalgamated with Consolidated Sudbury Basin Mines Limited to form Giant Yellowknife Mines Limited.

** On Oct. 11, 1960, amalgamated with Lake Cinch Mines Limited to form Dickenson Mines Limited.

There is no indication of any appreciable change in the world outlook for arsenic trioxide.

Prices and Tariffs

Prices per pound of arsenious oxide quoted in E & M J Metal and Mineral Markets on December 1, 1960, were as follows:

Refined, 99%	
Barrels	
Carloads, New York docks	4.0¢ to 5.0¢
f.o.b. Laredo, Tex.	4.5¢
Bulk	
Laredo, Tex.	3.5¢
Crude	
Barrels	
New York	4.5¢
Tacoma, Wash.	3.6¢
Bulk	
Laredo, Tex.	2.5¢
Tacoma, Wash.	2.1¢

Production statistics indicate that the average value of Canadian shipments of refined arsenic trioxide per pound was 4 cents in 1959 and 4.6 cents in 1960.

The crude and refined varieties enter Canada and the United States duty-free.

ASBESTOS

H.M. Woodrooffe*

In 1960, with world asbestos production at an all-time high, the sales of Canadian fibre increased 5 per cent. Asbestos shipments amounted to 1,118,456 short tons valued at $121,400,015 or 54,654 tons more than in 1955, the previous record year. The increase resulted mainly from a rise in the output of Quebec's Eastern Townships. The grades most in demand were those used by the asbestos-cement industry.

A major development of 1960 was the conversion of the Jeffrey mine of Canadian Johns-Manville Company, Limited, at Asbestos, Quebec, to an open-pit operation after several years of extensive underground operation. Another was the decision in October to have the Newfoundland deposit of Advocate Mines Limited ready for production by 1963. The property, situated at Baie Verte, is a potential source of fibre for asbestos-cement production.

Early in the year a potentially important new use for short fibre emerged when it was discovered that the addition of Group 7 fibre to asphalt paving mixes in the proportion of 2 or 3 per cent made road surfaces more resistant to loads and temperature variations, thus increasing flexibility and reducing cracking, especially at low temperatures. Test roads containing asbestos are now under observation in Canada.

Active exploration of asbestos deposits in Quebec and Newfoundland continued.

Domestic consumption of asbestos remains small, almost all production being exported to world markets. In value, exports to the United States were nearly equal to 50 per cent of all the asbestos shipments made by Canadian producers. Canada imports its crocidolite and amosite from the Union of South Africa.

Chrysotile asbestos occurs in several places in northern Ontario, Quebec, Newfoundland, British Columbia, and Yukon Territory, but in many cases the occurrences are not of economic grade. Consequently, production is restricted to British Columbia, Ontario, and Quebec, the last contributing 95 per cent of Canada's output of asbestos fibre. Production has been continuous since 1878.

(text continued on page 139)

*Mineral Processing Division, Mines Branch.

Asbestos - Production and Trade

	1960		1959	
	Short Tons	$	Short Tons	$
Production				
By shipments				
Crude................	330	337,114	432	480,383
Milled fibres	483,183	87,694,929	404,019	73,310,989
Shorts and refuse	634,943	33,367,972	645,978	33,641,972
Total	1,118,456	121,400,015*	1,050,429	107,433,344*
By provinces				
Quebec...............	1,054,424	107,788,172	992,196	95,226,769
British Columbia......	40,748	9,482,923	33,883	7,878,947
Ontario	23,284	4,128,920	24,350	4,327,628
Total	1,118,456	121,400,015*	1,050,429	107,433,344*
Exports				
Crude				
United States	88	104,405	111	97,685
Japan	54	46,765	24	23,778
Italy	40	36,844	19	19,573
West Germany	26	22,727	69	61,019
France...............	25	28,978	5	4,925
Other countries	8	7,291	188	219,261
Total	241	247,010	416	426,241
Milled fibres, Group 3				
United States	15,571	7,324,214		
United Kingdom	3,138	1,400,256		
West Germany	2,556	1,070,936		
France...............	1,678	746,227		
Japan	1,506	654,158		
Italy	782	321,957		
Belgium and Luxembourg	470	192,279		
Netherlands	324	137,402		
Brazil	237	85,613		
Australia.............	123	41,314		
Other countries	2,677	1,192,317		
Total	29,062	13,166,673		

Asbestos - Production and Trade (cont'd)

	1960		1959	
	Short Tons	$	Short Tons	$
Exports (cont'd)				
Milled fibres, Groups 4 and 5				
United States	131,077	22,277,411		
West Germany	38,811	6,647,655		
Japan	37,268	4,962,052		
United Kingdom	33,474	5,994,337		
Belgium and Luxembourg	28,943	5,107,067		
France	22,721	4,067,381		
Australia	20,327	3,146,056		
Netherlands	12,310	2,200,006		
Brazil	10,465	1,815,028		
Italy	9,363	1,626,455		
Other countries	84,232	14,792,528		
Total	428,991	72,635,976		
Total, milled fibres				
United States	146,648	29,601,625	145,667	28,757,149
West Germany	41,367	7,718,591	34,308	6,762,111
Japan	38,774	5,616,210	32,116	4,726,286
United Kingdom	36,612	7,394,593	32,043	7,052,135
Belgium and Luxembourg	29,413	5,299,346	22,206	4,041,719
France	24,399	4,813,608	22,453	4,706,532
Australia	20,450	3,187,370	20,827	3,377,530
Netherlands	12,634	2,337,408	10,898	2,083,702
Brazil	10,702	1,900,641	7,741	1,395,430
Italy	10,145	1,948,412	4,166	865,581
Other countries	86,909	15,984,845	69,158	12,607,678
Total	458,053	85,802,649	401,583	76,375,853
Short-fibre grades				
United States	450,102	24,198,276	483,453	25,783,343
United Kingdom	38,204	1,992,144	37,004	1,858,057
West Germany	37,759	1,897,645	31,737	1,734,176
Japan	32,592	2,836,041	23,108	1,987,068
Netherlands	8,170	444,409	6,976	372,419
Belgium and Luxembourg	7,001	411,594	4,053	250,382
France	6,846	378,626	5,631	316,930
Other countries	29,525	1,905,064	19,961	1,326,823
Total	610,199	34,063,799	611,923	33,629,198

Asbestos - Production and Trade (cont'd)

	1960		1959	
	Short Tons	$	Short Tons	$
Exports (cont'd)				
Total exports, unmanufactured asbestos......	1,068,493	120,113,458	1,013,922	110,431,292
Asbestos brake linings and clutch facings				
Venezuela		47,601		50,504
Cuba		29,827		82,596
Ecuador		22,207		21,328
Lebanon		21,320		31,838
United Arab Republic, Syria		20,988		5,855
Greece		20,509		12,619
Other countries		216,530		182,090
Total		378,982		386,830
Asbestos packing				
Peru		2,391		-
United States..........		2,072		96
Brazil................		984		-
Total.................		5,447		96
Asbestos manufactures, including asbestos roofing				
United States..........		439,488		302,283
Australia		89,905		-
Switzerland		51,348		13,089
Mexico		14,106		245
Yugoslavia............		7,568		-
Other countries		11,293		7,555
Total.................		613,708		323,172
Total exports, manufactured asbestos products..............		998,137		710,098

Asbestos - Production and Trade (cont'd)

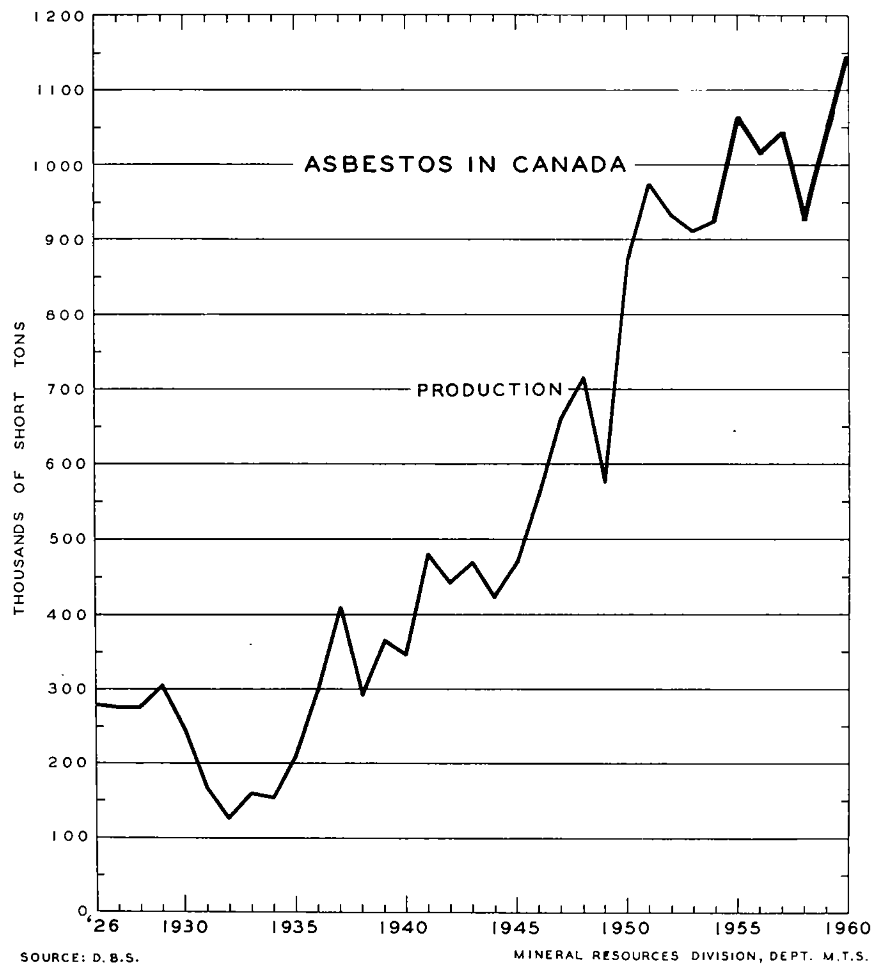
	1960		1959	
	Short Tons	$	Short Tons	$
Imports (manufactures)				
Packing...............		378,831		284,914
Auto brake linings		630,451		611,631
Auto clutch facings.....		282,776		364,443
Other brake linings and clutch facings		408,935		248,413
Other asbestos manufactures		2,797,506		2,568,873
Total		4,498,499		4,078,274

Source: Dominion Bureau of Statistics.
*Does not include the value of containers. This amounted to $3,534,945 in 1959 and $3,791,778 in 1960.

Asbestos - Production and Exports, 1950-60
(short tons)

	Production*				Exports			
	Crude	Milled	Shorts and Refuse	Total	Crude	Milled	Shorts and Refuse	Total
1950	904	305,194	569,246	875,344	845	289,798	539,336	829,979
1951	748	333,001	639,449	973,198	660	324,594	617,060	942,314
1952	741	351,644	576,954	929,339	692	339,818	561,548	902,058
1953	781	326,340	584,105	911,226	638	316,588	561,304	878,530
1954	725	326,653	596,738	924,116	641	312,844	574,243	887,728
1955	724	395,096	667,982	1,063,802	586	365,980	635,261	1,001,827
1956	717	392,983	620,549	1,014,249	560	377,044	586,317	963,921
1957	622	404,016	641,448	1,046,086	638	393,311	636,611	1,030,560
1958	605	342,562	582,164	925,331	483	318,280	547,867	866,630
1959	432	404,019	645,978	1,050,429	416	401,583	611,923	1,013,922
1960	330	483,183	634,943	1,118,456	241	458,053	610,199	1,068,493

Source: Dominion Bureau of Statistics.
*Producers' shipments.



What are believed to be the world's largest deposits of asbestos occur in the Eastern Townships, in a narrow band extending from east of the Chaudière River southwest almost to Sherbrooke, approximately 80 miles east of Montreal. All the producing deposits in the province are in this region. The persistence of the mineral at depth, as established by drilling, indicates that reserves are sufficient for many years.

Technology

The principal varieties of commercially applicable asbestiform minerals are: chrysotile, a hydrous magnesium silicate; crocidolite, a sodium-iron silicate; and amosite, a silicate of iron and magnesium with some water of hydration.

Chrysotile, the only variety mined in Canada, occurs generally in two forms - 'cross fibre' and 'slip fibre.'

In the former, individual fibres lie parallel across the vein so that the vein width is an approximate indication of fibre length. Many of the partings often found in the veins are caused by the inclusion of magnetite or other minerals. Some fibres are as long as 5 inches, but most of the fibre recovered commercially is half an inch or less in length.

Slip fibre, which frequently occurs along the Pennington Dike east of Thetford Mines, is normally found along fault planes in heavily sheared peridotite or serpentine bodies. Fibres of this type are arranged in an overlapping manner.

Many industrial uses of chrysotile are a result of the mineral's physical characteristics rather than of its chemical nature. These properties vary to some degree with the occurrence. Whereas Quebec is able to produce a fine, silky fibre ideally suited for spinning and being worked into textile products, the Ontario product has a harsh texture. This harshness is much desired in the asbestos-cement industry because it gives a fast-filtering quality to an asbestos-cement slurry.

The commercial fibre recovered in northern British Columbia is low in magnetite. This is an advantage to the electrical industry, in which the fibre is used to provide heat-resistant and nonconductive woven insulation.

Crocidolite, commonly called 'blue fibre,' is an asbestos of the amphibole group and has properties of commercial value. It is not mined in Canada, although occurrences have been reported from the iron-ore region near the Labrador-Quebec boundary.

Amosite, a heat-resistant type of anthophyllite, is used principally in the manufacture of thermal insulation. No Canadian occurrence is known.

Other asbestos minerals - fibrous tremolite, actinolite, and anthophyllite - occur in Canada, but none are produced. The fibres of these minerals are usually weak and unsuitable for most asbestos uses. There are, however, certain uses for which their natural chemical and physical properties are suited. During the war, it was reported that a small amount of tremolite was being produced in eastern Ontario.

Chrysotile is mined in Canada by both open-pit and underground methods. It is prepared for the market by a dry-milling process in which the ore is crushed, impact-milled, fiberized, and separated into different grades of commercial fibre and a waste product or tailing. Although the recovered fibre is graded for the market essentially by length, other factors, such as bulk volume, contained dust, and degree of openness, are also considered.

Production and Development

Newfoundland

Chrysotile occurs in several places in this province. A recent discovery of semiharsh fibre near Baie Verte, on the northeast coast of the island,is being developed by Advocate Mines Limited. Substantial reserves have been established, and the deposit is being prepared for early production. The company is controlled by an international group of asbestos firms headed by Canadian Johns-Manville Company, Limited.

Quebec

Asbestos is produced in the southern part of the province, in the counties of Richmond, Arthabaska, Megantic, and Beauce. There are 13 producing mines in the vicinities of Thetford Mines, Black Lake, East Broughton, and Asbestos.

The world's largest asbestos mine, the Jeffrey, is operated by Canadian Johns-Manville Company, Limited, at Asbestos, Richmond county, 80 miles east of Montreal. It was operated as an open-pit property for many years, but since the war extensive underground workings have been developed and much of the ore has been recovered by the block-caving mining method. Taking advantage of technical improvements, the company has embarked upon an extensive conversion program, which it has well in hand. Most mill feed is now recovered by open pit.

Asbestos Corporation Limited has three mills in operation in the Thetford Mines area. Two - the British Canadian, at Black Lake, and the Normandie, in Ireland township - process ore recovered from adjacent open pits. At Thetford Mines, the operations of the Beaver pit and King underground mine have been integrated with those of a common mill.

Johnson's Company Ltd., the oldest in the industry, has an underground mine at Thetford Mines. Its associate, Johnson's Asbestos Company, produces the mineral from an open pit at Black Lake, where a 4,000-ton mill was placed in operation in 1954.

The underground mine of Bell Asbestos Mines, Ltd., is also at Thetford Mines.

Flintkote Mines Limited and Nicolet Asbestos Mines,Limited recover asbestos from open-pit mines a few miles east of Thetford Mines and at St. Remi de Tingwick respectively.

Lake Asbestos of Quebec, Ltd., a subsidiary of American Smelting and Refining Company, operates a 5,000-ton-a-day mill at its deposit in the bed of Black Lake. Preparation of the deposit for open-pit mining required extensive dredging and the draining of Black Lake.

Carey-Canadian Mines Ltd., a subsidiary of Philip Carey Manufacturing Company, is in production with a 2,500-ton mill at its new property near Tring Junction, in Beauce county, east of Thetford Mines.

National Asbestos Mines Limited, a subsidiary of National Gypsum (Canada) Limited, recovers asbestos from a deposit along the Pennington Dike a few miles east of Thetford Mines.

Golden Age Mines Limited operated a pilot plant on its property at Rivière aux Plantes, near Beauceville.

Murray Mining Corporation Limited was actively exploring an occurrence 30 miles south of Deception Bay,in northern Quebec. Diamond-drilling during the year is reported to have added to the reserves of the deposit.

Ontario

Canadian Johns-Manville Company, Limited, has completed the conversion of its Munro mine to underground mining. The mine, which is east of Matheson, in northern Ontario, is the only producing asbestos mine in the province.

British Columbia

Cassiar Asbestos Corporation Limited recovers long- and medium-fibred asbestos from a deposit on Mount McDame, in northern British Columbia. The fibre is shipped over the Alaska Highway to Whitehorse, Yukon Territory, on the White Pass & Yukon Route (railway) to Skagway, Alaska.

World Review

To meet the diversified requirements of the market, world production of asbestos, including all varieties, rose in 1960 to a record level. World output is estimated to have amounted to 2.7 million short tons, of which Canada contributed 42 per cent.

During the past few years, the Union of Soviet Socialist Republics has markedly increased its production from deposits near Sverdlovsk in the Urals and is approaching Canada in volume of output. Although the U.S.S.R. does not publish statistics on the asbestos industry, its current level of production is estimated to be more than 900,000 short tons a year. Soviet fibre competes with Canadian asbestos in overseas markets.

Africa also makes an important contribution to the world's asbestos output. In 1960, the Federation of Rhodesia and Nyasaland produced 134,000 tons of chrysotile. Rhodesian fibre, because of its freedom from magnetic iron, finds a ready market in asbestos products used by the electrical industry.

The asbestos-mining industry of the Union of South Africa is the dominant world producer of crocidolite and amosite.

Uses

Chrysotile, because of its physical characteristics, is an important raw material in many industrial processes. When of the proper texture, the longer fibres may be processed in much the same manner 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 clothing, protective curtains and mats, electrical insulation, and heat-resistant friction materials. The most important single market for this commodity is the asbestos-cement industry.

Asbestos is combined with portland cement for manufacture into a number of products, such as pressure and nonpressure pipe, flat and corrugated sheeting shingles, roofing tile, and millboard. This use has grown considerably since the war, and the resulting products are well established throughout the world. Although many asbestos-cement products are used in the construction of buildings, other industrial applications are growing, particularly in the electrical field. The use of asbestos-cement pipe in municipal water supply and distribution and in the disposal of sewage waste is now well established. The durability of the pipe and its resistance to corrosion have been of advantage in these applications.

In thermal insulation, asbestos is used as a kind of paper. In combination with other materials, it is also widely used in the form of preformed sections or slabs for boiler and steam-pipe covering and in oil-refinery and chemical-plant construction.

The shorter-fibre grades of asbestos have the greatest number of uses. At present the volume of asbestos classified as short-fibre far exceeds that of all other grades combined. This type is used in the moulding of plastics, the manufacture of floor tiling and protective coatings, the paint industry, and other applications requiring a fibrous filler with the physical characteristics of asbestos.

The automobile industry uses asbestos products in large quantities, including woven and moulded brake linings, clutch facings, and pressure gaskets. Undercoating compounds provide an important use for very short grades of fibre.

Prices

Except for minor adjustments in Group 3 and No. 2 crude, the price of Canadian fibre remained unchanged throughout the year. Prices for carload lots, in Canadian funds per short ton f.o.b. Quebec producers, were as follows:

No. 1 crude	$1,470	6D fibre	86
2 "	750	7D "	75
3K fibre	480	7F "	71
3R "	408	7H "	61
3T "	383	7K "	50
3Z "	353	7M "	44
4K "	200	7R "	43
4M "	200	7T "	41
4T "	181	7RF floats	44
4Z "	181	7TF "	44
5D "	142	8S "	29
5K "	142	8T "	22
5R "	120		

BARITE

J. S. Ross*

Owing to a slump in exports to the United States, barite shipments fell more than one third below those of 1959. United States imports of barite were of about the same volume as in 1959 indicating that that country's imports of non-Canadian crude have therefore increased at the expense of the Canadian product. The extent of the market for barite, and especially that for Canadian barite, is determined primarily by oil- and gas-well-drilling activity in the western hemisphere.

Since 1953, domestic production has fluctuated greatly depending upon exports. Shipments in 1960 were the lowest since 1952, amounting to 154,292 short tons valued at $1,462,212. The production decline occurred in both the ground and the lump and crushed varieties.

Canada dropped from third to fifth place as a world producer of barite. The United States, West Germany, Mexico, Greece, and Canada, in that descending order, produced most of the world's 1960 output, estimated at 3.1 million short tons.

The volume of the exports of domestic barite, which is particularly affected by competition from such other countries as Mexico, Peru, and Greece, was 39 per cent lower in 1960 than in the previous year and was equivalent to 87.5 per cent of production. Eighty-six per cent of these exports, mainly in the crude form, went to the United States; the remainder was sent to Trinidad and Venezuela. Imports are minor and consist of the ground variety. Most Canadian barite is eventually ground and consumed in well-drilling. In 1960, the apparent consumption in Canada was 25,483 tons.

The decrease in the foreign demand for Canadian crude has affected the output of the leading producer and only domestic-barite exporter, Magnet Cove Barium Corporation. Since 1941, the bulk of the output has come from one barite mine near Walton, Nova Scotia, operated by this company.

A fourth barite-processing plant went into operation early in the year when Baroid of Canada, Ltd. started processing at its plant at Onoway, Alberta.

Deposits in Operation

Barite is recovered from deposits in Nova Scotia and British Columbia. It is known to occur in all provinces except Alberta, Saskatchewan, and Prince Edward Island.

*Mineral Processing Division, Mines Branch.

Barite - Production, Trade and Consumption

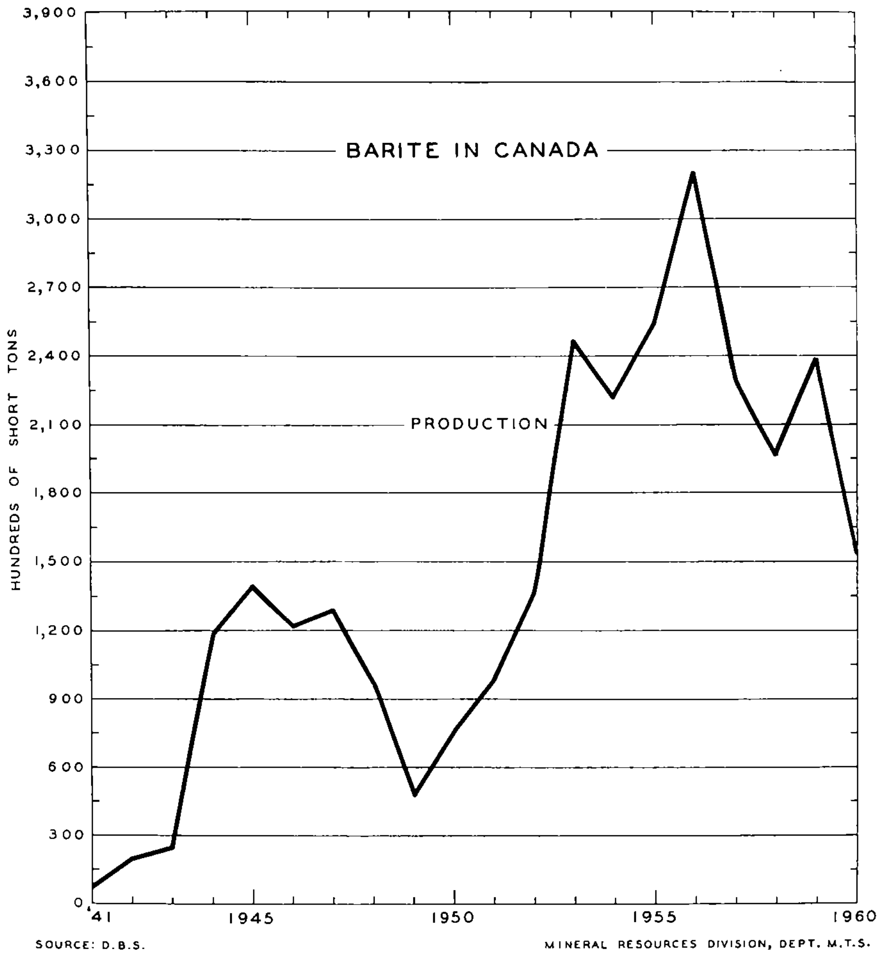
	1960**		1959	
	Short Tons	$	Short Tons	$
Production (mine shipments)				
Crushed and lump..........	142,789	1,231,258	214,977	1,817,962
Ground	11,503	230,954	23,990	436,620
Total	154,292	1,462,212	238,967	2,254,582
Imports (ground)				
United States	1,639	80,328	867	42,180
West Germany.............	337	9,610	750	20,671
United Kingdom............	45	1,241	45	1,617
Total	2,021	91,179	1,662	64,468
Exports				
United States	115,987	1,096,465	178,911	1,546,439
Trinidad	10,080	186,480	14,011	322,371
Venezuela.................	8,905	75,694	15,340	130,387
Other countries...........	-	-	13,459	249,002
Total	134,972	1,358,639	221,721	2,248,199

	1960	1959
Consumption*		
Paints	953	698
Rubber goods..............	218	173
Glass......................	364	356
Miscellaneous chemicals ...	23	65
Miscellaneous nonmetallic products	116	112
Well-drilling	23,809	21,000(e)

Source: Dominion Bureau of Statistics.

* These quantities are calculated from information provided by the Dominion Bureau of Statistics.

(e) Estimated.



Nova Scotia

Normally, about 90 per cent of the annual barite output is obtained from the Walton mine of Magnet Cove Barium Corporation.

In 1958, the deposit contained ore reserves estimated at 1.8 million tons. Ore is being recovered by blast-hole stoping and block-caving methods above the 850-foot level. It is concentrated at a beneficiation plant at the mine site and trucked to the port of Walton. Crushed and lump barite, as well as occasional cargoes of the ground variety, are shipped mainly by water to the United States, Trinidad, Venezuela, and other parts of Canada, and occasionally to the Middle East and other South American countries. With the exception of a few minor shipments, this barite is pulverized and used in well-drilling.

British Columbia

Mountain Minerals Limited mined barite from two vein deposits in southeastern British Columbia. Most of the ore was obtained from the deposit near Brisco by open-pit and underground methods. The rest was recovered from a stope at the mine near Parson. Virtually all mine shipments are sent by rail to Lethbridge, Alberta, where they are pulverized, mainly for use in well-drilling muds.

Baroid of Canada, Ltd., operator of Canada's newest barite-processing plant, purchased the 46-claim Giant property of Giant Mascot Mines,Limited, near Spillimacheen, which it had previously optioned, and during the year shipped crude barite from the open pit to its new grinding plant at Onoway. The company also mined crude barite from its Larrabee deposit near Invermere and shipped it to Onoway.

Barite is also obtained from the Mineral King mine of Sheep Creek Mines Limited, near Invermere. The mineral is recovered as a by-product during the open-stope mining of lead-zinc ore. It is shipped, as crude, to the grinding plant of Magcobar Mining Company, Limited, at Rosalind, Alberta.

Processed barite from the Rosalind and the Onoway plants is used as a weighting agent in well-drilling muds.

Quebec

Occasionally, Industrial Fillers Limited, Montreal, purchases and grinds barite as its markets require.

Other Occurrences

In most provinces there are many other barite deposits, some of which have been mined intermittently, particularly during the early part of this century. The more noteworthy are at the Buchans mine, Buchans, Newfoundland; near Lake Ainslie, Cape Breton Island; in Penhorwood and Langmuir townships, northern Ontario; on McKellar Island, Lake Superior; and near Mile 397 on the Alaska Highway, in British Columbia. Witherite (barium carbonate) occurs along the British Columbia section of the Alaska Highway, in a large deposit near Mile 497. Witherite, barylite, barytocalcite, and other, rarer, barium minerals occur in Canada but have not yet been utilized.

Barite deposits in British Columbia, the Northwest Territories, Ontario, and Nova Scotia were explored during the year.

Canadian reserves are adequate to meet normal domestic requirements for many years.

Uses and Specifications

In general, barite is consumed because of its inertness, color, relatively high specific gravity (4.3 to 4.6), or barium content. It is marketed in lump or crushed form or ground and bagged.

Most of the barite produced in the world is used as a heavy medium in well-drilling muds, where it assists in controlling liquid and gas pressures and in floating drill cuttings. Barite is normally the most desirable commodity for this purpose and is not likely to be replaced to any extent in the near future by heavy-media substitutes. Since 1955, the use of air and gas drilling in the oil and gas wells of western Canada has increased, but has not affected the barite industry.

About 93 per cent of Canada's apparent barite consumption is used for weighting by the Canadian well-drilling industry; more than 95 per cent of its production is used for the same purpose throughout the world. Specifications, which vary according to the particular needs of the consumer, may require a minimum specific gravity of 4.2 to 4.25, a minimum of 90 per cent barium sulphate ($BaSO_4$), and a mesh size that is 90 to 95 per cent minus-325. Soluble salts are objectionable, but a content of several per cent iron is not.

For the manufacture of barium chemicals, barite must be in lump form and contain a minimum of 94 per cent barium sulphate and a maximum of 1 per cent ferric oxide. The barium-chemicals industry is virtually nonexistent in Canada. The more common barium compounds manufactured throughout the world and some of their uses are as follows: precipitated barium sulphate, or blanc fixe, used as an extender and pigment in paints and a filler in paper; lithopone, a mixture of barium sulphate and zinc sulphate, employed as a white pigment in paints; barium chloride, for case-hardening and the prevention of scumming on brick; and barium carbonate, used in oil-well-drilling fluids and for the reduction of scumming on brick and ceramics. Barium oxide, hydrate, titanate, chlorate, nitrate, sulphide, and phosphate are also manufactured. Because barium titanate has a high dielectric constant and piezoelectric and ferroelectric properties, its use in relatively minor amounts has become widespread, particularly in the miniature-electronic-components and communications industry.

As a filler in paints, varnish, and paper, barite must have a high reflectivity and usually a minimum of 94 per cent barium sulphate and a minus 200 mesh size. When barite is used in rubber goods, the whiteness requirement depends on the consumer.

In glass production, barite acts as a flux and makes the glass more brilliant and workable. It must contain a minimum of 98 per cent barium sulphate and less than 0.15 per cent ferrix oxide and be between 20- and 200-mesh.

As a contribution to shielding against atomic radiation, barite is used as a heavy aggregate in concrete. Barite fragments for this purpose are commonly less than three quarters of an inch in size.

Statistics concerning the chief barium chemicals consumed in Canada are presented in the accompanying table.

Barium Compounds - Imports and Consumption

	1960		1959	
	Short Tons	$	Short Tons	$
Imports				
Lithopone (70% $BaSO_4$)........	893	121,667	979	138,039
Blanc fixe and satin white	1,205	113,492	1,014	78,506
Barium carbonate				265,684*
	1959		1958	
Consumption of the main barium compounds in the chemical and allied-products industries				
Barium chloride	627		611	
Barium nitrate	66		57	
Barite	914		816	
Blanc fixe	495		176	
Lithopone	877		1,064	

Source: Dominion Bureau of Statistics.
*Total value of import shipments valued at $1,000 or more.

Prices

Barite prices quoted in E & M J Metal and Mineral Markets of December 1, 1960, were as follows:

Canada

Crude, in bulk, f.o.b. shipping point, per long ton	$11.00
Ground, in bags, per short ton	$16.50

Missouri

Water-ground and floated, bleached, carload lots, f.o.b. mill, per short ton	$45.00 to $49.00
Crude ore, min. 94% $BaSO_4$, less than 1% Fe, per short ton	$16.00 " $18.00
Crude oil-well-drilling, min. specific gravity 4.3, bulk, per short ton	$18.00
Ground, oil-wall grade, per short ton	$26.75

U.S. Gulf ports

Foreign, crude, oil-well grade, min. specific gravity 4.25, bulk, c.i.f. ports, per short ton	$16.00 to $18.00

In 1960, the average value of production per short ton for Canadian lump or crushed barite, at the mine or mill, was $8. For the ground product, it was $17.59. In 1959, these prices were $8.46 and $18.20 respectively.

Tariffs

The Canadian and United States import tariffs on barite that follow are constantly subject to change.

Canada

	British Preferential	Most Favored Nation	General
Barite			
Crude or ground	free	25%	25%
For drilling-mud use	"	free	free

United States

Ore, per long ton	
Crude or unmanufactured	$2.55
Ground or otherwise manufactured	$6.50

BENTONITE

J. S. Ross*

Early in 1960, a third bentonite producer, Baroid of Canada, Ltd., began to process bentonite at its plant at Onoway, Alberta. This operation, along with those at Rosalind, Alberta, and Morden, Manitoba, has assisted in filling Canada's rapidly growing needs and in reducing its dependence upon foreign bentonite.

In industry, the term 'bentonite' normally includes clay materials consisting chiefly of clay minerals of the montmorillonite group. These minerals have ions in their structures that can be exchanged for others. Bentonites are roughly classified into two main types - swelling and nonswelling. In the swelling variety, the predominant exchangeable ion is sodium; in the nonswelling type it is calcium. When immersed in water, swelling bentonite grows noticeably in volume and forms permanent colloidal suspensions. Nonswelling bentonite can adsorb certain impurities from liquids and, when it is activated, its adsorption properties may increase appreciably. Fuller's earth is a naturally active nonswelling bentonite.

Production and Trade

Since 1952, production statistics for bentonite have not been available. The commodity is produced at two plants in Alberta and one in Manitoba. In Manitoba, Pembina Mountain Clays Ltd. recovers bentonite from the Vermilion River formation near Morden, dries and crushes it, and ships it to the company plant, in Winnipeg. There, it is activated by sulphuric acid to produce a good-quality bleaching clay.

At Rosalind, Alberta, Magcobar Mining Company, Limited recovers several grades of bentonite from the Edmonton formation and dries, grinds, and sizes it for various uses.

Baroid of Canada, Ltd., mines bentonite from the Edmonton formation, which is near the plant it opened in 1960 at Onoway, Alberta. At the plant, the company dries, pulverizes, and sizes it for use in well-drilling and foundries.

Statistics on Canadian exports of bentonite are not available separately. According to its own statistics, however, the United States imported 5,878 tons of artificially activated clays from Canada in 1960. The value of Canada's imports is greater than the apparent value of its exports. The bentonite imported into Canada during the year originated mainly in the United States and,

*Mineral Processing Division, Mines Branch.

Bentonite and Fuller's Earth - Imports and Consumption

	1960 ($)	1959 ($)
Imports(1)		
Bentonite		
United States	902,635	1,082,593
United Kingdom	33,394	-
Total	936,029	1,082,593
	(short tons)	(short tons)
Consumption(2)		
Bentonite and fuller's earth		
Well-drilling	39,144	35,244
Iron and steel foundries	13,283	14,010
Pelletizing	8,500(e)	7,800(e)
Petroleum-refining	1,871	1,244
Paper	277	337
Miscellaneous chemicals	568	175
Miscellaneous non-metallic products	1,228	1,448
Total	64,871	60,258

Source: Dominion Bureau of Statistics.
(1) Activated clays for oil-refining. They include clay catalysts in addition to adsorptive clays.
(2) These quantities are calculated from information provided by the Dominion Bureau of Statistics.
(e) Estimated.

to a minor extent, in the United Kingdom. Developments that have occurred in the domestic industry since 1957 have reduced the imports of activated bentonite despite an increase in domestic consumption.

Canadian Occurrences

Bentonite occurs in the four western provinces in formations of Cretaceous and Tertiary age. In Manitoba, nonswelling bentonite has been

Bentonite and Fuller's Earth - Production, Imports and Consumption, 1950-60

	Production(1)	Imports(2)	Consumption	
	Bentonite ($)	Bentonite ($)	Bentonite (short tons)	Fuller's Earth (short tons)
1950	534,873	335,971	31,544	6,669
1951	499,556	374,200	30,670	7,050
1952	388,542	460,734	30,622	8,620
1953		443,510	35,167	15,982
1954		835,433	23,844	1,732
1955		1,247,355	28,821	1,565
1956		1,484,124	30,562	1,783
1957		1,536,512	26,105	1,654
1958		980,585	23,429	1,595
1959		1,082,593	60,258(3)	
1960		936,029	64,871(3)	

Source: Dominion Bureau of Statistics.

(1) The value of producers' shipments is not available for publication for the years after 1952.

(2) Activated clays for oil-refining. They include clay catalysts in addition to adsorptive clays.

(3) The larger total is due in part to an increase in the survey coverage, particularly in well-drilling. It includes fuller's earth.

discovered in the Vermilion River formation at various places along a belt extending from the United States border through Morden northwest to Swan River. In Saskatchewan, nonswelling-bentonite horizons are in the Vermilion River and Riding Mountain formations in the southeastern part of the province and in the Ravenscrag formation near Rockglen. The swelling variety occurs in the southwestern part of Saskatchewan in the Ravenscrag formation.

In Alberta, swelling bentonite occurs in numerous places, such as the areas around Rosalind, Busby, Camrose, Drumheller-Rosedale, Irvine-Bulls Head, Bickerdike, and Grande Prairie. Those with the better swelling properties are in the Edmonton and Bearpaw formations.

Bentonite occurs in Tertiary formations in British Columbia, principally in the vicinity of Princeton, Merritt, Kamloops, and Clinton.

Consumption and Uses

For 1960, the consumption of bentonite and fuller's earth is estimated at 64,871 short tons, of which 60 per cent was used in well-drilling and 20 per cent in iron and steel foundries.

Natural and activated nonswelling bentonite are used mainly for decolorizing mineral, animal, and vegetable oils. Smaller quantities are used to decolorize beverages, syrups, sugar, and vinegar and as catalysts in the refining of petroleum.

Swelling bentonite is consumed in much greater quantities than the nonswelling type. It has numerous uses but is employed principally in well-drilling fluids, foundry mouldings, and the pelletizing of iron ores. In drilling fluids, bentonite controls viscosity, prevents the settling of drill cuttings, and retains the drilling fluid by coating the walls of the holes. It binds sand grains in foundry moulds and serves as a binder in the pelletizing of iron ores. The recent demand for higher-grade iron ores has greatly increased the consumption of bentonite in Canada. Several companies have announced that in the near future they intend either to expand their pelletizing plants or construct new ones. If bentonite is used as the binder in these operations, its domestic consumption can be more than doubled in a short period.

Swelling bentonite is used also to bond and plasticize abrasive, ceramic, and refractory raw mixes; as a filler in paper, rubber, pesticides, cosmetics and medicinal products, soaps, and cleansers; and in the grouting of water-bearing horizons. It is used to prevent seepage from such structures as dams and reservoirs. In the last few years swelling bentonite has been used in western Canada to form adhesive gels for firefighting. In this method, an aqueous slurry containing approximately 8 per cent bentonite is dropped from low-flying aircraft or sprayed directly on the fire or foliage.

Prices and Tariffs

According to advertising brochures, Canadian swelling bentonite in bags costs about $25 a ton for carload lots at the plant. The activated nonswelling type has a much higher price.

In its issue of December 26, 1960, the Oil, Paint and Drug Reporter lists the United States price for nonactivated bentonite, minus 200 mesh, bagged, carload lots, f.o.b. mines, at $14 a ton.

At present, the tariffs on bentonite are as follows:

Canada

	British Preferential	Most Favored Nation	General
Clays, unmanufactured, including clay for drilling mud	free	free	free
Activated clays			
For refining oils	10%	10%	25%
Not for refining oils	15%	20%	25%

United States

Bentonite, per long ton	
Unwrought and unmanufactured	37 1/2¢
Wrought and manufactured	84 1/4¢
Clays, artificially activated	1/10¢ per lb plus 12 1/2% ad valorem

BISMUTH

J.W. Patterson*

In 1960, bismuth production totalled 423,827 pounds, having risen from the 1959 level of 334,736 pounds. Ninety-four per cent of this by-product output was refined metal obtained from lead-zinc-silver ores by The Consolidated Mining and Smelting Company of Canada Limited (Cominco) at Trail, British Columbia, and semirefined metal from molybdenite-bismuth and copper ores produced by Molybdenite Corporation of Canada Limited at Lacorne, in western Quebec, and by Gaspé Copper Mines, Limited, at Murdochville, Quebec. The remaining 6 per cent was recovered in a silver-lead-bismuth bullion by Deloro Smelting & Refining Company, Limited, at Deloro, Ontario, in the refining of silver-cobalt ores from the Cobalt-Gowganda area of northern Ontario.

The demand for Canadian bismuth in the United States and the United Kingdom, Canada's chief customers, has been erratic, with the result that Canada's annual production has fluctuated extensively, as shown in the graph on page 4. In recent years, however, the demand has become more constant and the fluctuations have consequently been less marked.

World output in 1960, as reported by the United States Bureau of Mines, amounted to 2,600 tons, with Peru, Mexico, Canada, and Bolivia, in that order, as the leading producers. United States production is not reported separately.

Domestic Sources

British Columbia

The main source of the bismuth produced at Trail is the lead concentrate derived from the lead-zinc-silver ore of Cominco's Sullivan mine, at Kimberley. The lead bullion obtained at the Trail smelter from this concentrate and from other concentrates originating mainly at mines in British Columbia and Yukon Territory contains about 0.05 per cent bismuth. The residue resulting from the electrolytic refining of the bullion is treated for the recovery of bismuth, antimony, and precious metals. Analysis of the refined bismuth produced commonly shows it to be more than 99.99 per cent pure. For research and electronic uses, high-purity (up to 99.9999 per cent) bismuth is produced in the electronic-materials plant at Trail, which completed its first full year of operation in 1960.

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*Mineral Resources Division.

Bismuth - Production, Trade and Consumption

	1960* Pounds	1960* $	1959 Pounds	1959 $
Production				
All forms(1)				
British Columbia	213,009	419,628	151,703	288,236
Quebec	172,983	297,018	151,576	264,228
Ontario	37,835	45,402	31,457	37,748
Total	423,827	762,048	334,736	590,212
Refined metal(2)	248,000		182,000	
Imports				
Metal and residues				
Netherlands	6,598	12,723	1,100	2,129
United States	1,050	2,319	2,043	4,490
Peru	-	-	9,859	20,210
Total	7,648	15,042	13,002	26,829
Salts				
United Kingdom	8,164	19,119	9,557	23,930
United States	1,916	6,897	664	2,338
Total	10,080	26,016	10,221	26,268
Exports(3)				
Metal	286,000		300,000	

	1960 Pounds	1959 Pounds
Consumption		
Metal (by industries)		
Medicinals and pharmaceuticals	10,000	6,864
White-metal foundries	33,827	30,700
Miscellaneous	882	2,158
Total	44,709	39,722
Salts	1959	1958
Chemical and allied-products industries	13,807	17,306

Source: Dominion Bureau of Statistics.
(1) Refined metal from Canadian ores, plus the bismuth content of the bullion and concentrates exported. (2) Refined metal from domestic and foreign ores. (3) Bismuth metal, refined and semirefined. (e) Estimated.

Bismuth - Production, Exports and Consumption, 1950-60
(pounds)

	Production		Exports (2)	Consumption(3)
	All Forms(1)	Refined Metal		
1950	191,621	194,000	114,000	66,000
1951	230,298	208,000	90,000	108,000
1952	162,373	142,000	34,000	106,000
1953	117,366	72,000	-	68,000
1954	258,675	226,000	134,000	74,000
1955	265,896	160,000	56,000	92,000
1956	285,861	156,000	135,000	131,000
1957	319,941	146,000	143,000	55,000
1958	412,792	172,000	352,000	39,800
1959	334,736	182,000	300,000	39,700
1960	423,827	248,000	286,000	44,709

Source: Dominion Bureau of Statistics.
(1) Refined metal from Canadian ores, plus the bismuth content of the bullion and concentrates exported.
(2) 1950 to 1957, inclusive - refined metal; 1958, 1959, 1960 - refined and semirefined.
(3) Refined metal reported by consumers.

Quebec

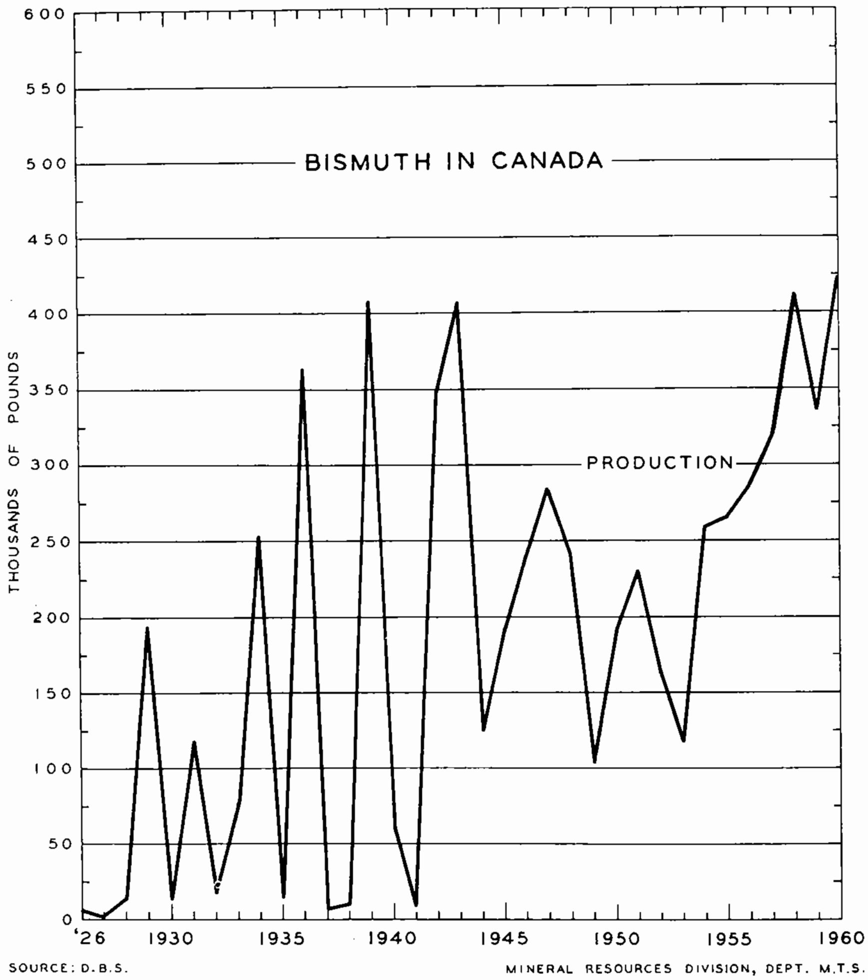
Molybdenite Corporation of Canada Limited produces molybdenite-bismuth ore at its Lacorne mine, 23 miles northwest of Val d'Or. A bulk concentrate containing about 8 per cent bismuth is obtained by flotation. By leaching, the bismuth is separated as bismuth oxychloride, which is smelted in electric-arc furnaces to produce a bullion containing about 98 per cent bismuth with minor amounts of lead and silver and traces of copper, iron, and antimony.

Production during the fiscal year ending on September 30, 1960, was 138,597 pounds.

Gaspé Copper Mines, Limited, produced 61,000 pounds of bismuth from the treatment of cottrell dust recovered in copper-smelting operations at Murdochville.

Ontario

Deloro Smelting & Refining Company, Limited, at Deloro, in south-eastern Ontario, recovered bismuth in silver-lead-bismuth bullion from the refining of silver-cobalt ores originating in the Cobalt-Gowganda district. The



bullion so produced, which contains about 20 per cent bismuth, was shipped from time to time to a custom smelter for treatment. In May 1960, the company announced that it planned to close its plant permanently early in 1961.

Uses and Consumption

Bismuth, in amounts up to 50 per cent, is used with tin, lead, and cadmium to make various low-melting-point alloys that find application in fire-protection devices, electrical fuses, and solders. Because bismuth expands on solidification and imparts expansion to its alloys, it is used in making type metal. Bismuth has another important use in compounds for medical and cosmetic preparations.

Several possible new applications for bismuth are being studied. For example, there is the alloy, bismuth telluride, which is gaining recognition as the thermoelectric material most suitable for the development of nonmechanical refrigerating units. In this type of refrigeration, the thermoelectric materials must produce coldness when an electric current flows through them in one direction and heat when the current flows in the opposite direction. Study is being given to the feasibility of constructing a nuclear thermal reactor with a solution of uranium in molten bismuth as the fuel component. In such a reactor the heat would be transferred by the medium in which it was generated.

The relative importance of the various uses of bismuth is shown in the following table on United States consumption during 1960 and 1959.

Bismuth - United States Consumption, by Principal Uses

(pounds)

	1960	1959
Fusible alloys	515,570	547,668
Other alloys	239,757	349,093
Pharmaceuticals	710,631	483,554
Experimental uses	24,667	161,040
Other uses	36,627	56,692
Total	1,527,252	1,598,047

Source: U.S. Bureau of Mines, Minerals Yearbook 1960, Bismuth (preprint).

Prices and Tariffs

Canadian prices quoted by The Consolidated Mining and Smelting Company of Canada Limited in 1960 were $2.25 a pound in lots of 1 ton or larger, and $2.50 a pound in lots of less than 1 ton delivered to eastern Canadian points. United States prices, which were the same as Canadian prices, have remained constant since September 5, 1950.

Bismuth metal enters Canada free of duty. In the United States there is a 1 7/8-per-cent ad valorem duty on bismuth metal and a 35-per-cent ad valorem duty on chemical compounds, mixtures, and salts.

CADMIUM

J.W. Patterson*

All cadmium produced in Canada is recovered as a by-product in the treatment of zinc ores and, to a lesser extent, in the treatment of lead ores. In both, it is present in minor amounts as a sulphide intimately associated with sphalerite. Production comes from two refineries - one at Trail, British Columbia, operated by The Consolidated Mining and Smelting Company of Canada Limited (Cominco), and the other at Flin Flon, Manitoba, operated by Hudson Bay Mining and Smelting Co., Limited. While most of the zinc concentrates treated at these plants are produced from mines owned by Cominco and Hudson Bay, a small proportion is from other companies. Some cadmium, not all of which is reported, is recovered by foreign smelters from the treatment of lead and zinc concentrates exported from Canada.

At Trail and Flin Flon, cadmium is obtained from cadmium-rich precipitates produced in purifying the zinc-bearing solutions prior to electrolysis. (At Trail, a small amount of the cadmium present in the solutions originates in lead concentrates, in which it is associated with the sphalerite not separated during milling. This cadmium, together with cadmium recovered from the retreatment of residues from the zinc-leaching plant, is removed during the blast-furnace operation and is later collected as a flue dust with zinc-oxide fume.) The precipitates, which contain about 55 per cent cadmium, are leached, and the cadmium is extracted electrolytically. About 70 per cent of the cadmium in zinc concentrate is recoverable, and metal not less than 99.95 per cent pure is produced in the form of balls, sticks, or slabs.

Owing to market changes, Canada's production has varied widely. In the last two years a growing demand for cadmium, especially in the plating industry, has caused it to increase. The 1960 output, at 2,357,497 pounds, nearly all refined, kept Canada well ahead as the greatest producer after the United States. Other leading producers of cadmium metal are shown on page 163. Mexico and South West Africa, not listed in the table, are important producers of lead and zinc concentrates containing cadmium. Some of the Mexican cadmium was exported in concentrates for refining; the remainder was produced as a lead-smelter flue dust. The lead and zinc concentrates produced in South West Africa were shipped principally to the United States, the United Kingdom, and Belgium, where the contained metals were recovered. The cadmium content of the flue dust and concentrates exported by these two countries in 1960 amounted approximately to 1,850,000 and 1,830,000 pounds respectively.

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*Mineral Resources Division.

Cadmium - Production, Exports and Consumption

	1960		1959	
	Pounds	$	Pounds	$
Production				
All forms(1)				
British Columbia....	1,778,866	2,525,990	1,695,821	2,170,651
Saskatchewan	256,498	364,227	253,697	324,732
Yukon Territory	145,496	206,604	141,750	181,440
Manitoba...........	110,138	156,396	69,095	88,442
Quebec	66,499	94,429	-	-
Total	2,357,497	3,347,646	2,160,363	2,765,265
Refined(2)...........	2,238,233		2,528,418	
Exports				
United Kingdom	1,030,116	1,371,545	821,506	998,776
United States........	992,581	1,211,372	1,045,293	1,127,447
Brazil..............	16,976	22,422	20,566	21,645
India	16,653	21,929	2,670	3,991
Netherlands.........	-	-	89,600	92,373
Other countries	7	163	3	61
Total...............	2,056,333	2,627,431	1,979,638	2,244,293
Consumption(3) (by uses)				
Plating	173,675		207,056	
Solders.............	12,759		14,769	
Other products	3,982		4,463	
Total................	190,416		226,288	

Source: Dominion Bureau of Statistics.
(1) Production of refined cadmium from domestic ore plus the cadmium content of some of the ores and concentrates exported.
(2) Includes metal derived from foreign ores.
(3) Consumption as reported by consumers. Other products include chemicals, pigments, and pipe, and alloys other than solders.

Much of the cadmium consumed in Canada is used by the plating industry. The total consumed is small, however, in relation to production. Most of the output is exported, chiefly to the United Kingdom and the United States.

Cadmium - Production, Exports and Consumption 1950-60

(pounds)

	Production		Exports	Consumption[3]
	All Forms[1]	Refined[2]		
1950	848,406	838,000	676,005	232,000
1951	1,326,920	1,266,000	824,850	290,000
1952	948,587	820,000	620,344	232,000
1953	1,118,285	978,000	969,563	254,000
1954	1,086,780	1,058,000	776,391	196,000
1955	1,919,081	1,714,000	1,562,337	220,000
1956	2,339,421	1,932,000	1,922,685	206,000
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

Source: Dominion Bureau of Statistics.

(1) Production of refined cadmium from domestic ores plus the cadmium content of some of the ores and concentrates exported.

(2) Includes metal derived from foreign ores.

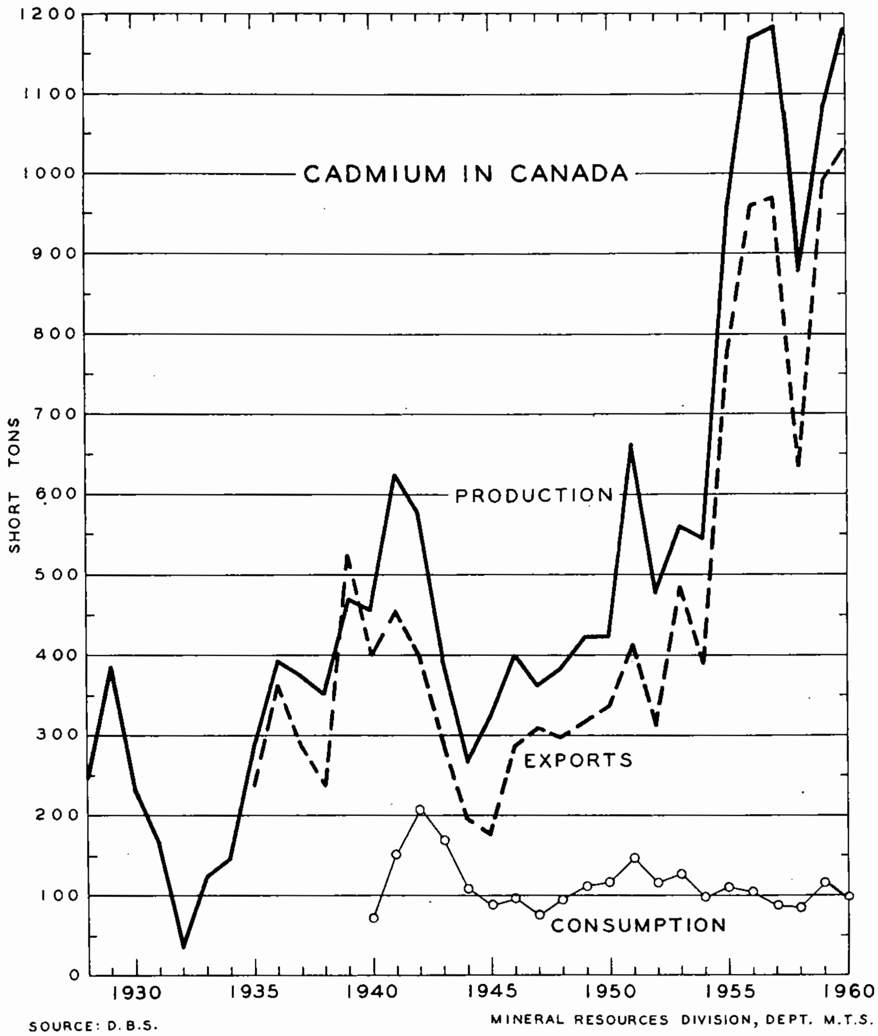
(3) 1950 and 1951 - producers' domestic shipments of refined metal; 1952 to 1959 - consumption as reported by consumers.

World Production of Cadmium Metal
('000 pounds)

	1960	1959
United States	10,180	8,602
Canada	2,357*	2,160*
Belgium	1,500	1,512
Japan	1,180	1,082
U.S.S.R.	1,035	1,005
Republic of the Congo	1,050	1,047
Other countries	4,398	4,392
Total	21,700	19,800

Source: U.S. Bureau of Mines, Minerals Yearbook 1960. except where otherwise indicated.

*Dominion Bureau of Statistics.



Domestic Sources

British Columbia

Canada's chief source of cadmium is the lead-zinc ores from Cominco's Sullivan mine, at Kimberley. Most of the 918 tons of cadmium recovered at the Trail refinery came from zinc concentrate that was produced in the Sullivan mill and averaged about 0.14 per cent cadmium. The company's H.B. mine near Salmo, its Bluebell mine at Riondel, and numerous custom shippers of zinc concentrates were also sources of cadmium.

Other companies that produced substantial amounts of zinc concentrate containing cadmium are listed in the following table.

Company	Location of Mine	Cadmium Production (pounds)
Canadian Exploration, Limited	Salmo	228,530
Howe Sound Company	Britannia Beach	47,236
Reeves MacDonald Mines Limited	Remac	159,851
Sheep Creek Mines Limited	Toby Creek	43,440
Violamac Mines Limited	Sandon	8,252

Yukon Territory

In the fiscal year ended on September 30, 1960, United Keno Hill Mines Limited recovered 181,132 pounds of cadmium in zinc concentrate produced from 176,745 tons of ore. In the previous fiscal year, 220,281 pounds were produced from 173,477 tons of ore. The decline in cadmium production for the second consecutive year was due to a decrease in the output of zinc concentrate resulting in part from a lower grade of mill feed.

Saskatchewan and Manitoba

Cadmium production, which in 1959 amounted to 322,792 pounds, totalled 366,636 pounds for 1960, as reported by Hudson Bay Mining and Smelting Co., Limited. The company produced this quantity from the copper-zinc ores of the Flin Flon mine, at Flin Flon, and the Coronation and Schist Lake mines, in the Flin Flon area, as well as from the zinc-lead-copper ore of the Chisel Lake mine, at Snow Lake, Manitoba. At the Coronation and Chisel Lake mines, the year was marked by the beginning of production. The zinc concentrates produced by Hudson Bay Mining and Smelting average about 0.14 per cent cadmium.

Eastern Canada

Zinc concentrates produced by mines in eastern Canada contain an estimated 0.2 per cent cadmium. They are all exported. No payment is received for the cadmium recovered from these concentrates, nor is any report made of the amount recovered.

Uses

Cadmium is used extensively as a resistant rustproof coating on iron and steel and, to a lesser extent, on copper-base alloys and other metals and alloys. Like zinc coatings, cadmium coatings on less active metals protect the metals electrochemically as well as by physical enclosure. Thus, metals that are commonly used as protective coatings, other than cadmium and zinc, must be applied in greater thicknesses to give the same protection. Where price is not important, cadmium is preferred to zinc as a coating because it can be deposited more uniformly in the recesses of intricately shaped parts, because it is more ductile, because it is slightly more resistant to atmospheric corrosion, and because it can be electrodeposited with less electric current per unit of area covered.

Cadmium-plated articles include a wide range of parts and accessories used in the construction of aircraft, automobiles, military equipment, and household appliances.

Cadmium is also used in making solders, particularly of the cadmium-silver type. Low-melting-point fusible alloys 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. In the field of atomic energy, cadmium is used in devices to control the fissionable elements in reactors. Cadmium is used in the manufacture of sterling silverware because it has a hardening effect when added to silver in small amounts.

Production of nickel-cadmium storage batteries is increasing. These batteries, each containing up to 7 pounds of cadmium, have a longer life than the standard lead-acid battery, are smaller, and are superior in their behavior at low temperatures. Because of these characteristics, they are being used in earth satellites, missiles, and ground equipment for polar regions.

Cadmium sulphide and cadmium sulphoselenide are used where bright, high-quality yellow or red colors are employed in electroplating solutions. Cadmium bromide and iodide are used in the making of photographic films and in photoengraving and photolithography. Cadmium stearate goes into the making of vinyl plastics.

Prices and Tariffs

The United States price per pound of cadmium in commercial sticks, according to E & M J Metal and Mineral Markets, was as follows:

	Jan. 1 to Sept. 27	Sept. 27 to Year-end
Ton lots	$1.30	$1.50
Less than a ton	$1.40	$1.60

Cadmium metal in crude form entered Canada duty-free from Commonwealth countries. The most-favored-nation and general duties were respectively 15 and 25 per cent ad valorem.

The United States duty on cadmium metal during 1960 was 3.75 cents a pound. Cadmium flue dust was duty-free.

CALCIUM

W.H. Jackson*

Calcium metal in quantity is required in only a few industrial processes. In small amounts it is used for diverse purposes, but chiefly as a deoxident or reducing agent. A falling-off in demand and changes in the production methods of the uranium industry have decreased its use. The resulting decline in Canadian output is evident in that production, which totalled 895,203 pounds in 1948, dropped to 25,227 pounds in 1958 rising to only 67,429 in 1959 and 134,801 in 1960.

Industrial demand in Canada is small, the metal being consumed in the production of lead alloys for battery plates, in the reduction of titanium and as an alloying agent with magnesium.

Production

All three of the alkaline-earth metals - calcium, barium, and strontium - are produced by Dominion Magnesium Limited, at Haley, Ontario.

To produce calcium, powdered lime (200-mesh) and commercial-purity aluminum (20-mesh) are charged into horizontal retorts. Under vacuum and at temperatures of about 1,170°C, the lime is reduced by the aluminum. Distilled calcium metal collects in the form of crystalline rings in the water-cooled head sections of the retorts. The head sections project through the furnace wall.

Four grades of metal are produced. They range in purity from the Chemical Standards Grade, nominally 99.9 per cent calcium, to the Commercial Calcium Grade, which contains 98 to 99 per cent. The maximum impurities contained in the Commercial Calcium Grade are 0.5 to 1.5 per cent magnesium, 1.0 per cent nitrogen, and 0.35 per cent aluminum. These impurities become progressively less in the other grades; in the Chemical Standards Grade they are present only in trace amounts. Nitrogen-free calcium is particularly desirable for some purposes. While calcium of the Chemical Standards Grade is available only in the form of granules in the range of minus 4 to plus 80 mesh size, other grades may be produced as granules, crystalline lumps, ingots, billets, and extruded shapes. Wire, tubes or other shapes, and strip are manufactured in some grades.

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*Mineral Resources Division.

Calcium - Production and Exports

	1960 Pounds	1960 $	1959 Pounds	1959 $
Production (metal)	134,801	159,241	67,429	76,409
Exports (metal)				
West Germany............		21,415		6,325
United Kingdom...........		19,201		36,250
India		15,870		14,000
United States		14,918		7,070
Belgium and Luxembourg ..		8,980		9,910
Union of South Africa......		5,850		-
Other countries...........		923		-
Total		87,157		73,555

Source: Dominion Bureau of Statistics.

Production of Calcium Metal, 1950-60

	Pounds	$
1950 to 1955 inclusive.......	(not available for publication)	
1956	394,900	515,305
1957	221,225	282,378
1958	25,227	31,256
1959	67,429	76,409
1960	134,801	159,241

Source: Dominion Bureau of Statistics.

Uses

Calcium metal is used mainly as a reducing agent in the production of such metals as uranium, thorium, titanium, zirconium, and chromium. As an alloying agent it imparts useful properties to aluminum, magnesium, platinum, and silver. It may also be used as a debismuthizer for lead, for the control of graphitic carbon in cast iron, and as a deoxidizer or desulphurizer for alloys of nickel, copper, or iron. In some of these metallurgical applications, calcium metal competes with calcium compounds prepared by other methods, the main advantage being that the metal has fewer undesirable impurities. Other minor uses include the removal of water from alcohol, the separation of argon from nitrogen, and the desulphurization of petroleum fractions.

Although calcium is extremely light and has interesting physical properties, its chemical reactivity with water, oxygen, and nitrogen has prevented the development of structural uses.

Prices

According to E & M J Metal and Mineral Markets of December 29, 1960, the United States price of calcium metal in ton lots, slabs, etc. was $2.05 a pound. This price prevailed throughout the year.

Tariffs

Canada

	British Preferential	Most Favored Nation	General
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%

United States

Calcium metal	17 1/2%

CEMENT

J.S. Ross*

The plant capacity of the Canadian cement industry increased considerably during 1960. One large plant began production; an additional kiln was installed in each of two others; accessory equipment was installed at another; and at a fifth plant there was a notable increase in efficiency. The largest expansion took place in the Montreal area, where plant capacity now exceeds demand. The increase in Alberta and Saskatchewan resulted mainly from other types of construction now in progress or proposed. Other expansion, in Quebec and Ontario, was due more to local conditions.

These programs have resulted in an increase in the annual production capacity of 1,260,000 tons (7.2 million barrels), or 17 per cent. At the end of 1960, Canada's rated annual cement-production capacity was 8,750,000 tons (50 million barrels); the excess annual capacity (2,962,775 tons) was 51 per cent of the 1960 production and approximated the increase in apparent domestic consumption of cement from 1948 to 1960.

This is the first year since 1947 in which the Canadian cement industry has not attained record production. This reflects a decrease in the cement requirements of both the domestic and the United States construction industries for the year under review.

The trend toward integration of the cement- and concrete-products industries was accelerated during the year and two new distributing stations began to operate.

Production

The Canadian cement industry produces portland, masonry, and oil-well cement and processes white cement clinker. Most of the output is of the normal portland variety used in general construction. Other types of portland cement and the air-entrained equivalents of most types are available from many plants. Special cements for certain large construction projects are produced on request.

The year under review was the first since 1944 in which the volume of Canada's cement production failed to increase. The industry operated at 69 per cent of its actual capacity, or 66 per cent of the year-end capacity. At 5,787,225 tons, production was the lowest since 1956, being 497,261 tons, or 8 per cent, below the volume of 1959. Most of the loss took place in

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*Mineral Processing Division, Mines Branch.

Cement – Production and Trade

	1960		1959	
	Short Tons	$	Short Tons	$
Production*				
Ontario	2,007,044	30,699,800	2,386,334	31,731,767
Quebec	1,875,997	28,315,159	1,975,452	29,520,710
Alberta	663,856	11,474,865	689,854	11,678,577
Manitoba	429,788	8,105,802	402,562	7,314,552
British Columbia	384,853	6,432,752	427,181	7,049,638
Saskatchewan	169,282	3,997,809	161,057	3,954,737
New Brunswick	163,245	2,546,622	170,793	2,606,301
Newfoundland	93,160	1,688,664	71,253	1,291,516
Total	5,787,225	93,261,473	6,284,486	95,147,798
Exports				
Portland cement				
United States	180,897	2,816,579	303,032	5,001,126
Other countries	220	4,428	94	2,181
Total	181,117	2,821,007	303,126	5,003,307
Imports				
Portland cement				
United Kingdom	9,384	266,633	8,187	243,767
United States	5,596	214,930	12,264	330,205
West Germany	3,876	140,622	3,471	129,029
Denmark	1,570	50,068	1,727	55,139
France	1,465	38,754	1,316	36,220
Belgium and Luxembourg	587	17,044	2,071	62,182
Other countries	–	–	220	2,321
Total	22,478	728,051	29,256	858,863
Portland-cement clinker				
Denmark	13,104	230,415	10,158	178,255
United States	4,676	101,626	6,536	143,092
Total	17,780	332,041	16,694	321,347

Source: Dominion Bureau of Statistics.
*Producers' shipments plus quantities used by producers.

Cement - Production, Trade and Consumption, 1950-60
(short tons)

	Production(1)	Exports	Imports(2)	Apparent Consumption(3)
1950	2,929,820	4,184	242,588	3,168,224
1951	2,976,367	453	407,300	3,383,214
1952	3,241,095	754	509,947	3,750,288
1953	3,891,708	2,577	434,487	4,323,618
1954	3,926,559	21,638	401,135	4,306,056
1955	4,404,480	168,907	517,890	4,753,463
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

Source: Dominion Bureau of Statistics.
(1) Producers' shipments plus amounts used by producers.
(2) Does not include cement clinker.
(3) Production plus imports less exports.

Ontario, where the output decreased 379,290 tons, or 16 per cent, from that of 1959. With the exception of Manitoba, Saskatchewan, and Newfoundland, where small gains were made, the other provinces showed a drop in shipments. The output of Ontario and Quebec represented 67 per cent of all the shipments of 1960. In value, cement remained tenth in mineral production.

Cement clinker was produced in all provinces except Nova Scotia and Prince Edward Island by 19 plants containing 45 kilns. In addition, two separate clinker-grinding plants were in operation. Clinker from the Exshaw, Alberta, plant is ground by Canada Cement Company, Limited, at Clover Bar, Alberta. Medusa Products Company of Canada,Limited grinds imported clinker from Pennsylvania at Paris, Ontario, for the production of white cement.

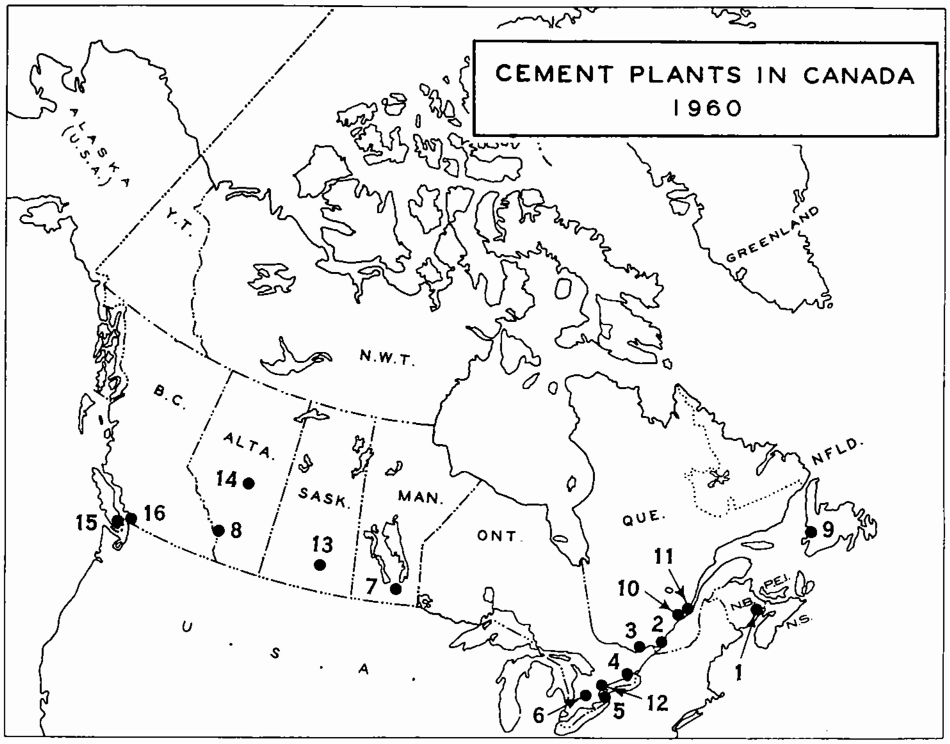
The locations of the clinker-producing plants are listed in the table on page 4 and are shown on the accompanying map. All are near industrialized areas,and 11 that account for 66 per cent of the total production capacity are in Ontario and Quebec.

World production of cement has increased substantially during the last decade, particularly in Russia and China. The record of 350 million short tons produced in 1960 was an 8-per-cent increase over the output of 1959. Canada was in twelfth place in 1960.

Approximate Plant Capacities(1) at End of 1960

Company(2)	Short Tons/Year	Barrels/Year
Canada Cement Company, Limited		
(1) Havelock, N.B.	149,000	850,000
(2) Montreal, Que.	1,313,000	7,500,000
(3) Hull, Que.	193,000	1,100,000
(4) Belleville, Ont.	700,000	4,000,000
(5) Port Colborne, Ont.	210,000	1,200,000
(6) Woodstock, Ont.	568,000	3,250,000
(7) Fort Whyte, Man.	542,000	3,100,000
(8) Exshaw, Alta.	525,000	3,000,000
North Star Cement Limited		
(9) Corner Brook, Nfld.	105,000	600,000
Ciment Quebec Inc.		
(10) St. Basile, Que.	315,000	1,800,000
St. Lawrence Cement Company		
(11) Villeneuve, Que.	262,000	1,500,000
(12) Clarkson, Ont.	613,000	3,500,000
St. Mary's Cement Co., Limited		
(6) St. Mary's, Ont.	525,000	3,000,000
Saskatchewan Cement Company Limited		
(13) Regina, Sask.	228,000	1,300,000
Inland Cement Company Limited		
(14) Edmonton, Alta.	595,000	3,400,000
British Columbia Cement Company Limited		
(15) Bamberton, B.C.	577,000	3,300,000
Lake Ontario Portland Cement Company Limited		
(4) Picton, Ont.	368,000	2,100,000
Lafarge Cement of North America Ltd.		
(16) Lulu Island, B.C.	262,000	1,500,000
Miron Company Limited		
(2) St. Michel, Que.	700,000	4,000,000
Total	8,750,000	50,000,000

Source: Company correspondence.
(1) Not including the capacities of the separate grinding plants.
(2) The numbers in brackets refer to locations on the map.



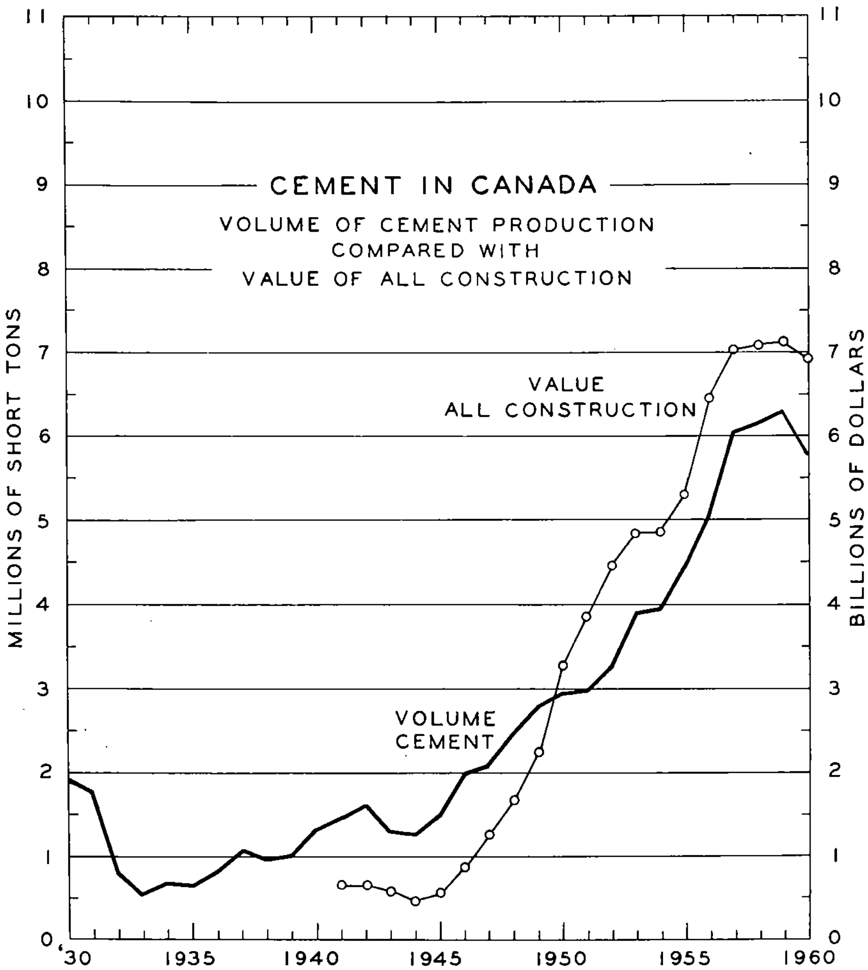
MINERAL RESOURCES DIVISION, DEPT. M.T.S.

Trade

International trade in cement is normally proportionately low because cement has a relatively low unit value and is produced in quantity throughout the world.

Since 1955, Canadian cement exports have been noteworthy. In 1960, they were worth $2,821,007, or 3 per cent of the value of production, and went almost entirely to the United States. In 1957, imports decreased appreciably and since then have been minor and have continued to diminish. They are now mainly of special types and originate chiefly in the United Kingdom, the United States, and West Germany.

Exports of cement from Canada to the United States continue to cause concern in the latter country. During 1959 and 1960, the United States Tariff Commission investigated certain Canadian cement exports to determine whether they were sold in violation of the International Antidumping Act. The Commission ruled that the exports investigated had not violated legislation. United States imports of Canadian cement were 0.5 and 0.3 per cent, respectively, of the volume of United States shipments for 1959 and 1960.



Developments

The Committee on Hydraulic Cements, Canadian Standards Association, continued its compilation of revised specifications for portland cement. The results, in a fifth edition, are to be published shortly.

During the early part of 1960, a highly automated cement plant was brought into production by Miron Cement Inc. at St. Michel, Quebec. This one-kiln plant has an annual rated output of 4 million barrels and is surpassed in capacity by only one other plant in Canada. Following the recent trend toward the use of dry processing in the Canadian cement industry, the company employs the largest dry-process rotary kiln in the western hemisphere. The kiln is 550 feet by 15 feet and is operated entirely by automation.

A $4.5-million addition was completed at mid-year at the Edmonton plant of Inland Cement Company Limited. This expansion included the installation of a new 11- by 340-foot rotary kiln and the necessary accessory equipment. The rated annual output of the plant was thus increased from 2.2 million to 3.4 million barrels.

The plant capacity of Saskatchewan Cement Company Limited, at Regina, has been increased from 800,000 to 1,300,000 barrels a year by the completion of a $1-million expansion. These developments in western Canada are the result of a general rise in the demand for cement in Saskatchewan, Alberta, and eastern British Columbia. Major construction projects in progress and those planned for the erection of dams in Saskatchewan and British Columbia will further increase cement consumption.

In November, the installation of a third kiln and accessory equipment was completed by Ciment Quebec Inc. at St. Basile, Quebec. The rated capacity of the plant was thus raised from 700,000 to 1,800,000 barrels a year. The dimensions of the wet-process kiln are 11 feet by 375 feet.

By improved efficiency, Lake Ontario Portland Cement Company Limited has increased the rated annual output of its Picton, Ontario, plant by 400,000 barrels to 2.1 million barrels.

British Columbia Cement Company Limited is erecting a new limestone crushing plant with a capacity of 500 tons an hour. The plant, at Bamberton, British Columbia, now produces pozzolana and is prepared to produce pozzolanic cements upon request.

Fly ash is being used as a pozzolana in the construction of the Squaw Rapids dam, in Saskatchewan.

Two cement-distribution plants were put into operation during 1960 by St. Lawrence Cement Company. One is situated at Ottawa and the other at London, Ontario.

The trend in Canada toward the integration of the cement- and concrete-products industries is continuing. Lafarge Cement of North America Ltd., one of the two producers in British Columbia, has acquired control of Anglo Canadian Cement Limited, as well as of Deeks-McBride Limited and its affiliated companies. The two last-mentioned companies produce ready-mixed concrete, sand and gravel, and concrete products in British Columbia, primarily in the Vancouver area. Deeks-McBride Limited owns 12 ready-mixed-concrete plants in that province. Lafarge Cement has also acquired a substantial interest in the three ready-mixed-concrete plants of Island-Ready-Mix Limited, on Vancouver Island.

A substantial amount of foreign capital, in addition to that involved in many of the foregoing developments, was invested in two major cement companies. One of these was the integrated group of construction-products companies of

Miron et Frères,Limitée purchased in mid-1960 by Cimenteries et Briqueteries Réunies, a subsidiary of Société Générale de Belgique, for $50 million. The group, which includes the cement plant formerly owned by Miron Cement Inc., at St. Michel, Quebec, now operates as Miron Company Limited and has as many as 3,000 employees. The other was Canada Cement Company, Limited, of which Associated Portland Cement Manufacturers, controlled by United Kingdom interests, purchased 10 per cent of the outstanding shares for about $5.4 million. Associated Portland Cement owns British Columbia Cement Company Limited.

Further integration took place between the concrete- and the asbestos-products industries when United Asbestos Corporation Limited, which owns the deposit being mined by Lake Asbestos of Quebec,Ltd., Black Lake, Quebec, purchased control of Thorold Concrete Products Limited, Thorold, Ontario; Capital Concrete Products Limited, Iroquois, Ontario; and Transit Mixed Concrete Limited, St. Catharines, Ontario.

Consumption and Uses

Because cement is used almost exclusively for construction, its output is directly proportionate to construction expenditures. This is indicated by the graph on page 6. Each type of construction requires different proportions of cement, the nonresidential type consuming more than the residential per unit of cost. In 1960, construction expenditures unexpectedly dropped 2.7 per cent below their 1959 total to $6,889 million. For the same period, the apparent domestic consumption of cement was 6.4 per cent less than in 1959.

It is estimated that the value of the construction planned for 1961 will approximate $7,132 million, a new high. If this prediction is realized, cement shipments should be from 5 to 10 per cent greater than those of 1960.

About one third of the cement consumed is used in the manufacture of concrete products, and in 1958 the cement used for this purpose amounted to 2,117,500 tons. The concrete products involved include ready-mixed concrete and concrete blocks, bricks, pipe, tile, and other shapes.

Production of Concrete Products

	1960	1959
Concrete bricks (number)	95,302,943	118,594,195
Concrete blocks (except chimney blocks)		
Gravel (number)	97,995,559	97,773,920
Cinder (number)	7,783,206	11,639,745
Other (number)	28,005,969	28,247,788
Concrete drain pipe, sewer pipe, water pipe, and culvert tile (tons)	767,396	895,506
Concrete, ready-mixed (cubic yards)	7,312,228	7,241,895

Source: Dominion Bureau of Statistics.

The use of cement in soil cement, a mixture of cement and clay or gravel, is increasing. Soil cement may be used to stabilize road bases prior to other types of paving, or it may be used by itself as top-pavement. Soil cement was first employed in Canada during World War II and until 1960 was used sparingly. During 1960, more than 100 miles of roads were improved with soil cement, particularly in western Canada.

Portland cement is also used as an extender pigment in paint.

Specifications, Prices and Tariffs

Cement produced in Canada meets the specifications developed by the Canadian Standards Association.

Prices vary depending on supply and demand, location, and type of cement required. The average value of the total 1960 production was $15.99 a short ton, or $3.26 a barrel.

Canadian import tariffs per 100 pounds are as follows:

	British Preferential	Most Favored Nation	General
Portland cement and hydraulic (water) lime, in bulk or barrels or in casks, the weight of the barrel, bag, or cask to be included in the weight for duty	5¢	8¢	8¢
White portland-cement clinker for use in the manufacture of white portland cement	2¢	3 1/2¢	6¢

The United States import tariff on portland, roman, and other hydraulic cements or cement clinker is 2 1/4 cents per 100 pounds, including the weight of the containers. For white nonstaining portland cement, it is 3 cents per 100 pounds, including the weight of the containers.

CHROMIUM

V.B. Schneider*

Canadian imports of chrome ore (chromite) increased in 1960 for the second consecutive year; they totalled 59,023 tons valued at $1,521,812. Consumption of ferrochrome was slightly higher than in 1959, but exports of ferrochrome, at 4,611 tons, were the lowest since 1943, when the Dominion Bureau of Statistics first listed them as a separate export item. A 677-ton increase in the consumption of ferrochrome was due to an increase in the production of stainless steel, which accounts for what is by far the greater part of the ferrochrome consumed in Canada.

In 1960, 4,757 tons of ferrochrome valued at $2,050,120 were imported from the United States. This was mostly of the low-carbon type, which is not made in Canada.

Canada has no known deposits of commercial-grade chrome ore. During the period 1940-50 some chromite was produced in the Province of Quebec; peak production, reached in 1943, amounted to 29,595 tons. The Bird River deposits in the Lac du Bonnet district of southeastern Manitoba are large but of low grade - about 26 per cent chromic oxide (Cr_2O_3) and 12 per cent iron. The chromium-to-iron ratio is about 1.4:1.

Chromite is consumed in Canada by Union Carbide Canada Limited, Metals and Carbon Division, at Welland, Ontario, where high-carbon ferrochrome and ferrochrome-silicon are produced; by Chromium Mining & Smelting Corporation, Limited, at Sault Ste. Marie, Ontario, where exothermic chromium alloys are produced; by Canadian Refractories Limited at its refractories plant at Marelan, Quebec, about 50 miles west of Montreal; and by General Refractories Company of Canada Limited, Smithville, Ontario.

World Production and Trade

World production at 4,920,000 tons exceeded 1959 production by 570,000 tons. Increases in production were recorded by all the main producing countries, with the Philippines replacing the Union of South Africa as the leading producer in the non-Communist world. As in other years, Russia continued as the leading producer. The main producing countries in 1959 were Russia (940,000 tons), the Union of South Africa (749,873), the Philippines (720,345), Southern Rhodesia (543,104), and Turkey (427,324).

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*Mineral Resources Division.

Trade and Consumption

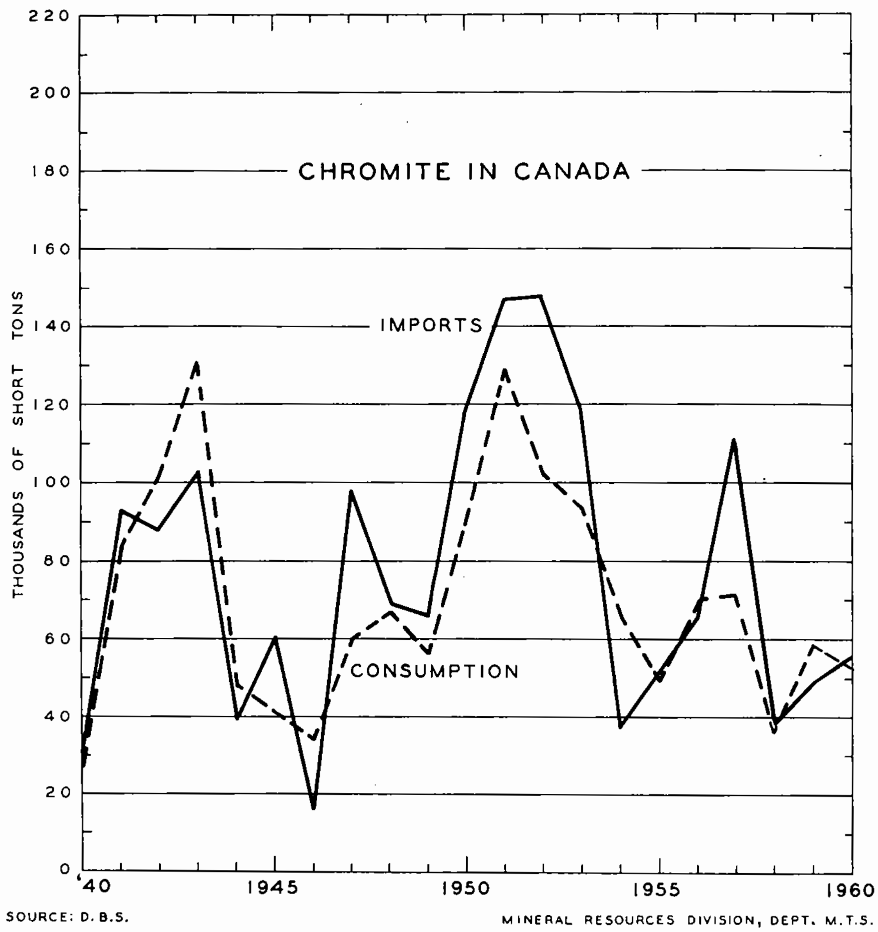
	1960 Short tons	1960 $	1959 Short tons	1959 $
Imports (chromite)				
Philippines	38,912	892,684	11,760	220,605
United States	13,343	442,375	22,245	778,268
Cyprus	2,822	99,154	-	-
Rhodesia Nyasaland	2,155	55,772	8,687	313,395
Union of South Africa	1,132	12,135	-	-
Cuba	659	19,692	1,090	28,956
U.S.S.R.	-	-	2,645	94,410
Malta	-	-	2,251	89,804
Total	59,023	1,521,812	48,678	1,525,438
Exports (ferrochrome)				
Norway	2,727	476,422	-	-
United States	1,866	487,614	7,394	1,961,664
Mexico	12	4,732	76	22,132
Other countries	6	1,859	44	10,382
Total	4,611	970,627	7,514	1,994,178
Consumption (chromite)	54,331		58,532	

Source: Dominion Bureau of Statistics.

Trade and Consumption, 1950-60
(short tons)

	Imports	Exports	Consumption	
	Chromite	Ferrochrome	Chromite	Ferrochrome
1950	119,325	32,916	90,798	3,589
1951	146,998	43,731	128,570	5,100
1952	148,343	44,290	101,919	6,362
1953	118,092	33,824	92,678	4,986
1954	37,517	15,304	64,782	3,500
1955	51,854	12,354	49,176	6,406
1956	64,965	9,897	69,835	7,091
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	8,829

Source: Dominion Bureau of Statistics.



The United States is the leading importer and consumer of chromite, Rhodesia, the Union of South Africa, and the Philippines being the principal suppliers. Traditionally Turkey supplies the bulk of the metallurgical-grade ore, the Philippines the bulk of the refractory-grade ore, and the Union of South Africa the bulk of the chemical-grade ore. In 1959 and 1960, however, the Federation of Rhodesia and Nyasaland replaced Turkey as the principal supplier of metallurgical-grade ore. In 1960, the United States imported 1,157,341 tons of chromite; of this 444,403 tons were of metallurgical grade, 384,929 of refractory grade, and 328,009 of chemical grade.

In 1952, Free World chromite reserves were estimated to total about 300 million long tons.[1] In 1960, the chromite reserves of Southern Rhodesia were estimated at 608 million tons, of which some 300 million were considered to be of metallurgical grade.[2] The reserves of chrome ore in South Africa were recently estimated to amount to several hundred million tons.

World Production of Chromite, 1960
(short tons)

U.S.S.R.	1,010,000
Union of South Africa	850,916
Philippines	809,579
Southern Rhodesia	668,401
Turkey	528,690
Albania	330,700
Yugoslavia	111,170
United States	107,000
Other countries	503,544
Total	4,920,000

Source: U.S. Bureau of Mines, Mineral Trade Notes, August 1961.

Uses

Chromite consumed in industry is graded as metallurgical, refractory, or chemical. These grades are based on physical and chemical properties, but technological advances are making them interchangeable to an ever-increasing extent. In the United States over the last four years, the metallurgical industry has accounted for 62 per cent of all chromite consumed, the refractory industry for 27 per cent, and the chemical industry for 11 per cent. In Canada during 1959 and 1960 the metallurgical industry accounted for about 35 per cent of the chromite consumed.

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 2.8:1. It is consumed in the steel industry as ferrochrome alloys made by electric smelting processes. Manufacturers of chrome exothermic additives may use chrome ores of less rigid specifications than those outlined.

Several grades of ferrochrome are made. They are distinguished by their carbon and silicon content. Low-carbon ferrochrome of various grades

(1) President's Materials Policy Commission, Paley Report, 1952.
(2) Stanley, R., Department of Mines, Southern Rhodesia. Chromium in Southern Rhodesia, page 16.

ranging from 0.02 to 2 per cent maximum is used in stainless and heat-resistant steels. High-carbon ferrochrome, in which the carbon content varies from 4 to 9 per cent, is used in the production of other chromium-bearing steels and alloy cast irons. Chromium greatly increases corrosion resistance in steels, and hardness, strength, and resistance to corrosion in cast irons.

Chromium metal is used in high-temperature corrosion-resistant alloys and in chromium bronzes, hard-facing alloys, welding-electrode tips, certain high-strength aluminum electrodes, and aluminum-base hardener alloys used by fabricators and foundries making up their own alloy compositions. High-temperature alloys contain from 13.5 to 27 per cent chromium, together with varying amounts of cobalt, columbium, nickel, tungsten, molybdenum, manganese, titanium, and vanadium. High-temperature alloys are used mainly in the highly stressed parts of missiles and in gas and steam turbines, jet-engine compressor blades, and jet-engine exhaust systems.

Chromium plating is extensively used to produce brilliant, nontarnishing, and durable finishes. Many articles such as dies, gauges, and punches are plated with a relatively thick layer to improve their wearing qualities and performance.

Refractory-grade Chromite

Specifications for refractory-grade chromite are not so rigid as for metallurgical grade. For brick of the best quality, the mineralogical constitution is nevertheless of great importance. Because it is desirable to keep the silica content as low as possible and because refractoriness is inversely proportional to the iron content, the chromic oxide and alumina combined should not be less than 57 per cent, and the iron and silica should usually be 10 and 5 per cent respectively. The ore must be hard and lumpy and above 10-mesh. Chromite fines are suitable for the manufacture of brick cement or chrome-magnesite brick.

Bricks made from refractory-grade chromite are used extensively for lining furnaces. Because of its high melting point and chemical inactivity, chromite is widely used where contact with basic or acid fluxes is involved. Hence, it is common practice to use chromite bricks near the slag line in open-hearth furnaces and between the silica bricks of the roof and of the sides. Chrome refractory materials are used for patching brickwork and in making ramming mixtures for furnace bottoms.

Chemical-grade Chromite

In chemical consumption, specifications are not so rigid as for metallurgical and refractory grades. Standard chemical ores contain a minimum of 45 per cent Cr_2O_3, and iron is not a problem within reasonable limits. The ores should not contain more than 15 per cent aluminum oxide (Al_2O_3) and 20 per cent iron oxide (FeO), or less than 8 per cent silicon dioxide (SiO_2); the sulphur must be low. The chromium-iron ratio is usually about 1.6:1. Fines are preferred because the ore is ground in processing to sodium and potassium chromates and bichromates.

Sodium bichromate or its derivatives are used as pigments in the paint and dye industries, as mordants and waterproofing material in the textile industry, in the surface treatment of metals, and as a source of electrolytic chromium metal.

Prices

E & M J Metal and Mineral Markets of December 29, 1960, quotes chrome prices in United States currency as follows:

Chrome metal	Per lb delivered, electrolytic, 99.8%, according to size of lot	\$ 1.15 to \$ 1.19
Chrome ore	Per long ton, dry basis, subject to penalties if guarantee not met, f.o.b. Atlantic ports	
	Rhodesian (term contracts)	
	48% Cr_2O_3, 3:1 ratio	\$35.75 " \$36.25 (nominal)
	48% Cr_2O_3, 2.8:1 ratio	\$32.00 " \$33.50 (")
	48% Cr_2O_3, no ratio	\$27.00 " \$28.00 (")
	South African (Transvaal)	
	48% Cr_2O_3, no ratio	\$25.50 " \$27.00
	44% Cr_2O_3, " "	\$19.75 " \$20.50
	Turkish (basis 48%, 3:1)	
	48% Cr_2O_3, 3:1 ratio, lump and concentrates	\$36.00 " \$37.00 (nominal)
	46% Cr_2O_3, 3:1 ratio, lump and concentrates	\$33.50 " \$34.00 (")

E & M J Metal and Mineral Markets of December 8, 1960, quotes the following prices:

Ferrochrome	Per lb contained Cr, carload lots, delivered, lump, continental U.S.	
	High-carbon, 4-9% C, 65-70% Cr	28.75¢
	Low-carbon, 0.10% C, 67-72% Cr	33.75¢
	Special, 0.01% C, 63-66% Cr	35.00¢

Tariffs

Canada

	British Preferential	Most Favored Nation	General
Chrome ore	free	free	free
Chrome metal in lumps, powder, ingots, blocks, or bars and in scrap of alloy metal containing chromium for use in alloying	"	"	"
Ferrochrome	"	5%	5%
Materials for use in the manufacture of chromium oxide	"	free	20%

United States

Chrome ore	free
Chromium metal	10 1/2%
Ferrochrome	
Less than 3% C	10 1/2%
3% or more C	5/8¢ per lb on Cr content
Chromic acid	12 1/2%
Chromium carbide; chromium-nickel, -silicon, and -vanadium	12 1/2%
Chrome brick	25%
Chrome colors	12 1/2%

CLAYS AND CLAY PRODUCTS

J.G. Brady*

In 1960, the value of the clay products made in Canada from domestic and imported clays was 8.5 per cent less than in 1959, the peak year. The decline was mainly in the manufacture of clay products from domestic raw materials. The value of clay-product imports was 3 per cent less than in 1959 and 11 per cent below the record high of 1956. Clay-product exports were of slightly higher value than in 1959.

The term 'clay products' applies to such materials as fire-clay refractories, common and face brick, structural tile, partition tile, drain tile, quarry tile, sewer pipe, conduit, flue lining, wall tile, floor tile, electrical porcelain, sanitary ware, dinnerware, and pottery. The foregoing, from fire-clay refractories to flue lining, inclusive, have clay as their principal ingredient. The remainder are prepared bodies and, in addition to clay, may contain ground silica, feldspar, nepheline syenite, talc, or other components of whiteware-type bodies.

Common clays and shales suitable for certain types of clay products occur in all regions of Canada. Deposits of such high-quality clays as china clay (kaolin), ball clay, and very refractory fire clay are scarce in Canada. Consequently, most clays of this type are imported.

Production, Trade, and Consumption

The value of the clay products manufactured in Canada in 1960 was $60.2 million, or about $5.6 million less than in 1959. Products such as building brick and tile, drain tile, and sewer pipe, which are manufactured from domestic clays and shales, accounted for $37.1 million of this total. Such products as whitewares and refractories, which are manufactured mainly from imported clays, accounted for an estimated $23.1 million.

From domestic raw materials, particularly common clay and shale and stoneware clay, 81 plants manufactured such clay products as face brick, common brick, structural tile, partition tile, conduit, quarry tile, and drain tile. Most of these plants are close to large centres of population and sources of raw material. Almost half of them are large and modern and can operate during the winter. The rest, because of lack of facilities for winning, processing, and storing clays in winter, operate only during frost-free seasons.

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*Mineral Processing Division, Mines Branch.

Clays and Clay Products - Production and Trade
(dollars)

	1960	1959
Production		
Domestic sources		
Clays, including bentonite	1,130,081	680,762
Clay products from:		
Common clay	30,101,393	34,541,553
Stoneware clay	4,873,304	5,682,548
Fire clay	816,206	771,212
Other products	1,305,554	839,373
Total	38,226,538	42,515,448
Foreign sources - from:		
Stoneware clays		746,648
Fire clays		2,859,287
China clays		20,341,009
Total	23,100,000(e)	23,946,944
Total production	61,326,538	66,462,392
Imports		
Clay		
Fire clay, ground	415,292	483,423
China clay, ground	2,375,213	2,331,691
Pipe clay, ground	22,981	39,187
Clays, ground, not otherwise provided	508,533	556,892
Activated clay for refining of oils	936,029	1,082,593
Total	4,258,048	4,493,786
Clay products		
United States	23,381,646	24,160,938
United Kingdom	14,051,594	14,815,377
Other countries	4,972,026	4,635,419
Total	42,405,266	43,611,734
Exports		
Clay, unmanufactured		
United States	263,279	242,408
United Kingdom	3,338	100
Other countries	1,790	150
Total	268,407	242,658

Clays and Clay Products - Production and Trade (cont'd)
(dollars)

	1960	1959
Exports (cont'd)		
Clay products		
United States	3,491,639	3,550,965
Chile	239,567	296,437
Mexico	182,083	27,410
Belgium and Luxembourg	178,460	123,879
West Germany	152,327	91,731
Brazil	103,785	126,422
Other countries	649,497	648,205
Total	4,997,358	4,865,049

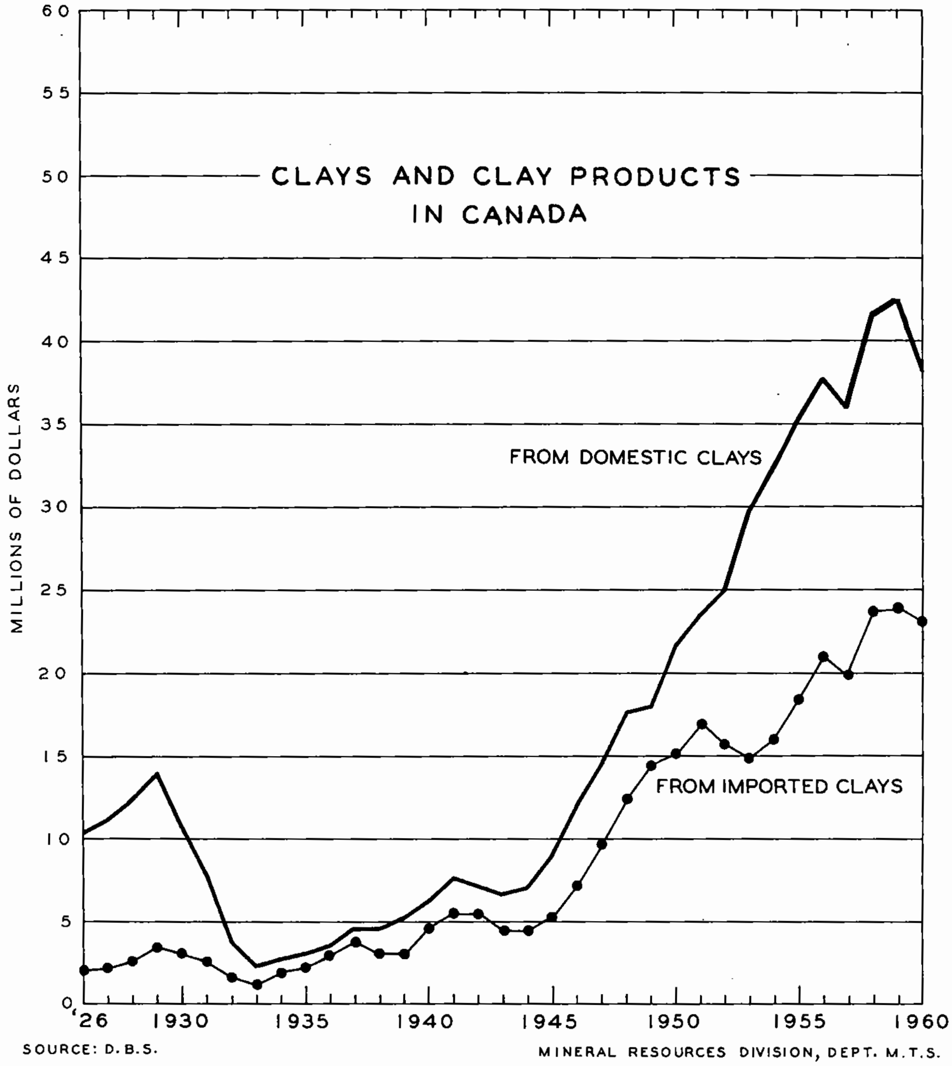
Source: Dominion Bureau of Statistics.
(e)Estimated

Clays and Clay Products - Production and Trade, 1950-60
($ millions)

	Production			Imports	Exports
	From Domestic Clays	From Imported Clays	Total		
1950	21.8	15.1	36.9	31.5	2.2
1951	23.5	16.9	40.4	39.8	2.5
1952	25.0	15.7	40.7	33.5	2.5
1953	29.8	14.9	44.7	36.5	1.9
1954	32.4	16.0	48.4	35.0	2.2
1955	35.3	18.4	53.7	41.0	2.7
1956	37.8	20.9	58.7	52.4	3.5
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	23.1(e)	61.3	46.7	5.3

Source: Dominion Bureau of Statistics.
(e)Estimated

Ten plants manufactured clay sewer pipe and flue lining in 1960. Plants of this type use mainly such domestic materials as low-grade fire clay, stoneware clay, common clay, and plastic shale. Three plants in Ontario and Quebec, however, import the low-grade fire clay they use in the manufacture of these products. The imported material is mixed with local domestic clay to form the sewer-pipe or flue-lining body.



Seventeen refractory plants in Canada used refractory fire clay as one of the principal ingredients of their products. Only four, all in western Canada, were utilizing domestic material. Firebrick, refractory castables, refractory mortars, plastic firebrick, stove linings, and miscellaneous refractory shapes are the principal products made in Canada from fire clay. For certain products kaolin, ball clay, and some nonclay ingredients are mixed with fire clay. The known domestic materials are suitable for high-heat-duty refractory products or lower-quality products if they are used as the principal part of a refractory body. Because of the higher temperatures developed in many processes, the requirements for most refractory products are becoming more stringent. Consequently, Canada imports highly refractory clay products and very high grade fire clay.

Three sanitary-ware plants, seven electrical-porcelain plants, three wall-tile plants, two dinnerware plants, and numerous souvenir and art potteries were the principal users of ceramic-grade kaolin and ball clay. Raw kaolin was used mainly by the paper industries. All the kaolin required by Canadian industry was imported. Although ball clay occurs in Saskatchewan, the bulk of the ball clay used in Canada was imported.

The value of imported clay products was $42.4 million, or $1.2 million less than in 1959. Clay imports declined from $4.5 million in 1959 to $4.3 million.

The exports of clay products were valued at $5.0 million, or about the same as in 1959.

The clay products consumed in Canada were worth $97.6 million, or $6.8 million less than in 1959. Imported goods, and goods manufactured from imported clays accounted for about 66 per cent of this total.

Consumption statistics for the various types of clays, except those for kaolin, are not available.

Consumption of China Clay, by Industries, 1959
(short tons)

Paper	87,435
Ceramics(1)	8,058
Rubber and linoleum	5,110
Other products(2)	7,061
Total	107,664

Source: Dominion Bureau of Statistics.

(1) The quantity of china clay consumed by a few important users in the ceramic industry was not available for this table. A more accurate estimate would place the quantity of ceramic-grade china clay consumed in Canada in 1959 at 10,000 to 12,000 tons.

(2) These include paints, chemicals, cosmetics, 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. 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 color.

China clay usually occurs in a crude form, which is beneficiated to separate the clay from undesirable impurities. Purified china clay consists almost entirely of the clay mineral kaolinite. The theoretical composition of pure kaolinite - silica 46.54 per cent, alumina 39.5 per cent,and combined water 13.96 per cent - gives a very refractory mixture that is nearly white in both the unfired and the fired condition. Good-quality commercial kaolins have minor amounts of alkalis, alkaline material, and iron and titanium compounds and usually approach closely the theoretical composition of kaolinite.

Because of problems associated with beneficiation and the limited extent 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 small, 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 at removing impurities from Canadian kaolins have so far not met with success.

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

A deposit of china clay occurs along the Fraser River near Prince George, British Columbia. The extent of the deposit is not definitely known and no proper development has been undertaken, possibly because of its remoteness. Preliminary drilling indicates that the material varies from very plastic to very sandy. The upper beds are considerably iron-stained.

A china-clay deposit at Arborg, Manitoba, contains colloidal iron, considerable quartz, and some other impurities. Kaolinized material occurs in Quebec at St. Remi d'Amherst, Papineau county; Brebeuf, Terrebonne county; Lac Labelle, Labelle 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 anorthite with about 25 per cent kaolinite. In the past two or three years, various companies have shown considerable interest in Quebec's kaolinized deposits.

Some of the china clay in the kaolin deposit at St. Remi d'Amherst is white, but exploration has revealed a considerable tonnage of a light-brown iron-stained type containing excessive quartz. Kaolinite also occurs in the quartzite of this area. At St. Remi d'Amherst, limited development by open-pit, underground mining and beneficiation by the removal of china clay from quartzite were discontinued in 1948 because of operational difficulties.

Laurentian Art Pottery Inc., St. Jerome, Quebec, used clay from the Brebeuf deposit for several years but stopped doing so some 15 years ago, mainly because of beneficiation difficulties and the cost of hauling the crude clay to St. Jerome. When washed, this clay fires to a light buff.

In 1960, Quebec Clay Mining Ltd. was developing the Chateau Richer deposit. Work at the Mines Branch, of the Department of Mines and Technical Surveys, and elsewhere shows that the crude clay, if ground to pass 200-mesh and separated from its magnetic impurities, is suitable whiteware raw material. It is also suitable for mixing with a plastic stoneware-type clay for the production of buff face brick.

Ball Clay

Ball clays are used in the whiteware industry to impart plasticity and a high green strength. They fire to a white or light cream color and so do not interfere with the fired color of the whiteware products. Being extremely refractory, they are used as a plastic bond clay in various types of refractory products.

As sedimentary materials with a high proportion of very fine particles, ball clays have an extremely high dry strength. Mineralogically, those obtained in Canada are similar to high-grade, plastic fire clays. They are made up principally of a kaolinite-group clay mineral and some quartz.

Ball clays are known to occur in Canada 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, and Flintoft and in other areas. Clay from the Willows area has been used for many years in the potteries at Medicine Hat, Alberta, and in Vancouver and has been tested in the United States. Lack of proper quality control and distance from large markets have been the principal disadvantages affecting the use of this material. A plant established near the Willows deposits at Assiniboia, Saskatchewan, for processing the ball clay and sandy kaolin of that province, chiefly for use as fillers, suspended operations during the year because of operational difficulties.

Fire Clay

Canadian fire clays are used principally for the manufacture of medium-heat and high-heat firebrick and refractory specialties. High-heat refractories require raw materials having a PCE (pyrometric cone equivalent) of about 31 1/2 (approximately 3,090°F) to 32 1/2 (approximately 3,135°F). Intermediate-duty refractories require raw materials having a PCE of about 29 (approximately 3,018°F) or higher. Clays having a PCE of less than 29 but greater than 15 (approximately 2,606°F) may be suitable for low-heat refractories or ladle brick, as well as for other clay products. No known Canadian fire clays are sufficiently refractory for the manufacture of superduty refractories without the addition of some very refractory material such as alumina.

Good-quality fire clays are low in alkali, alkaline-bearing materials, and iron-bearing minerals. The Canadian deposits are made up of a kaolinite-group mineral and quartz. The clays usually fire to a cream or buff color, and the products generally have dark specks owing to the presence of iron-bearing minerals. Ordinarily, fire clay is not beneficiated.

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

Fire clay and kaolin occur in the James Bay watershed of northern Ontario, along the Missinaibi, Abitibi, Moose, and Mattagami rivers. In the past,exploration work has been done in this area, but adverse terrain and climate have made it difficult. Recent work carried out by Ventures Limited has been discontinued.

Some seams of clay in the deposit at Shubenacadie, Nova Scotia, are sufficiently refractory for medium-duty refractories, and preliminary work has been carried out on the production of ladle brick from them. Clay from Musquodoboit, Nova Scotia, is being used by a few foundries in the Atlantic Provinces.

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

Stoneware Clays

Stoneware clays are similar to low-grade plastic fire clays. They are used extensively in sewer pipe, flue liners, face brick, pottery, stoneware crocks and jugs, chemical stoneware, and other clay products.

Stoneware clays are plastic buff-firing materials that fire to a dense condition over a long temperature range. In general, they are of intermediate composition, being between common noncalcareous clays and good-quality fire clays. They usually contain more alkalis, alkaline-bearing materials, and other low-melting substances than fire clays. The main clay mineral found in Canadian stonewares is of the kaolinite group. The principal impurities are quartz and small quantities of such nonplastic materials as mica, feldspar, and pyrite.

The principal source of stoneware clay in Canada is the Whitemud formation of southern Saskatchewan and southeastern Alberta. The Eastend, Saskatchewan, area was formerly the source of a large quantity of clay, which was used mainly at Medicine Hat, Alberta. Stoneware-clay pits were recently opened in the Alberta Cypress Hills southeast of Medicine Hat and at Avonlea, Saskatchewan.

Stoneware, or low-grade, fire clays occur on Sumas Mountain, near Abbotsford, British Columbia. They are used in the manufacture of sewer pipe, flue lining, face brick, and tile. Similar types of materials occur at Shubenacadie and Musquodoboit, in Nova Scotia. The Shubenacadie clays, which were developed only recently, are used principally for the manufacture of buff face brick. Musquodoboit clay is used in small quantities by foundries in the Maritimes. Other similar deposits occur at Swan River, Manitoba, where some buff brick has been manufactured, and at Chimney Creek bridge, Williams Lake, and Quesnel, in British Columbia. Quebec and Ontario import their stoneware clay.

Common Clays and Shales

Common clays and shales are the principal type of raw material available in Canada for the manufacture of clay products. They are used mainly for the manufacture of common and face 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 face brick, sewer pipe, and flue lining.

Because of the presence of iron from various sources, common clays and shales usually fire to a salmon color or red. Their fusion points are low - usually well below cone 15 (approximately 2,606°F), 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 occasionally a member of the montmorillonite or kaolinite group is 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 the quality of the ware is lowered. Many clays and shales contain calcite and/or dolomite, which, if present in sufficient quantities, cause the clay to fire to a buff color and make it difficult to fire the product to strength and high density. Common clays and shales are usually higher in alkalis, alkaline materials, and iron-bearing minerals and much lower in alumina than the higher-quality stoneware clays, fire clays, 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 other 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. Good plasticity and suitable drying and firing properties are all essential for such extruded products as stiff-mud brick, building tile, and drain tile. The raw materials for dry-press clay products need not be very plastic, and drying is not a critical problem. In the clays used in soft-mud bricks,which are made in Canada only in negligible quantities, good drying and firing properties are essential.

Bentonite

Bentonite is the subject of Review 33 of 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 commercial use by the various industries. For example, the paper industry's specifications and requirements for china clay are different from those of the ceramic industry. The price of ball clays and high-quality fire clays is about the same as that of most china clays. Low-grade fire clays 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, while low-grade fire clays, stoneware clays, and common clays and shales are usually sold in bulk.

The following, taken from Oil, Paint and Drug Reporter of June 5, 1961, is typical of china- and ball-clay prices.

China clay	Per short ton, U.S. dry-ground, air-floated, 99% 325-mesh, bags, car lots, works, Georgia	\$11.00 to \$17.00
Ball clay	Per short ton, car lots, Tennessee	
	Bags, air-floated	\$17.00 " \$21.50
	Bulk, crushed, containing shed moisture	\$ 8.00 " \$11.25

COAL AND COKE

COAL

T.E. Tibbetts*

Marketing problems resulting from high mining and transportation costs and ever-increasing competition from other sources of energy continued to plague Canada's coal-mining industry in 1960. A gain in exports took up part of the year's small increase in production, and Government assistance made it possible for Canadian coal to compete with other fuels in markets where, without such aid, competition would have been impossible. Nevertheless, consumption was lower than in the previous year.

In 1959, recognizing the importance of the coal industry in the national economy, the federal government appointed a Royal Commission on Coal to investigate the industry's problems and make recommendations for their solution. The Commission's findings were published in September 1960, and it is generally hoped that its recommendations, when carried into effect, will bring an improvement.

Production

A sign of possible recovery was the 3.6-per-cent increase that raised output from the 1959 level of 10.6 million tons to a 1960 total of more than 11 million. This left production still far below the 19.1 million tons obtained in 1950, but it was the first significant gain in 10 years. Furthermore, it occurred despite a general slackening in the expansion of Canada's economy.

The greatest increase in output was the 11.5 per cent gained by lignite, all of which was mined in Saskatchewan. The production of bituminous coal rose by 5.1 per cent. Subbituminous coal, mined solely in Alberta, decreased by 11.2 per cent.

Nova Scotia was the leading producer, 41.5 per cent of Canada's output coming from that province. Alberta produced 21.7 per cent, Saskatchewan 19.7 per cent, New Brunswick 9.3 per cent, and British Columbia and the Yukon Territory the remaining 7.8 per cent.

At 4.6 million tons, Nova Scotia's output was 4.1 per cent higher than in the previous year, and New Brunswick's production increased by 2.4 per cent to a record high of 1,028,064 tons. In Alberta, although the production of

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* Fuels and Mining Practice Division, Mines Branch.

Production of Coal, by Provinces and Territories
(short tons)

		Bituminous(1)	Subbituminous(1)	Lignite(1)	Total
Nova Scotia	1960	4,570,240	-	-	4,570,240
	1959	4,391,829	-	-	4,391,829
New Brunswick	1960	1,028,064	-	-	1,028,064
	1959	1,003,387	-	-	1,003,387
Saskatchewan	1960	-	-	2,170,797	2,170,797
	1959	-	-	1,947,380	1,947,380
Alberta	1960	851,122	1,540,577	-	2,391,699
	1959	816,275	1,733,883	-	2,550,158
British Columbia and Yukon Territory	1960	850,338	-	-	850,338
	1959	733,968(2)	-	-	733,968
Total	1960	7,299,764	1,540,577	2,170,797	11,011,138
	1959	6,945,459	1,733,883	1,947,380	10,626,722
Value	1960	$64,088,851	$6,753,760	$3,833,629	$74,676,240
	1959	$62,448,411	$7,681,440	$3,746,044	$73,875,895

Source: Dominion Bureau of Statistics.

(1) Coals classed according to "A.S.T.M. Classification of Coal by Rank - A.S.T.M. Designation D388-38," A.S.T.M. Standards on Coal and Coke.

(2) Includes 3,879 tons from Yukon Territory.

bituminous coal increased 4.3 per cent, the 11.2-per-cent decrease in subbituminous coal output, already referred to, resulted in a general decrease of 6.2 per cent.

The substantial increase that occurred in Saskatchewan's lignite production resulted from the use of coal in that province's new thermoelectric generating station. At 2.2 million tons, the output was 11.5 per cent higher than in 1959. Production in British Columbia increased 15.8 per cent.

Strip mining accounted for about 39 per cent of Canada's 1960 coal output, and the average output per man-day for all strip mines increased from 13.2 to 15.1 tons. Saskatchewan's whole output was from strip mines, the average per man-day being 33.9 tons, substantially more than the 25.3 tons

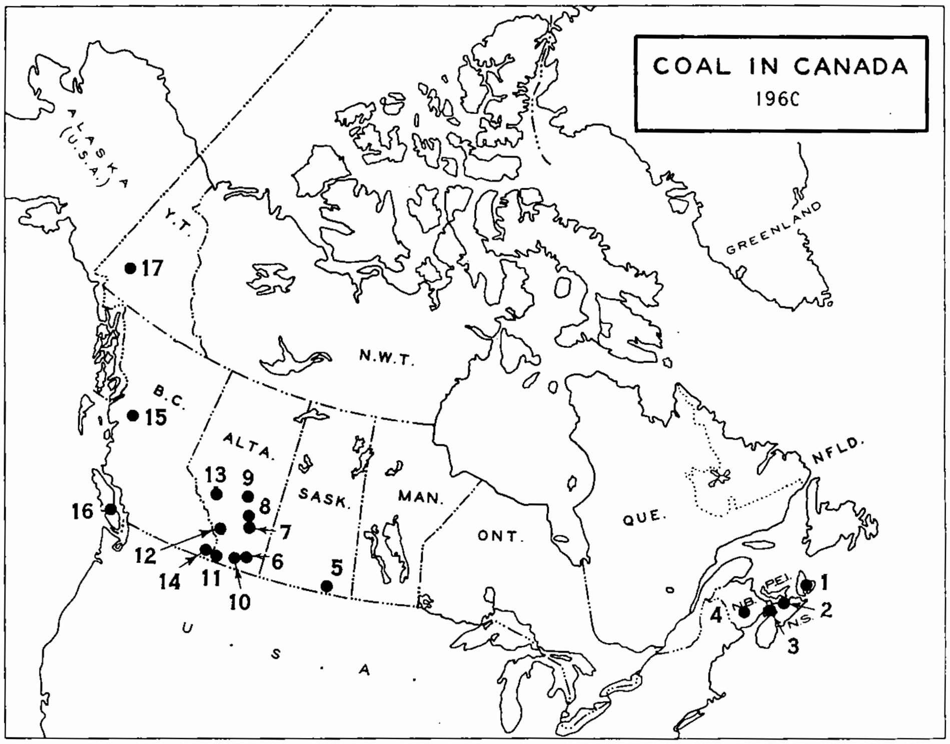
Production of Coal, by Type of Mining,
and Average Output per Man-day, 1960*

	Production		Average Output per Man-day
	Short Tons	%	Short Tons
Nova Scotia			
Strip mines	-	-	-
Underground	4,570,240	100.0	2.671
New Brunswick			
Strip mines	870,637	84.7	6.190
Underground	157,427	15.3	1.768
Saskatchewan			
Strip mines	2,170,797	100.0	33.864
Underground	-	-	-
Alberta			
Strip mines	1,156,265	48.3	15.128
Underground	1,235,434	51.7	4.326
British Columbia			
Strip mines	83,030	9.8	29.195
Underground	760,838	90.2	4.218
Yukon			
Underground	6,470	100.0	3.306
Canada			
Strip mines	4,280,729	38.9	15.071
Underground	6,730,409	61.1	2.967
All mines	11,011,138	100.0	4.326

Source: Dominion Bureau of Statistics.
*Subject to revision.

produced in 1959. Because of heavier overburden and related mining problems, the average output per man-day in Alberta's strip mines, whence 48 per cent of this province's coal is derived, decreased from the 1959 level of 17.4 tons to 15.1 tons; and in British Columbia, where 9.8 per cent of production is strip-mined, the same problems lowered the output per man-day from 31.7 to 29.2 tons. New Brunswick, which strip-mines 85 per cent of its coal, increased its average output per man-day from 5.61 to 6.19 tons.

(text continued on page 202)



MINERAL RESOURCES DIVISION, DEPT. M.T.S.

Coal Areas and Principal Producers
(approximate production in thousands of short tons)

Nova Scotia

1. Sydney and Inverness areas (high-volatile bituminous)

Dominion Coal Co. Ltd.	3,362
Beaver Coal Co. Ltd.	28
Bras d'Or Coal Co. Ltd. (Four Star mine)	85
Indian Cove Coal Co. Ltd.	30
Old Sydney Collieries Ltd.	642
Doucet and Sons Ltd.,S.J.	11
Evans' Coal Mines Ltd.	30
Chestico Mining Corp. Ltd.	11
Crystal Coal Co., Ltd.	2

2. Pictou area (medium- and high-volatile bituminous)

Acadia Coal Co. Ltd.	198
Drummond Coal Ltd.	47
Greenwood Coal Co. Ltd.	20

3. Springhill and Joggins areas (high-volatile bituminous)

Cumberland Fuel and Trading Ltd.	12
Joggins Coal Co. Ltd.	66
River Hebert Coal Co. Ltd.	17
Springhill Coal Mines Ltd.	6

New Brunswick

4. Minto area (high-volatile bituminous)

Avon Coal Co. Ltd.	261
King Mining Co. Ltd.	5
Miramichi Lumber Co. Ltd.	261
Lafferty Bros.	25
Newcastle Coal Co. Ltd.	33
Wasson Ltd.,A.W.	15

New Brunswick (cont'd)

McMann Ltd.,V.C.	55
McEwan Mining Co. Ltd.	11
Dufferin Mining Ltd.	91
Mills Ltd., D.W. and R.A.	267
Michiels Ltd.	21
Wasson, Mrs. Gretta P.	5

Saskatchewan

5. Souris Valley area (lignite)

Manitoba and Saskatchewan Coal Co. Ltd.	535
Western Dominion Coal Mines Ltd.	576
Old Mac Coal Ltd.	62
North West Coal Co. Ltd.	86
Utility Coals Ltd.	726
Great West Coal Co., Ltd.	185

Alberta

6. Brooks and Taber areas (subbituminous)

Kleenbirn Collieries Ltd.	9
Alberta Coal Sales Ltd.	55

7. Drumheller, Sheerness, and Carbon areas (subbituminous)

Amalgamated Coals Ltd.	151
Red Deer Valley Coal Co. Ltd.	101
Federated Co-ops Ltd.	37
Subway Coal Co.	14
Century Coals Ltd.	161
Western Dominion Coal Mines Ltd.	179
Nottal Bros.	13
Halbert, H.J.	5
East Trochu Coal Co.	2
Fox, Alfred	3
Utility Coals Ltd.	3

8. Castor, Ardley, and Camrose areas (subbituminous)

Straub, Robert R.	14
Forrestburg Collieries Ltd.	291
Battle River Coal Co. Ltd.	197
Allyn Mann Construction	18
Lynass, John	13
Camrose Collieries Ltd.	25
Stettler Coal Co. Ltd.	8
Remillard, O.V.	1

9. Edmonton, Tofield, and Pembina areas(subbituminous)

Star-Key Mines Ltd.	49
Egg Lake Coal Co. Ltd.	18
Black Gem Coal Co. Ltd.	13
Whitemud Creek Coal Co. Ltd.	21
Black Nugget Coal Co. Ltd., The	15
Alberta Coal Ltd.	62
Warburg Coal Co. Ltd.	11
Jet Construction Ltd.	3

10. Lethbridge area (high-volatile bituminous)

Lethbridge Collieries Ltd.	118

11. Crowsnest area (medium-volatile bituminous)

Coleman Collieries Ltd.	211
West Canadian Collieries Ltd.	317

12. Cascade area (low-volatile bituminous and semianthracite)

Canmore Mines Ltd., The	210

13. Coalspur area (high-volatile bituminous)

Canadian Collieries Resources Ltd.	1

British Columbia

14. East Kootenay (Crowsnest) area (medium-volatile bituminous)

Crow's Nest Pass Coal Co., Ltd., The	743

British Columbia (cont'd)

15. Northern area (medium- and high-volatile bituminous)

Bulkley Valley Collieries Ltd.	5

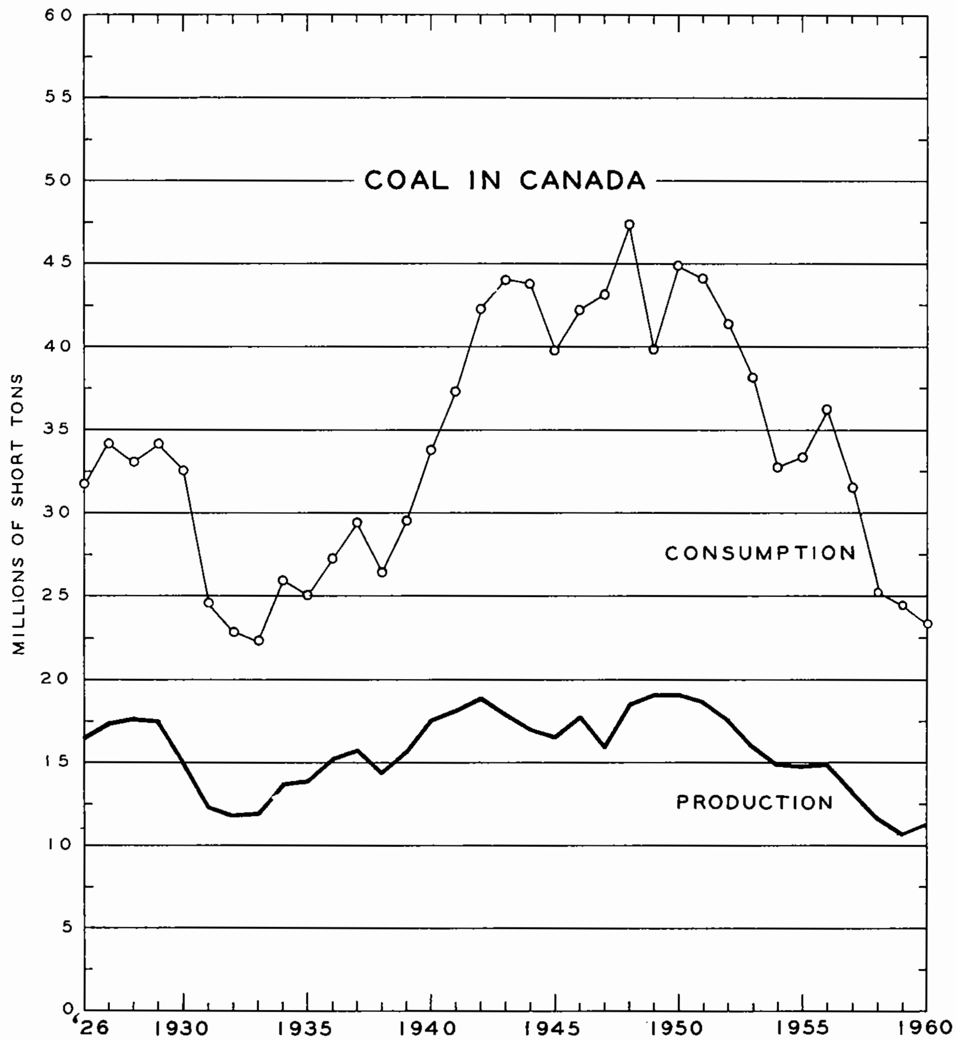
16. Vancouver Island (Comox) area (high-volatile bituminous)

Canadian Collieries Resources Ltd.	39
Comox Mining Co. Ltd.	49

Yukon Territory

17. Carmacks area (high-volatile bituminous)

Yukon Coal Co. Ltd.	6



SOURCE: D.B.S.

MINERAL RESOURCES DIVISION, DEPT. M.T.S.

Across Canada, the trend to mechanization in underground mines continued. In Nova Scotia's Sydney area, both longwall and room-and-pillar operations are mechanized. In the Minto area of New Brunswick, trials were conducted during the year with a mechanized longwall operation. Although conditions in Alberta and British Columbia are not highly favorable, mechanized mining is being tried in those provinces wherever possible.

In spite of increased mechanization in underground mines, the output per man-day decreased in 1960 by 0.036 tons to 2.967 tons. Only British Columbia and Yukon mines increased their average output.

Comparison of Average Values of Canadian Coals

		1960		1959	
	Average Btu lb(1)	Average Value per Short Ton(2) ($)	Average Value per Million Btu(1) (¢)	Average Value per Short Ton(2) ($)	Average Value per Million Btu(1) (¢)
Nova Scotia					
Bituminous	13,180	9.842	37.34	9.957	37.77
New Brunswick					
Bituminous	11,990	8.426	35.14	8.319	34.69
Saskatchewan					
Lignite	7,730	1.766	11.42	1.924	12.44
Alberta					
Bituminous	12,360	5.596	22.64	6.383	25.77
Subbituminous	9,350	4.383	23.43	4.430	23.69
British Columbia					
Bituminous	13,820	6.617	23.94	6.989	25.29
Yukon Territory					
Bituminous	11,450	15.016	65.57	15.003	65.50
Canada					
Bituminous	13,040	8.779	33.66	8.990	34.47
Subbituminous	9,350	4.383	23.44	4.430	23.69
Lignite	7,730	1.766	11.42	1.924	12.44
Average	11,460	6.781	29.59	6.951	30.33

(1) Fuels and Mining Practice Division, Mines Branch.

(2) Dominion Bureau of Statistics.

The value of Canada's 1960 coal output was $74,676,240 f.o.b. the mines. Coals of all types were lower in value than in the previous year, bituminous coal having dropped in value per ton to $8.779 from $8.990, lignite to $1.766 from $1.924, and subbituminous to $4.383 from $4.430. Only bituminous coal from New Brunswick increased in value, by 1.3 per cent.

At 11.42 cents per million Btu, lignite maintained its position as by far the cheapest source of coal-derived energy. If the small output of Yukon Territory is excluded, Nova Scotia coal, at 37.34 cents per million Btu, is the most expensive.

More stringent market requirements arising from the consumer's effort to get as much heat as possible from his fuel purchases is one of the main reasons for the increase in emphasis on coal preparation. Another factor behind the movement toward coal-cleaning is the deterioration that mechanization has caused in the run of mine coal. Still another is that the exhaustion of the best reserves and the consequent necessity of mining inferior coal are forcing the industry to adopt coal-preparation techniques to meet the competition of other fossil fuels.

Mine mechanization and the greater friability of the seams worked are causing fine coal, widely recognized as the least amenable to present coal-cleaning methods, to appear in the mine run in increasing quantities. Because of this, the Mines Branch is directing much of its coal-preparation research toward the upgrading of fine coal. During 1960, the Branch and the industry also studied methods of briquetting and waterproofing.

A 1960 highlight of the industry's attempt to maintain or improve its competitive position was the installation of fine-coal cleaners and thermal dryers.

Disposition of Coal

Nova Scotia and New Brunswick

High-volatile bituminous coking coal is produced in the Sydney, Cumberland, and Pictou areas of Nova Scotia, and noncoking high-volatile bituminous coal in the Inverness area of the same province. New Brunswick produces only high-volatile bituminous coking coal, mainly in the Minto area but also from strip mines in the Chipman and Coal Creek areas.

A large part of the output of the two provinces is used locally for industrial steam-raising (including that in thermoelectric plants) and household and commercial heating. Nova Scotia coal finds its greatest single use in the manufacture of metallurgical coke for the steel industry of the province. The railways are no longer important consumers of eastern Canadian coal.

Much of the coal produced in these two provinces is shipped to Quebec and Ontario. Nova Scotia shipped more than 52 per cent of its output to other provinces, 83.3 per cent of this to central Canada. Some Nova Scotia coal went

Interprovincial Shipments of Coal, 1960

(short tons)

Destination	Originating Province				
	Nova Scotia	New Brunswick	Saskat-chewan	Alberta	British Columbia
Newfoundland	130,702	-	-	-	-
Prince Edward Island	36,521	648	-	-	-
New Brunswick	230,197	-	-	-	-
Quebec	1,763,219	140,987	-	157	-
Ontario	219,172	18,781	83,666	40,305	525
Manitoba	-	-	1,013,181	201,372	141,551
Saskatchewan	-	-	-	362,383	1,983
Alberta	-	-	-	-	12,434
British Columbia	-	-	-	367,623	-
Total	2,379,811	160,416	1,096,847	971,840	156,493

Source: Dominion Bureau of Statistics, The Coal Mining Industry, 1960.

Exports of Coal, 1960

(short tons)

Destination	Shipments from Mines(1)						
	From Nova Scotia Mines	From New Brunswick Mines	From Saskat-chewan Mines	From Alberta Mines	From British Columbia Mines	From All Mines	Total Exports(2)
St. Pierre	6,489	-	-	-	-	6,489	6,632
United States	-	70,663	2,074	30,283	20,128	123,148	241,892
Japan	-	-	-	361,336	272,729	634,065	604,397
Total	6,489	70,663	2,074	391,619	292,857	763,702	852,921
Value							$6,789,163

Source: Dominion Bureau of Statistics.

(1) Direct to destination.

(2) Cleared through Customs. Differences from the amounts reported as shipped from mines are made up from coal shipped from stock and coal shipped to industrial dealers but ultimately consigned to the export market. The latter circumstances apply to New Brunswick, Alberta, and British Columbia coals going to the United States. The statistics shown in Trade of Canada on shipments to Japan are incomplete.

to the island of St. Pierre. New Brunswick shipped 15 per cent of its output to central Canada and 7 per cent to the United States.

Saskatchewan

Saskatchewan produces only lignite, mainly in the Bienfait and Roche Percee areas of the Souris Valley. Output from the Estevan area serves the provincially owned thermoelectric generating station.

About 51 per cent of the output for 1960 went to Manitoba and Ontario for industrial, commercial, and household use. Almost all of the remainder was used within the province for similar purposes.

Alberta

Alberta produces coals ranging from low-volatile bituminous (almost anthracite) to subbituminous (almost lignite).

The greatest output is from the subbituminous mines, 54 such mines operating in 1960 producing 64 per cent of Alberta's total. These mines are in the following areas: Drumheller, Edmonton, Brooks, Camrose, Castor, Carbon, Sheerness, Taber, Pembina, Ardley, Tofield, Redcliff, Champion, Gleichen, Westlock, Wetaskiwin and Whitecourt. Their production is used mainly for commercial and household heating, increasing quantities being employed industrially, particularly for thermoelectric power generation.

Bituminous coking coals are produced in the Crowsnest area. A large part of this production was exported in 1960 to Japan, where it is used to upgrade the Japanese coal blends for metallurgical use. A total of 361,336 tons of Alberta coal went to Japan and more than 30,000 tons to the United States. The export of coal from western Canada is now facilitated by a new bulk-loading dock at Port Moody, British Columbia.

In the Lethbridge, Coalspur, and Halcourt areas lower-quality bituminous noncoking coals were produced, mainly for household and commercial heating but also for the production of industrial steam.

The Cascade area produced semianthracite, some of which was shipped as far east as Quebec, where it competes with imported anthracites.

More than 40 per cent of Alberta's coal production was shipped to other provinces, Saskatchewan and British Columbia each taking 15 per cent. More than 8 per cent went to Manitoba and 1.7 per cent to central Canada.

British Columbia

Bituminous coking coal was mined on Vancouver Island (Comox area only) and in the Crowsnest (East Kootenay) district. Very small tonnages were produced in the Northern and Nicola-Princeton districts. About 78 per cent of the coal production was from the Crowsnest area and 272,729 tons were exported to Japan for metallurgical use. About 17 per cent of the output was shipped to Manitoba and 1.5 per cent to Alberta. Small quantities went to Saskatchewan and Ontario.

Subvention Assistance

In 1960, mainly because of a rise in subvention-covered exports of British Columbia and Alberta coal to Japan, there was an increase in the coal tonnage to which the federal government applied subvention payments through the Dominion Coal Board. The value of this assistance, which in 1959 amounted to $13,420,799, rose in 1960 to $16,344,196. One of the recommendations made by the Royal Commission on Coal was that subsidies be paid, with certain stipulations, directly to coal-mine operators instead of to the carrier in the form of freight subventions, as at present.

The federal government also made payments through the Atlantic Provinces Power Development Act, which indirectly aids the marketing of coal. These payments totalled about $1.75 million in 1959 and the same amount in 1960.

Coal Moved under Subvention

(short tons)

Origin of Coal	1960	1959
Nova Scotia	2,048,073	2,154,034
New Brunswick	173,063	137,613
Saskatchewan	79,377	111,006
Alberta and British Columbia	685,797	323,813
Total	2,986,310	2,726,466

Source: Dominion Coal Board.

Imports

The quantity of coal imported decreased in 1960 by 5 per cent. Imports of anthracite coal declined 19.1 per cent while bituminous coal from the United States, which makes up the bulk of coal imports, decreased 3.2 per cent.

Imports of Coal for Consumption (1)
(short tons)

Country of Origin		Anthracite	Bituminous	Total
United States	1960	1,232,601	11,994,420(2)	13,227,021
	1959	1,507,095	12,389,882(3)	13,896,977
United Kingdom	1960	64,866	509	65,375
	1959	96,814	-	96,814
Total	1960	1,297,467	11,994,929	13,292,396
	1959	1,603,909	12,389,882	13,993,791
$ Value	1960	13,577,411	61,990,786	75,568,197
	1959	17,934,649	65,524,942	83,459,591

Source: Dominion Bureau of Statistics, Trade of Canada.
(1) Includes briquettes but not coal imported and subsequently sold for use on board ship.
(2) Includes lignite (quantities not separately reported) and 15,528 tons of briquettes.
(3) Includes lignite (quantities not separately reported) and 24,521 tons of briquettes.
* Subject to revision.

Consumption

The slow-up in the expansion of the Canadian economy continued in 1960 and, combined with increasing competition from oil and gas in most of the markets formerly dominated by coal, resulted in a further decrease of 5.3 per cent in coal consumption. Some 23.2 million tons of coal, of which less than 10 million tons was Canadian-produced, were consumed in 1960.

The railways, which 10 years ago provided an annual market for 10.5 million tons of coal, in 1960 used only 77,000 tons.

In 1960, the consumption of coal for household and commercial-building heating was more than a million tons below the consumption of the previous year, mainly owing to competition from oil and gas.

The 9.9 million tons of coal used in 1960 by industrial consumers, including thermoelectric power plants, represented a decrease of 1 per cent in this market. About 50 per cent of this coal was Canadian.

The consumption of coal in the production of coke decreased by more than 6 per cent to 5.3 million tons. In 1960, the consumption of Canadian coal in coke-making was 60,000 tons higher than in 1959, but only 16 per cent of total coal used was Canadian.

(text continued on page 211)

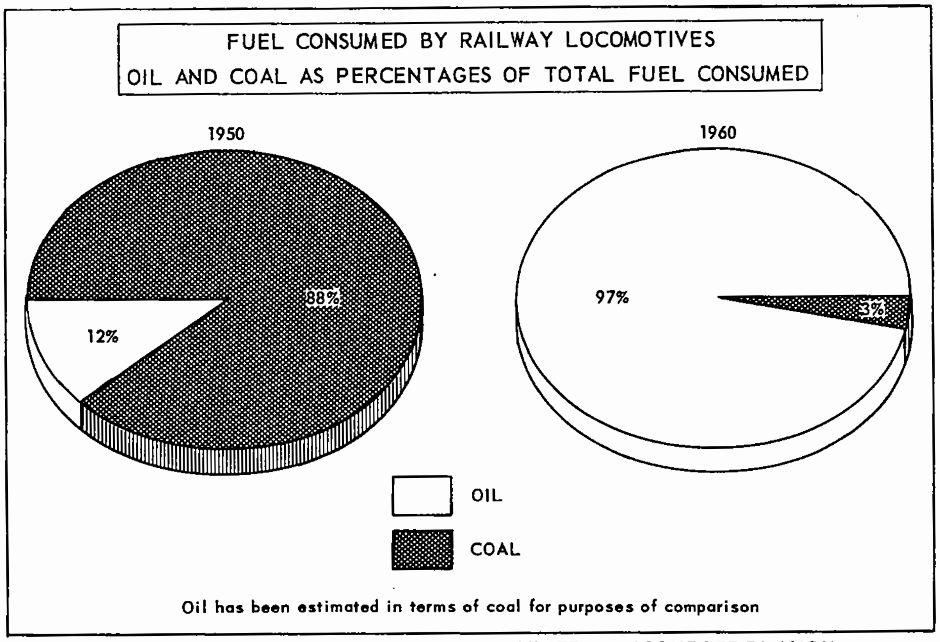
Consumption of Canadian and Imported Coal, 1952-60

	Canadian		Imported		Total
	Short Tons(1)	% of Consumption	Short Tons(2)	% of Consumption	Short Tons
1952	16,749,316	40.5	24,603,789	59.5	41,353,105
1953	15,240,105	40.0	22,900,392	60.0	38,140,497
1954	14,466,212	44.1	18,322,056	55.9	32,788,268
1955	14,060,039	42.1	19,322,134	57.9	33,382,173
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

Source: Dominion Bureau of Statistics.

(1) The sum of Canadian coal-mine sales, colliery consumption, coal supplied to employees, and coal used in making coke and briquettes, less the tonnage of coal exported.

(2) Deductions have been made to take into account foreign coal re-exported from Canada and bituminous coal removed from the warehouse for ships' stores. Imports of briquettes are not included.



MINERAL RESOURCES DIVISION
DEPARTMENT OF MINES AND TECHNICAL SURVEYS

Fuel Consumed by Railway Locomotives and Rail Motor Cars, 1943-60

	Coal(1)	Fuel and Diesel Oil(1)	Estimated Heat Equivalent of Oil in Terms of Coal(2)	Estimated Heat Equivalent of Oil as % of Total of Coal and Oil
	(thousands of tons)	(millions imp. gal)	(thousands of tons)	
1943	11,987	79.0	538.6	4.3
1944	11,993	80.9	551.6	4.4
1945	12,084	78.3	533.8	4.2
1946	11,632	82.2	560.4	4.6
1947	12,331	86.7	591.1	4.6
1948	12,422	96.3	656.6	5.0
1949	11,444	139.3	949.7	7.7
1950	10,452	217.9	1,485.6	12.4
1951	10,505	260.4	1,775.4	14.5
1952	9,798(3)	291.9	1,990.2	16.9
1953	8,323(3)	308.2	2,101.3	20.2
1954	6,502(3)	326.6	2,226.8	25.5
1955	5,587(3)	384.6	2,622.2	31.9
1956	5,587(3)	444.6	3,031.3	35.2
1957	3,322(3)	419.4	2,859.3	46.3
1958	1,394(3)	390.6	2,662.8	65.6
1959	554(3)	400.2	2,728.6	83.1
1960	77(3)	352.9	2,406.1	96.9

(1) Dominion Bureau of Statistics, Railway Transport.
(2) Estimated in terms of coal at 13,000 Btu/lb, oil being taken at 9.33 lb/gal with calorific value of 19,000 Btu/lb.
(3) Inclusive of railway briquettes.

Bituminous Coal Used to Make Coke

(short tons)

	1960	1959
Imported	4,415,680	4,824,928
Canadian	872,537	812,168
Total	5,288,217	5,637,096

Source: Dominion Bureau of Statistics.

Consumption of Fuels for Domestic and Building Heating, 1947-60

	Fuel Oil and Distillate(1) (barrels)	Natural Gas(2) (M cubic feet)	Manufactured Gas(2) (M cubic feet)	Coal and Coke(3) (short tons)
1947	16,273,423	28,198,903	20,525,540	13,117,157
1948	17,036,106	30,824,172	21,570,466	13,429,436
1949	18,733,890	32,164,544	23,864,281	12,473,258
1950	24,669,930	40,004,435	20,363,572	12,653,394
1951	29,787,032	43,048,025	24,072,327	11,436,717
1952	34,863,926	43,328,304	22,527,092	10,515,475
1953	38,585,104	46,390,654	21,418,959	8,941,428
1954	46,808,256	56,864,148	22,090,283	8,599,993
1955	52,861,644	68,591,360	15,742,947	8,283,432
1956	61,276,831	77,937,257	16,392,636	8,048,673
1957	63,170,085	92,217,497	13,478,976	6,952,821
1958	68,108,400	112,939,734	5,232,899	6,061,924
1959	74,003,854	142,682,865	1,318,286	5,751,361
1960	77,375,067	161,298,388	823,734	4,717,156

(1) Dominion Bureau of Statistics, Consumption of Petroleum Fuels.

(2) Dominion Bureau of Statistics, The Crude Petroleum and Natural Gas Industry - manufactured and natural gas for household and commercial purposes.

(3) Dominion Bureau of Statistics, The Coal Mining Industry, "Sales of Coal and Coke by Retail Fuel Dealers." Not available prior to 1947.

Industrial Consumption of Coal

(short tons)

Type of Coal	1960	1959
Canadian		
Bituminous	3,562,038	3,643,336
Subbituminous	274,231	
Lignite	1,121,138	1,025,256
Total	4,957,407	4,668,592
Foreign		
Anthracite	239,473	222,985
Bituminous	4,695,165	5,133,197
Total	4,934,638	5,356,182
All coal	9,892,045	10,024,774

Source: Dominion Bureau of Statistics.

Briquettes

Both the production and the consumption of briquettes decreased greatly in 1960. In Saskatchewan, the output remained virtually the same. The new market opened for this product by the development of a special 'charcoal'-type briquette from lignite has been an important factor in the maintenance of production. In Alberta and British Columbia, the output of briquettes(exclusive of 1,216 short tons of char produced in Alberta) fell respectively 55.5 and 95.5 per cent below the 1959 level.

Consumption of briquettes by the railways in 1960 was reduced by 89.1 per cent of the 1959 total.

Briquettes - Production and Consumption

(short tons)

	1960	1959
Production		
Saskatchewan	34,885	34,789
Alberta	45,453(1)	99,499
British Columbia	844	18,846
Total (Canada)	81,182	153,134
Consumption		
Briquettes available for consumption	95,968(2)	178,405
Consumption of briquettes by railways	7,723	70,609
Railway consumption as a percentage of the total available	8.0	39.6
Railway consumption as a percentage of all Canadian production	9.5	46.1

Source: Dominion Bureau of Statistics.
(1) Includes 1,216 short tons of char.
(2) Production (including char) plus 'landed' imports less exports.

COKE

E.J. Burrough*

In Canada, coal finds its greatest nonfuel use in the production of coke. The coke is used mainly in the making of pig iron and, to a lesser extent, in foundry practice, base-metal recovery, and chemical processes.

Canadian-produced by-product coke is usually manufactured in Canada in batteries of slot-type ovens of some 50 units to a battery. The coal capacity of the ovens is about 18 tons, and the mean width is 17 inches. The plants at present in operation vary in annual coal capacity from 500,000 to 2 million tons.

In Canada, petroleum coke is used mainly in the production of electrodes for the aluminum industry; and 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.

Although the plants that produce manufactured gas and domestic coke have reached the point of near extinction, the capacity for the production of metallurgical coke for the steel and base-metal industries has been sustained.

The gas industry, which has continued to expand its facilities for the distribution of natural gas, is contending for space-heating and other domestic and commercial outlets. The gas-retort plants, which for many years were the main producers of manufactured gas and also a source of domestic coke, have now been superseded. In areas where natural gas is not available, propane or other liquid petroleum gases are distributed. Liquid petroleum gases are also used as source materials for stand-by plants and the peak-load requirements of several natural-gas distribution systems.

The standard by-product-coke-oven plants, with the exception of a few custom plants built primarily for the production of domestic coke, are owned and operated by the steel plants.

In recent years the uses of metallurgical coke have changed owing to alterations in the methods of producing pig iron and steel. An increase in the use of sintered ores in the iron blast furnace and a corresponding increase in the fuel requirements for sintering, which is done mainly with coke breeze, have resulted in an increase in the demand for small sizes of coke or coke breeze. This has made possible, to a greater extent than was previously considered practical, the preparation of sized coke for iron blast furnaces.

Developments in the use of liquid and gaseous fuels in iron blast furnaces have led to an increase in the throughput of standard furnaces and a reduction in the quantity of by-product coke used per ton of pig iron produced.

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* Fuels and Mining Practice Division, Mines Branch.

Coke - Production and Trade

	1960**		1959	
	Short Tons	$	Short Tons	$
Production				
From bituminous coal				
Ontario	2,931,929	45,444,900	3,178,068	49,269,505
Newfoundland, Nova Scotia, New Brunswick, and Quebec	940,873	16,440,080	777,631	14,089,144
Manitoba, Alberta and British Columbia			134,134	1,789,906
Total	3,872,802	61,884,980	4,089,833	65,148,555
Of pitch coke	3,414	84,481	3,463	67,097
Of petroleum coke	534,979	4,891,502	529,580	5,011,026
Total	4,411,195	66,860,963	4,622,876	70,226,678
Bituminous coal used to make coke*				
Imported	4,415,680	46,762,051	4,824,928	51,105,124
Canadian	872,537	9,528,104	812,168	8,860,954
Total	5,288,217	56,290,155	5,637,096	59,966,078
Imports (all types)				
United States	700,979	11,230,457	697,220	10,940,563
United Kingdom	119	3,534	195	4,521
Total	701,098	11,233,991	697,415	10,945,084
Exports (all types)				
United States	151,508	2,167,214	138,858	1,935,040
United Kingdom	8,918	393,465	27,175	1,207,990
Other countries	764	22,758	9,987	200,529
Total	161,190	2,583,437	176,020	3,343,559

Source: Dominion Bureau of Statistics.
*Includes additional quantities of coke (used as catalytic carbon) not reported prior to 1958. Production value for 1960 is estimated on basis of 1959 costs.
**Selling value for 1960 is estimated on basis of 1959 prices.

An increase in the use of electrical reduction for the production of pig iron has also increased the demand for low-volatile fuels, such as coke breeze, for the carbon required in the process. The changes have contributed materially to a more efficient use of coke in the production of pig iron as well as to a considerable increase in the capacity or throughput of standard blast furnaces. In essence, more 'work' is being done outside the blast furnace than was done under former methods of operation.

The Canadian steel industry's expansion of recent years, together with a corresponding increase in coke-oven capacity, is expected to continue. Dominion Foundries and Steel, Limited, The Steel Company of Canada, Limited, and The Algoma Steel Corporation, Limited, which have reported coke-oven-capacity increases, are considering further expansion.

Apart from the standard by-product-coke ovens, Canada has a Curran Knowles carbonization plant at the Crowsnest Pass collieries in Michel, British Columbia, and a distinctive coking stoker-type plant designed and operated by Shawinigan Chemicals Limited, Shawinigan, Quebec.

The Hamilton by-product-coke plant, originally built to supply the city of Hamilton, Ontario, with manufactured gas and market domestic coke, has been purchased by The Steel Company of Canada, Limited, whose property it adjoins, and its operations have been discontinued.

About 80 per cent of the coal used in the production of coke is processed at five plants in eastern Canada, namely: Dominion Steel and Coal Corporation, Limited, at Sydney, Nova Scotia, with a rated annual capacity of 1,001,900 tons of coal; Quebec Natural Gas Corporation, at Ville La Salle, Quebec, with a rated annual capacity of 656,000 tons; The Algoma Steel Corporation, Limited, with a metallurgical-coke plant at Sault Ste. Marie, Ontario, which has a rated annual capacity of 2 million tons; Dominion Foundries and Steel, Limited, at Hamilton, Ontario, with an annual capacity of 930,000 tons; and The Steel Company of Canada, Limited, also at Hamilton, with a rated capacity of 1,470,000 tons of coal a year.

COBALT

V.B. Schneider*

In 1960 cobalt production amounted to 3,568,811 pounds valued at $6,763,016; in 1959 it totalled 3,150,027 pounds valued at $5,954,916.

No cobalt ores have been produced in Canada since 1957, but cobalt has been obtained as a by-product from the silver ores of the Cobalt and Gowganda areas of Ontario and from the smelting and refining of nickel-copper ores from the vicinity of Sudbury, Ontario, and Lynn Lake, Manitoba.

Deloro Smelting & Refining Company, Limited, announced that it would close its smelter at Deloro, Ontario, after a final clean-up run, to be completed early in 1961. Silver ores have filled only from 10 to 15 per cent of the company's smelter capacity, and the decline in the price of cobalt has prevented its paying the mines enough to warrant their mining cobalt ore. Since 1957, when the shortage of ore shipments began, the company has kept the smelter operating by augmenting the silver ores with cobalt ore from a small Canadian Government stockpile and with low-grade residues accumulated over the years.

The Deloro smelter began to operate about 1868, when gold was discovered in Hastings county; and the gold ores, which were arsenical, were milled and refined at Deloro from that year until 1903. The rich silver ores from Cobalt, Ontario, which also contained arsenic and were recognized as suitable raw material, were then used for the continued operation of the refinery. In 1912, through the combined efforts of Professor H.T. Kalmus of Queen's University, the Government of Ontario, and Deloro, cobalt was first produced in Canada. The Deloro smelter was producing it on a commercial scale by 1914 and remained the leading producer until 1925, when Belgian refineries began to produce cobalt from the copper-cobalt deposits of Katanga, Belgian Congo.

(text continued on page 218)

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*Mineral Resources Division.

Cobalt - Production, Trade and Consumption

	1960		1959	
	Pounds	$	Pounds	$
Production(1)				
All forms, cobalt content	3,568,811	6,763,016	3,150,027	5,954,916
Exports				
Cobalt metal				
United States................	459,912	788,807	516,828	921,170
United Kingdom	108,700	163,645	102,095	174,210
Austria....................	99,300	136,476	-	-
United Arab Republic (Egypt)..	88,188	153,254	-	-
Italy	28,700	39,138	-	-
Sweden	27,300	39,517	-	-
West Germany	26,600	38,102	50,900	89,300
Other countries	5,593	8,862	10,500	18,275
Total......................	844,293	1,367,801	680,323	1,202,955
Cobalt alloys(2)				
United States	1,664	5,137	114	568
Colombia	210	1,220	-	-
Hong Kong	64	1,698	152	2,673
France	-	-	2,915	13,134
Brazil	-	-	99	457
Total	1,938	8,055	3,280	16,832
Cobalt oxides and salts(2)				
United Kingdom	1,068,857	1,624,663	893,039	1,315,529
United States	51,715	61,409	127,165	158,824
Brazil.....................	20,834	24,621	19,556	24,893
Netherlands................	17,600	22,159	35,200	46,490
France	12,000	14,534	-	-
Other countries	4,200	5,140	25,774	31,767
Total......................	1,175,206	1,752,526	1,100,734	1,577,503
Imports				
Oxides(2)				
United Kingdom	17,227	19,384	14,716	21,508
United States	3,000	5,245	10,000	18,193
Total......................	20,227	24,629	24,716	39,701
Consumption(3)				
Cobalt metal and cobalt contained in oxides and salts..	252,050		250,046	

Source: Dominion Bureau of Statistics.

(1) Production of cobalt metal from domestic ores and production of cobalt contained in alloys, oxides, salts, and concentrates. Excludes the cobalt content of nickel-oxide sinter shipped to the United Kingdom by International Nickel, but includes the cobalt content of Falconbridge shipments of nickel-copper matte to Norway.

(2) Gross weight.

(3) Consumption as reported by consumers.

Cobalt - Production, Trade and Consumption 1950-60
(pounds)

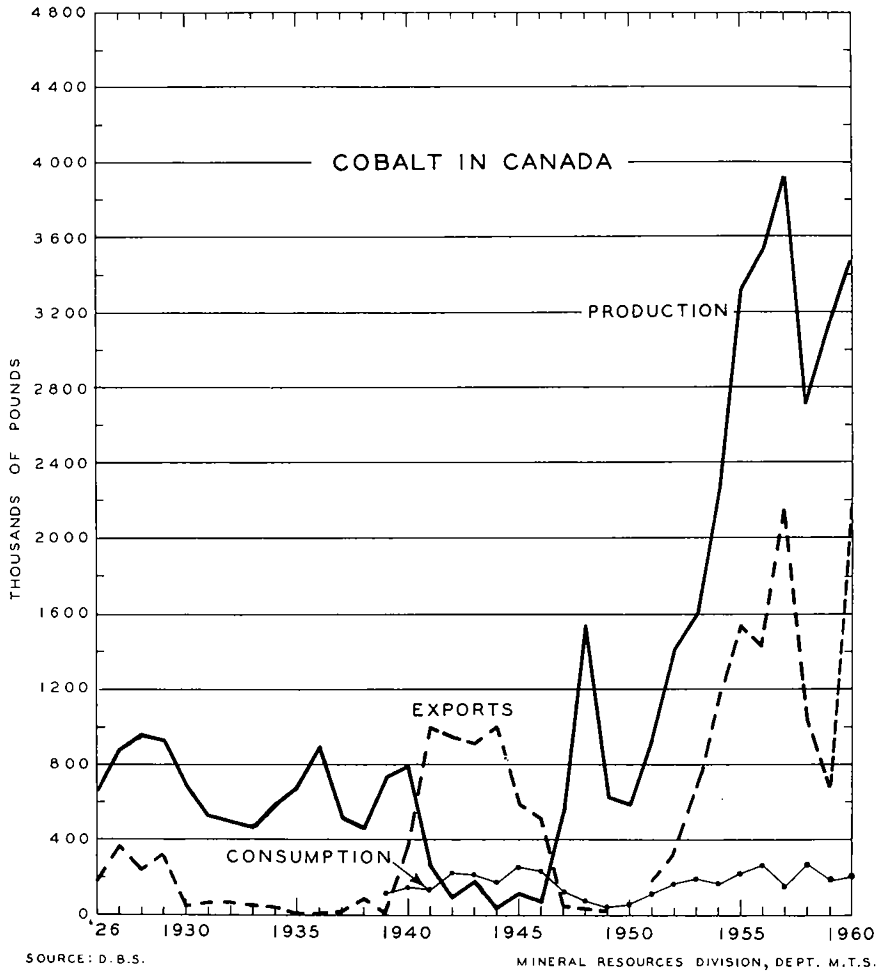
	Production(1)	Exports				Imports		Consumption(2)
	All Forms	Cobalt in Ores and Concentrates	Metallic Cobalt	Cobalt Alloys	Cobalt Oxides and Salts	Cobalt Ores	Cobalt Oxide	Metal
1950	583,806	16,700	-	1,011	388,203	3,912,500	25,880	54,000
1951	951,607	35,300	192,260	730	659,486	3,687,800	-	114,000
1952	1,421,923	-	315,500	20,445	785,976	14,943,400	-	164,000
1953	1,602,545	37,100	769,369	11,874	932,499	4,288,000	28,500	192,000
1954	2,252,965	3,300	1,139,039	4,926	836,205	10,400	6,935	122,000
1955	3,318,637	-	1,542,988	12,357	1,640,282	37,800	8,000	224,000
1956	3,516,670	16,000	1,432,884	11,343	1,289,145	1,900	11,353	262,000
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(3)
1960	3,568,811	-	844,293	1,938	1,175,206	-	20,227	182,000(3)

Source: Dominion Bureau of Statistics.

(1) Metallic cobalt from Canadian ores and the cobalt content of oxides, alloys, and salts sold and concentrates exported.

(2) Producers' domestic shipments, metal only.

(3) Consumption of cobalt metal as reported by consumers.



Producers

Ontario

Sudbury Area

The International Nickel Company of Canada, Limited, recovered cobalt from its nickel-refining operations at Port Colborne, Ontario, and Clydach, Wales. High-purity electrolytic cobalt is produced at the Port Colborne refinery; cobalt oxides and salts are produced by The Mond Nickel Company, Limited, a United Kingdom subsidiary, at Clydach. In 1960 International Nickel reported deliveries of 2,360,000 pounds of contained cobalt in all forms, or 40,000 pounds less than in 1959.

Falconbridge Nickel Mines,Limited produced electrolytic cobalt in the refining of nickel-copper matte exported to its nickel refinery at Kristiansand, Norway. Metal deliveries reported for 1960 amounted to 827,000 pounds, or 95,000 pounds more than in 1959.

Cobalt and Gowganda Areas

Silver ores shipped via the Temiskaming Testing Laboratories in 1960 contained 175,525 pounds of cobalt, or 46,529 pounds less than in the previous year. These concentrates, from companies in the Cobalt and Gowganda areas, were shipped mainly to Deloro Smelting & Refining Company, Limited. The more important shippers in 1960 were: Agnico Mines Limited; Deer Horn Mines Limited; McIntyre-Porcupine Mines,Limited, Castle Division; Langis Silver & Cobalt Mining Company Limited; and Silver-Miller Mines Limited.

Manitoba-Alberta

Sherritt Gordon Mines,Limited produced 310,410 pounds of cobalt, or 6,067 pounds less than in 1959. The company's powder-rolling plant at Fort Saskatchewan, Alberta, which is designed to produce metal strip, rod, and wire direct from powder, was virtually completed by the end of the year and was in production on a limited scale. These products of powder metallurgy will have particular application in such fields as electronics, radio, television, telephone communication, and the production of welding-rod wire.

World Mine Production

Preliminary figures indicate that cobalt production, which in 1959 amounted to 17,300 short tons, declined slightly to 16,800 short tons in 1960. Minor increases occurred in Canada and Morocco, but these were more than offset by decreases in the Republic of the Congo and Northern Rhodesia. According to a report of the United States Bureau of Mines,* American mine production, confined to Bethlehem Corporation and National Lead Company, was down from that of the preceding year. The same report, however, shows that the cobalt production and shipments of United States refiners and processors were respectively 114,000 pounds and 230,000 pounds over those of 1959. Freeport Nickel Company converted concentrates from Cuba to cobalt metal in its refinery at Port Nickel, Louisiana, and sold 307,840 pounds of cobalt to the United States government under a Defense Production Act contract.*

The Republic of the Congo (Leopoldville) is by far the largest producer of cobalt. Its output since 1948 has been about 65 per cent of the world's total, averaging more than 8,600 tons annually. Production in the Congo, which is derived from the copper mines of Union Minière du Haut-Katanga, totalled 9,083 tons in 1960.

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*U.S. Bureau of Mines, Mineral Market Reports, M.M.S. No. 3174, December 27, 1960.

In Morocco, cobalt is derived from the mines of Minière de Bou-Azzer et du Graara. An expansion program completed in 1959 is expected to increase the company's cobalt output, which for that year amounted to 1,391 tons.

In Northern Rhodesia, Rhokana Corporation Ltd. and Chibuluma Mines Ltd. recover cobalt as a by-product of copper-refining. Chibuluma is selling its cobalt to the United States government as payment on a $14 million loan. It is expected that by June 30, 1961, the loan will have been reduced to about $1.4 million.

Free World Production of Cobalt
(short tons)

	1960*	1959
Republic of the Congo (Leopoldville)	9,083	9,294
Northern Rhodesia	2,036	2,270
Canada	1,784	1,575
Morocco	1,401	1,330
United States	(1)	1,165
New Caledonia	-	93
Other countries	2,496	1,573
Total, Free World	16,800	17,300

(1) Not available for publication; production included in world figure.
Sources: U.S. Bureau of Mines, Mineral Trade Notes, September 1961.

Consumption and Uses

Free World cobalt production capacity, some 18,000 tons a year, is about double Free World consumption. Much of the excess output has been absorbed into United States stockpiles. The United States Bureau of Mines reports:# "As of September 30, 1960, the Defense Production Act inventory of cobalt was 24.8 million pounds. This, combined with consumers and refiners or processors stocks of about 2.2 million pounds, totalled 27 million pounds or about 3 times the average annual consumption rate for the past 5 years."

The United States is the leading consumer and importer of cobalt. During the last 10 years its production has supplied only 27 per cent of the country's domestic requirements. Preliminary reports indicate that in 1960 the United States consumed 8,915,843 pounds of cobalt in all forms, or 982,859 pounds less than in 1959. Imports, at 12.2 million pounds, were about 9 million pounds below those of the previous year. Imports from the

U.S. Bureau of Mines, Mineral Market Reports, M.M.S. No. 3174, December 27, 1960.

Republic of the Congo (Leopoldville) registered the largest decline – from 11.9 million pounds in 1959 to 4.7 million pounds in 1960.

United States Consumption of Cobalt, by Uses
(percentages of total consumption)

Use	1959	1960
Metallic		
Steel		
High-speed steel	2.1	1.8
Other tool and alloy steel	6.3	7.0
Permanent-magnet alloys	30.2	26.9
Cutting and wear-resisting materials	1.4	2.9
High-temperature high-strength materials	24.5	22.5
Alloy hard-facing rods and materials	4.1	5.0
Cemented carbides	3.4	3.6
Nonferrous alloys and other materials	6.6	6.8
Total, metallic	78.6	76.5
Nonmetallic (exclusive of salts and driers)		
Ground-coat frit	5.5	5.2
Pigments	2.0	2.1
Other materials	2.6	3.1
Total, nonmetallic	10.1	10.4
Salts and driers		
Lacquers, varnishes, paints, inks, pigments, enamels, feed, electroplating, etc. (estimated)	11.3	13.1
Grand total	100.0	100.0

Source: U.S. Bureau of Mines, Cobalt Report No. 141, February 24, 1961.

The most important application of cobalt is in high-temperature cobalt-base alloys used for such parts as nozzle guide vanes and turbine rotor blades in the jet-engine and gas-turbine-engine industry and in guided missiles. The metal is an important constituent of permanent-magnet alloys, cemented carbides, hard-facing rods, and high-speed steel. A radioisotope, Cobalt 60, is widely used for radiographic examinations by industry and also in the 'cobalt bomb' for the treatment of cancer.

Cobalt oxide is used in ground-coat frit for bonding porcelain enamel to a metal base. It is also used as a coloring agent in making glass and ceramics.

Organic salts of cobalt are used as driers in paint, varnish, enamel, ink, etc. Inorganic salts such as cobalt sulphate and cobalt carbonate are used in animal-feed nutrient.

Canadian consumers of cobalt include: in Ontario - Deloro Smelting & Refining Company, Limited, Deloro and Belleville; Canadian General Electric Company Limited and Nuodex Products of Canada, Limited, both of Toronto; Dussek Bros. (Canada) Limited, Belleville; Indiana Steel Products Company of Canada Limited, Kitchener; Ferro Enamels (Canada) Limited, Oakville; Atlas Steels Limited, Welland; in Quebec - Dominion Glass Company, Limited, and Mallinckrodt Chemical Works Limited, both of Montreal; Canadian General Electric Company Limited, Quebec City.

St. Lawrence Chemical Company, Limited, Canadian sales agent for The Mond Nickel Company, Limited, supplies the domestic market with cobalt salts in the form of acetate, carbonate, hydrate, and sulphate. Its sales in 1960, by industries, were in the following proportion:

Ceramics-manufacturing	10%
Chemical-manufacturing	3%
Drier-manufacturing	26%
Animal-feed-manufacturing	61%
Total	100%

Sherritt Gordon Mines, Limited sells its cobalt as cobalt-metal powder, strip, wire rod, and rondelles.

Deloro Smelting & Refining Company, Limited, sells cobalt in the following forms: gray and black oxide, carbonate, sulphate, and metal shot. Sales of contained cobalt in 1960 amounted to 377,066 pounds in the following forms: oxide, 116,912 pounds; salts, 7,845 pounds; and metal, 252,309 pounds.

Prices

Cobalt prices in the United States at the end of 1960, according to E & M J Metal and Mineral Markets, were as follows:

Cobalt metal	
Per lb. f.o.b. New York	
500-lb lots	$1.50
100-lb "	$1.52
Less than 100 lb	$1.57
Fines	$1.75

Cobalt oxide	
(ceramic grade, 350-lb containers)	
Per lb, 72 1/2% to 73 1/2% Co	
East of Mississippi	$1.15
West of Mississippi	$1.18
Per lb, 70% to 71% Co	$1.12 to $1.15
Cobalt ore	
Per lb Co, free market	
10% Co content	$0.60 (nominal)
11% " "	$0.70 "
12% " "	$0.80 "

Tariffs

Canada

	British Preferential	Most Favored Nation	General
Ore	free	free	free
Cobalt metal	"	10%	25%
Cobalt oxide	"	10%	10%

United States

Ore	free
Metal	"
Cobalt oxide	4¢ lb
Cobalt sulphate	2 1/2¢ lb
Cobalt linoleate	5¢ lb
Other cobalt compounds and salts	15%

COPPER

A.F. Killin*

In consequence of the prolonged strike that affected most of the major copper producers in the United States, world stocks of copper were below normal at the beginning of 1960. The strike, which lasted until February at some plants, caused an estimated production loss of 330,000 tons of copper. Early in the year production was accelerated so that inventories could be replenished. By mid-year production had outstripped demand, and in the second half of the year prices declined as inventories increased.

Despite increased production in South American and African countries, Canada maintained its position as the fifth-ranking copper producer in the world with a record output of 439,262 tons valued at $264,846,637. This exceeded the 1959 output by 43,993 tons and $31,743,824. The production of refined copper rose to 417,029 tons from the 365,366 tons reported for 1959. The tonnage and value of all classes of exports rose in 1960, but the domestic consumption of refined copper decreased to 117,636 tons from the 129,973 tons consumed in 1959. Although copper consumption in Canada and the United States declined owing to a drop in the level of industrial activity, European consumption was high. Europe and Japan provided a ready market for Canadian and United States copper exports.

Prices were well maintained throughout the first and second quarters. In the third quarter, a growing inventory of copper and continued lack of demand on the United States market put increasing pressure on copper prices, especially in the speculative segments of the market. At the beginning of the fourth quarter, producer prices in North America were reduced drastically but remained relatively stable at this lower level for the rest of the year.

Barring widespread labor disturbances or political upheavals in copper-producing areas, and unless further voluntary production cuts are made, output will probably exceed consumption for at least the first half of 1961. The demand for copper is expected to remain brisk on the European, Japanese, and Russian markets, but an increase in consumption on the Canadian and United States markets is not likely to appear until the second quarter of 1961.

Smelter and Refinery Production

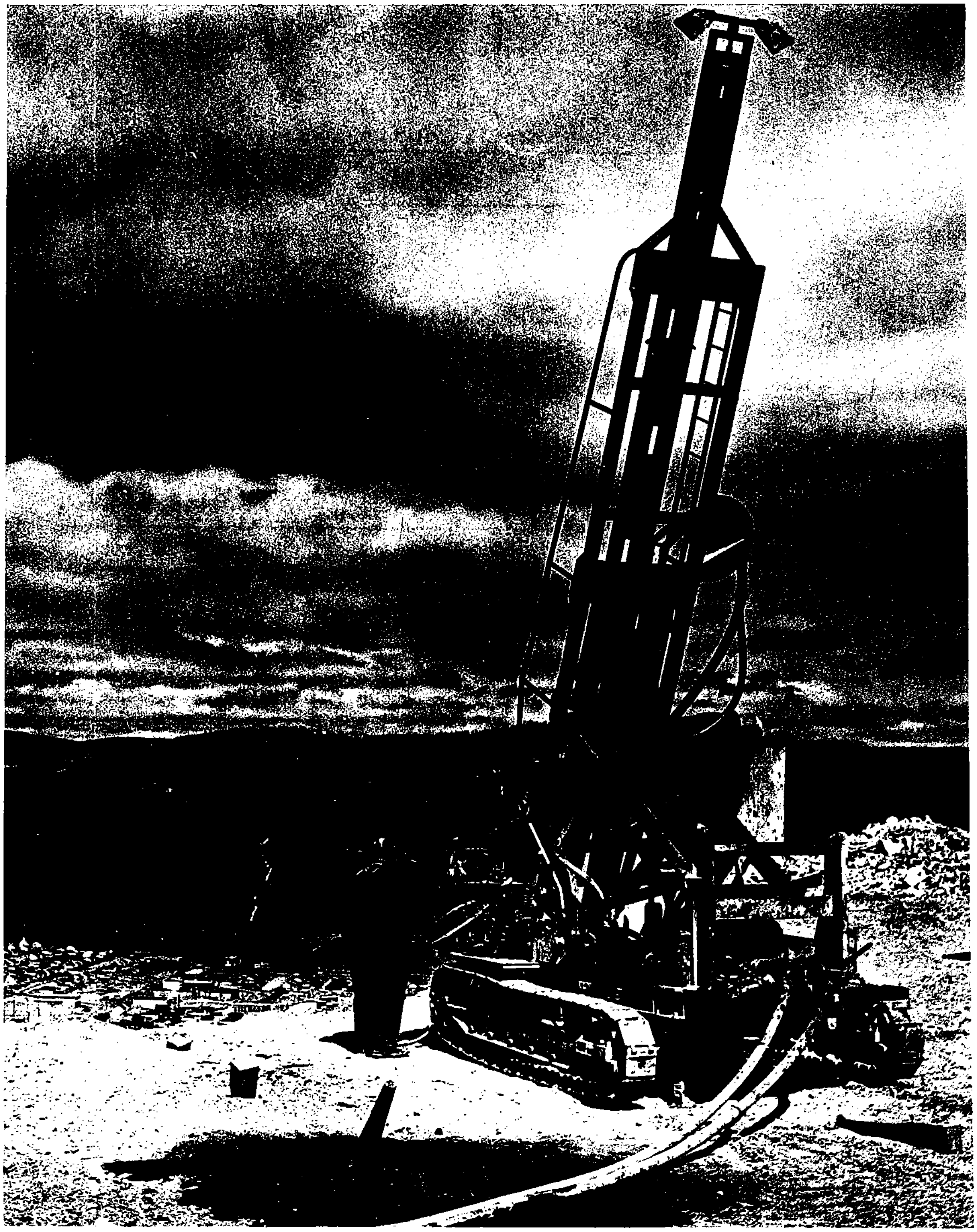
For the treatment of Canadian copper and copper-nickel ores and concentrates, six smelters are operated in Canada. About 95 per cent of the domestic production is treated in these plants, the remainder being shipped to smelters in the United States and Japan.

(text continued on page 229)

*Mineral Resources Division.

Copper - Production, Exports and Consumption

	1960		1959	
	Short Tons	$	Short Tons	$
Production(1)				
All forms				
Ontario	206,272	123,750,235	188,272	110,547,037
Quebec	157,470	95,395,158	134,912	79,894,820
Saskatchewan	31,785	19,255,437	35,536	21,044,574
British Columbia	16,559	9,982,552	8,121	4,781,508
Newfoundland	13,863	8,398,362	14,989	8,876,570
Manitoba	12,793	7,749,877	12,945	7,666,147
Northwest Territories	520	315,016	494	292,157
Total	439,262	264,846,637	395,269	233,102,813
Refined	417,029		365,366	
Exports				
In ore and matte				
Norway	18,723	10,237,168	16,974	9,023,805
United States	17,151	9,363,236	7,311	3,891,662
Japan	9,094	4,936,447	5,999	3,150,125
United Kingdom	1,739	954,251	1,079	578,044
West Germany	533	290,984	265	140,110
Belgium and Luxembourg	393	212,688	442	233,649
Total	47,633	25,994,774	32,070	17,017,395
Ingots, bars, slabs, etc.				
United Kingdom	110,540	67,518,140	83,488	48,203,218
United States	104,602	65,033,398	101,501	60,323,522
West Germany	12,940	7,867,171	9,510	5,469,552
France	12,880	7,618,932	10,038	5,870,194
India	10,908	6,758,987	7,619	4,534,156
Netherlands	5,318	3,186,530	2,939	1,645,647
Japan	4,861	2,823,187	110	62,678
Belgium and Luxembourg	4,480	2,661,692	3,738	2,133,038
Other countries	11,537	6,685,121	3,494	2,004,941
Total	278,066	170,153,158	222,437	130,246,946



An Airtrac drill in operation in the Needle Mountain open pit of Gaspé Copper Mines, Limited, with the town of Murdochville, Quebec, left background.

Blasting in the Needle Mountain open pit at Gaspé Copper Mines, Limited, Murdochville, Quebec.

Copper - Production, Exports and Consumption (cont'd)

	1960		1959	
	Short Tons	$	Short Tons	$
Exports (cont'd)				
In scrap, slag, and skimmings				
West Germany	4,814	2,402,901	1,047	490,559
Japan	1,915	833,946	931	444,288
United States	1,501	680,570	2,745	1,330,017
Netherlands	774	403,607	457	215,589
Spain	442	227,304	-	-
United Kingdom	396	194,371	-	-
India	387	212,443	460	234,740
Belgium and Luxembourg	380	196,605	177	82,994
Italy	334	165,927	-	-
Other countries	583	303,090	419	211,315
Total	11,526	5,620,764	6,236	3,009,502
Rods, strips, and sheets				
Switzerland	5,437	3,097,877	3,854	2,128,521
United Kingdom	3,711	2,447,680	2,054	1,279,397
United States	3,628	2,922,697	4,856	3,903,574
Pakistan	562	379,263	225	131,064
Denmark	448	261,553	-	-
New Zealand	360	299,960	186	162,778
Other countries	270	253,533	1,494	947,429
Total	14,416	9,662,563	12,669	8,552,763
Copper tubing				
United States	3,834	4,434,662	1,537	1,707,015
New Zealand	636	667,058	359	375,833
Puerto Rico	467	469,578	318	311,477
Colombia	336	297,867	146	142,058
United Kingdom	257	284,536	28	31,894
Other countries	1,308	1,401,501	1,833	1,772,176
Total	6,838	7,555,202	4,221	4,340,453
Wire and cable, screening, and other copper manufactures				
United States		2,855,218		904,504
Philippines		674,179		85,642
Venezuela		292,683		644,635
Dominican Republic		232,202		272,499
Panama		162,228		85,937
Other countries		712,800		906,735
Total		4,929,310		2,899,952

Copper - Production, Exports and Consumption (cont'd)

	1960		1959	
	Short Tons	$	Short Tons	$
Consumption(2)				
Refined..................	117,636		129,973	

Source: Dominion Bureau of Statistics.
(1) Blister copper plus recoverable copper in matte and concentrate exported.
(2) Producers' domestic shipments.

Copper - Production, Trade and Consumption,1950-60
(short tons)

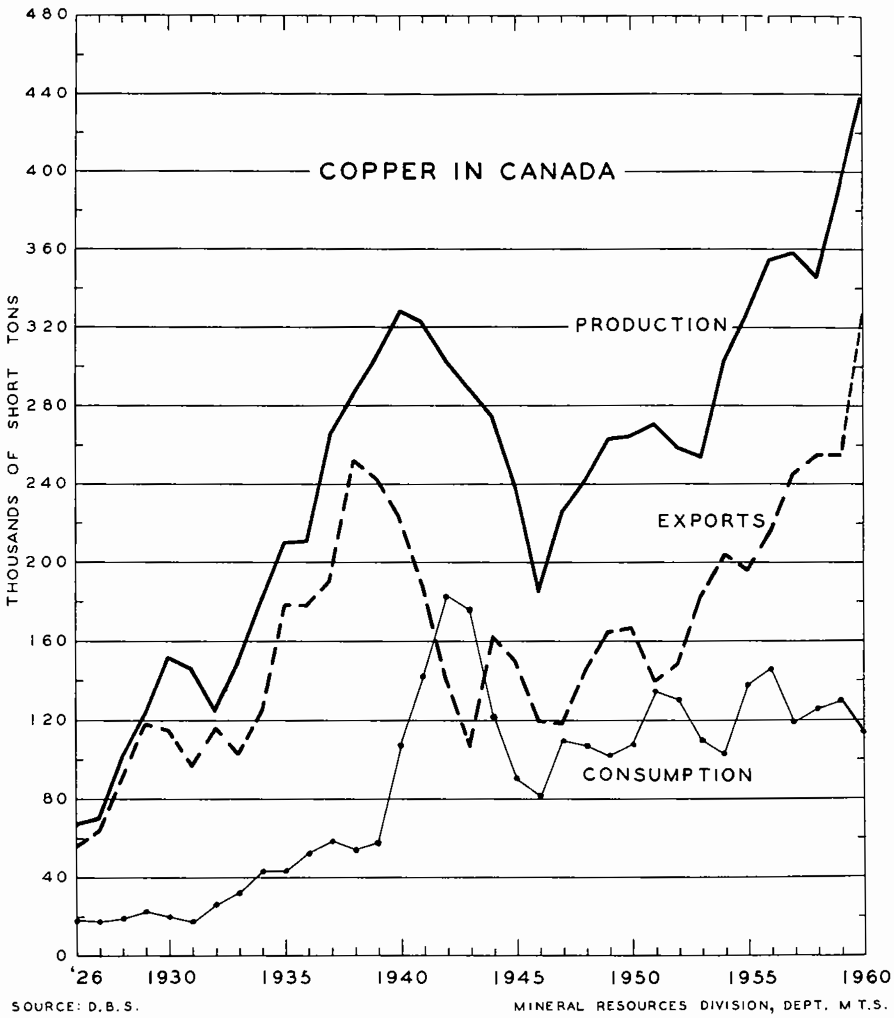
	Production		Exports			Imports	Consumption(3)
	All Forms(1)	Refined	In Ore and Matte	Refined	Total	Refined	Refined
1950	264,209	238,204	32,299	134,244	166,543	122	106,876
1951	269,971	245,466	36,853	101,832	138,685	1,511	134,174
1952	258,038	196,320	34,437	113,675(2)	148,112	12,973	130,347
1953	253,252	236,966	51,158	131,994(2)	183,152	5,515	105,482
1954	302,732	253,365	47,411	156,130(2)	203,541	1,703	102,432
1955	325,994	288,997	41,565	153,199	194,764	35	138,559
1956	354,860	328,458	40,993	174,844	215,837	2,541	145,286
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	117,637

Source: Dominion Bureau of Statistics.
(1) Blister copper plus recoverable copper in matte and concentrate exported.
(2) Includes blister and anode copper exported for refining, as follows:

1952	-	27,974 short tons
1953	-	3,527 " "
1954	-	4,712 " "

(3) Producers' domestic shipments.

The International Nickel Company of Canada, Limited, operates smelters at Copper Cliff and Coniston, in the Sudbury district of Ontario, for the treatment of ores and concentrates from the company's six mines. Falconbridge Nickel Mines, Limited treats ores and concentrates from its mines in the Sudbury area at its smelter at Falconbridge, Ontario. The nickel-copper matte produced is shipped to the company's refinery at Kristiansand, Norway.



The smelter of Noranda Mines, Limited, at Noranda, Quebec, operated at capacity during the year, treating copper ores and copper concentrates from most of the copper and copper-zinc mines in Ontario and Quebec. This smelter treated 1,540,900 tons of ore, concentrate, refinery slag, scrap copper, and scrap brass, of which 852,900 tons of copper-bearing materials were treated on a toll basis. The smelter of Gaspé Copper Mines, Limited, at Murdochville, Quebec, treated ores and concentrates from the company's mine at Murdochville and from the Tilt Cove, Newfoundland, mine of Maritimes Mining Corporation Limited. The Murdochville smelter treated 288,700 tons of concentrate and fluxing ore, from which 49,100 tons of anodes were produced.

Hudson Bay Mining and Smelting Co., Limited, treated ores and concentrates from its mines in Manitoba and Saskatchewan at the company smelter at Flin Flon, Manitoba. In September, Hudson Bay started smelting copper concentrates from the Lynn Lake, Manitoba, mine of Sherritt Gordon Mines,Limited. In 1960 the Flin Flon smelter treated 431,325 tons of copper ores, concentrates, and residues.

Two copper refineries operate in Canada for the treatment of the blister- and anode-copper output of the domestic smelters. In 1960 these refineries produced 416,403 tons of refined copper. International Nickel ships blister copper from its smelter to the company's refinery at Copper Cliff, Ontario. Canadian Copper Refiners Limited, at Montreal East, Quebec, produced 267,400 tons of refined copper from the treatment of the anodes from Noranda and Murdochville and the blister copper from Flin Flon.

Mine Production

Newfoundland

Copper production amounting to 13,863 tons was obtained from a copper and a zinc-lead-copper mine in 1960.

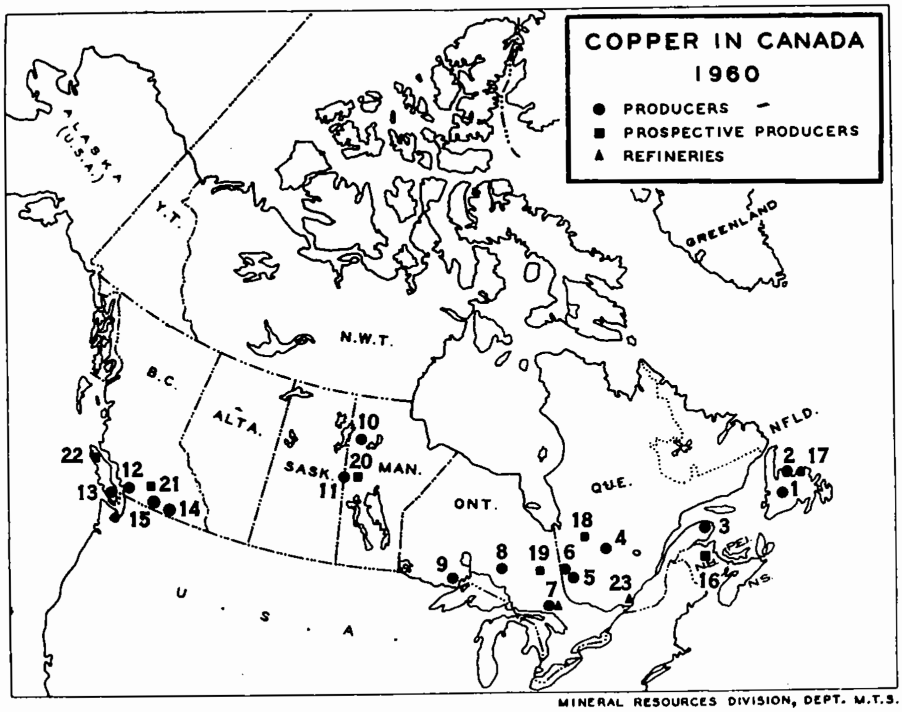
Maritimes Mining Corporation Limited operated a 2000-ton-a-day mine and mill at Tilt Cove, on the northwest coast of Notre Dame Bay. Shaft-sinking to 2,000 feet below the collar was completed during the year, and exploration of the mineralized structure is continuing from the shaft. American Smelting and Refining Company (Buchans Unit) operated a 1,200-ton-a-day mine and concentrator in central Newfoundland. The orebodies contain zinc, lead,and copper, and the copper concentrate is shipped to the United States for treatment.

Quebec

Production from four new mines helped to increase Quebec's copper output to 157,470 tons in 1960. Copper Rand Chibougamau Mines Ltd. obtained production from the Copper Rand mine and the mines of Chibougamau Jaculet Mines Limited and Portage Island (Chibougamau) Mines Limited. Campbell Chibougamau Mines Ltd. started production from the Henderson mine.

Gaspé Copper Mines, Limited, continued production at 6,500 tons a day from its mine at Murdochville. Anodes from the Murdochville smelter are shipped to Montreal East for refining.

In the Chibougamau area, Opemiska Copper Mines (Quebec) Limited, at Chapais, increased the mill capacity to 2,000 tons a day. Exploration and development of the orebodies continued. Campbell Chibougamau Mines Ltd. obtained production from the Main, Kokko Creek, and Cedar Bay mines, and development ore from its Henderson mine was shipped to the mill. At the Main mine, the company started a program of exploration at depth to



Producers

1. American Smelting and Refining Company (Buchans Unit)
2. Maritimes Mining Corporation Limited
3. Gaspe Copper Mines, Limited (smelter)
4. Opemiska Copper Mines (Quebec) Limited
   Campbell Chibougamau Mines Ltd.
   Merrill Island Mining Corporation, Ltd.
   Copper Rand Chibougamau Mines Ltd.
5. Manitou-Barvue Mines Limited
   East Sullivan Mines Limited
   Noranda Mines, Limited (smelter)
   Quemont Mining Corporation, Limited
   Waite Amulet Mines, Limited
6. Normetal Mining Corporation Limited
7. International Nickel Company of Canada, Limited, The (6 mines, 2 smelters, 2 refineries)
   Falconbridge Nickel Mines Limited (6 mines, 1 smelter)
8. Geco Mines Limited
   Willroy Mines Limited
9. North Coldstream Mines Limited
10. Sherritt Gordon Mines Limited
11. Hudson Bay Mining and Smelting Co., Limited (5 mines, 1 smelter)
12. Howe Sound Company (Britannia Division)
13. Cowichan Copper Co. Ltd.
14. Mid-West Copper & Uranium Mines Ltd.
15. Phoenix Copper Company Limited
    Consolidated Woodgreen Mines Limited

Prospective Producers

16. Newcastle-Bathurst area
17. Atlantic Coast Copper Corporation Limited
18. Mattagami Lake Mines Limited
19. Kam-Kotia Porcupine Mines Limited
20. Hudson Bay Mining and Smelting Co., Limited (Stall Lake)
21. Bethlehem Copper Corporation Ltd.
    Craigmont Mines Limited
22. Coast Copper Company, Limited

Refinery

23. Canadian Copper Refiners Limited

investigate an ore occurrence indicated in 1959 by downhole drilling. This program involves the sinking of a winze, diamond-drilling, and level development. Merrill Island Mining Corporation, Ltd., which adjoins Campbell Chibougamau's Main mine, continued production and has started a program of deep exploration below the present workings, with encouraging results. Copper Rand Chibougamau Mines Ltd., started production of concentrates at its mill on the Gouin Peninsula. The mill, which has a capacity of 1,500 tons a day, treats ore from the mines of Copper Rand, Chibougamau Jaculet, and Portage Island (Chibougamau). Anacon Lead Mines Limited (Chibougamau Operation) operated its gold-copper mine, 26 miles south of Chibougamau, until August, when operations were suspended.

In the Noranda-Val d'Or area, Manitou-Barvue Mines Limited, near Val d'Or, continued operation of its 1,300-ton-a-day mine and mill. Exploration diamond-drilling for lateral and downward extensions of the orebody is in progress. East Sullivan Mines Limited started a program of drifting and crosscutting on the lower levels of the mine to permit systematic exploratory diamond-drilling of the ore zone. Production of low-grade copper-zinc ore was steady throughout the year. Noranda Mines, Limited, operated the Horne mine and a custom smelter at Noranda. An internal shaft will be sunk 2,000 feet below the 6,000-foot level. Quemont Mining Corporation, Limited, which adjoins Noranda on the north, mined and milled copper-zinc ore of a slightly lower grade in 1960 than that mined in 1959. Zinc concentrate was shipped to the United States and copper concentrate to Noranda for treatment. Waite Amulet Mines, Limited, continued production of copper-zinc ore from the Waite Amulet and Amulet Dufault orebodies. Although minable reserves in the Waite Amulet mine are expected to be exhausted early in 1961, there will be enough ore in the Amulet Dufault zone to supply the mill for another two years. To explore the ore at the 6,160- and 5,560-foot horizons, Normetal Mining Corporation, Limited, started a program of crosscutting, drifting, and diamond-drilling on these levels, with satisfactory results. Zinc concentrates were shipped to the United States for treatment after being roasted at Arvida, Quebec, or Port Maitland, Ontario. Copper concentrates, with the exception of a small consignment to Japan, were shipped to Noranda.

Ontario

Paced by an increase in the demand for nickel, Ontario's nickel-copper, copper, and copper-zinc mines combined to produce a record output of 206,272 tons of copper.

In the Sudbury area, The International Nickel Company of Canada, Limited, Canada's leading copper producer, operated six mines, three mills, two smelters, and a copper refinery. Ore from the Frood-Stobie mine and Frood open-pit and the Murray, Garson, Creighton, Levack, and Victor mines was milled in the Copper Cliff, Creighton, and Levack concentrators. Deliveries of refined copper amounted to 146,270 tons. Falconbridge Nickel Mines, Limited operated six mines, three mills, and a smelter. Nickel-copper matte from the smelter was shipped to Kristiansand, Norway, for treatment.

(text continued on page 236)

Ore was obtained from the East, Falconbridge, Longvack, McKim, Hardy, and Fecunis mines and concentrated in the Falconbridge, Hardy, and Fecunis mills.

The Manitouwadge district had two producing mines. Geco Mines Limited continued production, exploration, and development at its 3,500-ton-a-day operation. Copper concentrate was shipped to Noranda, Quebec, for treatment. Willroy Mines Limited continued production and started a program of shaft-sinking and development to explore at depth an indicated extension of the No. 3 zone.

In northwestern Ontario, North Coldstream Mines Limited renewed production at its mine near Kashabowie, about 70 miles west of Fort William.

Manitoba-Saskatchewan

Production from the mines of Sherritt Gordon Mines, Limited and Hudson Bay Mining and Smelting Co., Limited, accounted for the 44,578 tons of copper produced in these provinces.

Hudson Bay, Canada's second-ranking copper producer, operates five mines in Manitoba and Saskatchewan and a mill and smelter at Flin Flon, Manitoba. All the ore from the Flin Flon, Birch Lake, Chisel Lake, Schist Lake, and Coronation mines was treated in the Flin Flon mill. The Birch Lake mine was closed on April 14, ore reserves being exhausted. The Coronation mine, in Saskatchewan, started production on April 1, and the Chisel Lake mine, near Snow Lake, Manitoba, started on September 1. Sherritt Gordon operated two nickel-copper mines and a concentrator at Lynn Lake, Manitoba. The mill produced a nickel-copper and a copper concentrate. The nickel-copper concentrate was shipped to the company's refinery at Fort Saskatchewan, Alberta. Copper concentrate was shipped to Noranda until September, after which it was shipped to Flin Flon for treatment in the Hudson Bay smelter.

British Columbia

Copper production totalling 16,559 tons was obtained from the Howe Sound, Cowichan Copper, Phoenix Copper, Consolidated Woodgreen, and Mid-West Copper mines.

At Britannia Beach, Howe Sound Company (Britannia Division) operated at 1,200 tons a day and shipped copper concentrate to Tacoma, Washington, and zinc concentrate to Black Eagle, Montana, for smelting. Cowichan Copper Co. Ltd. mined ore from the Blue Grouse and Sunnyside zones at Cowichan Lake and shipped copper concentrate to Japan. Phoenix Copper Company Limited mined and milled ore from the old Granby mine, near Greenwood. Mill capacity was increased from 700 tons a day to 1,000 tons a day in 1960 and concentrates were shipped to Tacoma. In the same area, Consolidated Woodgreen Mines Limited produced steadily from the old Motherlode mine, near Greenwood. Mid-West Copper & Uranium Mines Ltd. leased the Velvet mine, near Rossland, to a group of independent miners, who continued intermittent production from the property. Giant Nickel Mines Limited shipped nickel-copper concentrates to Japan from its property at Choate.

Northwest Territories

All the copper production of the Northwest Territories was contained in the nickel-copper concentrates from the mine of North Rankin Nickel Mines Limited, on the west shore of Hudson Bay.

Exploration and Development

Companies interested in the exploration and development of copper properties were active in all the provinces that are actually or potentially copper-producing.

Newfoundland

Atlantic Coast Copper Corporation Limited, at Little Bay, Notre Dame Bay, in northeastern Newfoundland, started construction of an 800-ton-a-day mill. Indicated ore reserves are 2 1/2 million tons averaging 2.1 per cent copper. Production is scheduled for early 1961.

Several interesting occurrences on the Burlington Peninsula are being explored.

New Brunswick

Activity in New Brunswick was centred in the Newcastle-Bathurst area. Heath Steele Mines Limited, jointly owned by American Metal Climax, Inc. and The International Nickel Company of Canada, Limited, unwatered the workings at its mine 35 miles northwest of Newcastle. A program of underground development and exploration was started. The Consolidated Mining and Smelting Company of Canada Limited continued exploration and development at its Wedge property on the Nepisiguit River, 36 miles southwest of Bathurst. Shaft-sinking was completed and a program of drifting, crosscutting, sampling, and diamond-drilling is under way.

Quebec

Solbec Copper Mines, Ltd., announced production plans for its copper-zinc-gold prospect 50 miles northeast of Sherbrooke, in the Eastern Townships. Estimated reserves at the property total 1 million tons averaging 2.16 per cent copper, 3.9 per cent zinc, and 0.02 ounce of gold per ton. Sinking of a three-compartment shaft was started late in the year, and preparations were made to build a 1,000-ton-a-day mill.

The announced building of a railroad stimulated exploration and development at the three major prospects in the Mattagami Lake area. Mattagami Lake Mines Limited started shaft-sinking at its Watson Lake property. Ore reserves, indicated by diamond-drilling in two zones, are as follows: zone 1 - 21 million tons averaging 12.76 per cent zinc, 0.68 per cent copper, 0.018 ounce of gold per ton, and 1.31 ounces of silver per ton; zone 2 - 2 million tons averaging 12.86 per cent zinc, 0.86 per cent copper, 0.013 ounce of gold per ton, and 0.99 ounce of silver per ton. New Hosco Mines Limited continued a program of exploration by diamond-drilling at its Allard River copper-zinc orebody. Orchan Mines Limited has completed a program of diamond-drilling from the surface at its property adjoining Mattagami Lake Mines Limited on the south. Underground exploration and development are planned for 1961.

Exploration in the Noranda-Amos-Senneterre area has indicated some interesting prospects.

Ontario

In the Kamiskotia area, west of Timmins, Kam-Kotia Porcupine Mines, Limited started mill construction and planned to produce from an open pit early in 1961. By diamond-drilling near Kam-Kotia's property, Bidcop Mines Limited, through its subsidiary, Maple Bay Copper Mines Limited, has discovered interesting mineralization. Falconbridge Nickel Mines, Limited, in the Sudbury area, continued the exploration and development of its Strathcona orebody.

Manitoba-Saskatchewan

Hudson Bay Mining and Smelting Co., Limited, continued underground exploration and development of the Stall Lake mine 4 miles southeast of Snow Lake, Manitoba. A road was started to the company's Osborne Lake mine under the federal government's Roads to Resources Program. The Osborne Lake mine is 13 miles northeast of Snow Lake.

British Columbia

Two companies have continued exploration and development programs at their properties in the Highland Valley-Merritt area. Craigmont Mines Limited completed a program of underground development and exploration at its copper-iron prospect 10 miles northwest of Merritt. Excavation was begun for the foundations of a 4,000-ton-a-day concentrator, which is expected to start production late in 1961. Bethlehem Copper Corporation Ltd. continued a program of bulk-sampling and diamond-drilling at its property in the Highland Valley, 25 miles southeast of Ashcroft.

On Vancouver Island, Coast Copper Company Limited, plans to go into production in 1962 at its copper property near Benson Lake, in the northern part of the island, and Cowichan Copper Co. Ltd. will develop the Sunro property at Jordan River, on the southwest coast. Production at 300 tons a day is planned at Sunro for late in 1961.

Domestic Consumption and Uses

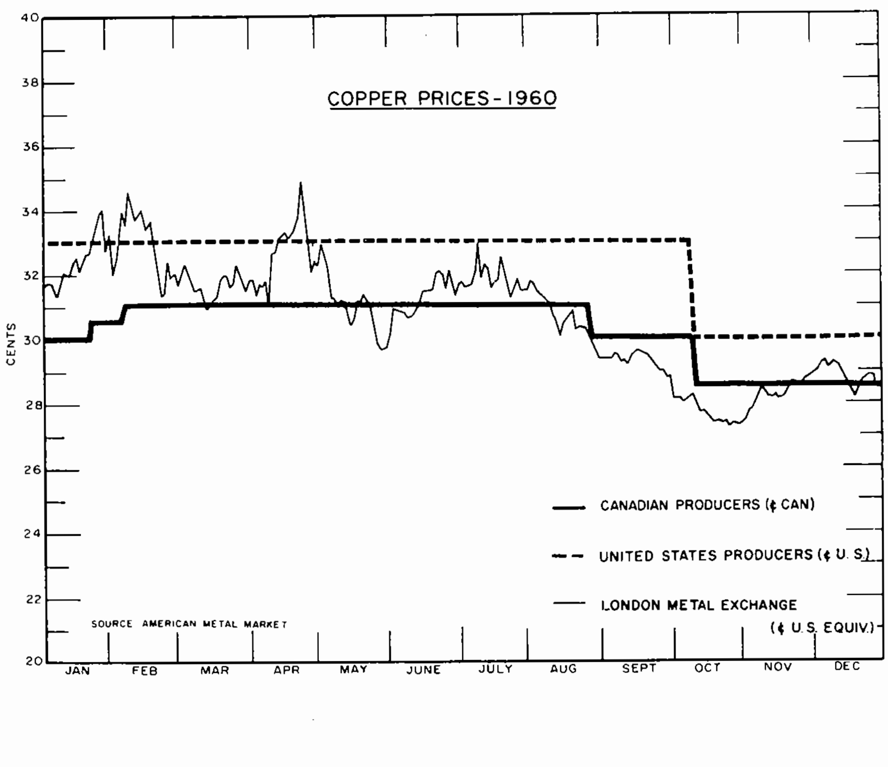
A total of 117,636 tons of refined copper was consumed in Canada in the fabrication of copper wire and cable and copper and brass pipe, tubing, strip, and sheet.

The principal copper and brass fabricators in Canada are: British Columbia - Western Copper Mills Ltd., Vancouver; Ontario - Anaconda American Brass Limited, New Toronto; Canada Wire and Cable Company Limited, Toronto; Phillips Electrical Company Limited, Brockville; Ratcliffs (Canada) Limited, Richmond Hill; Wolverine Tube Division of Calumet & Hecla of Canada Limited, London; Quebec - Noranda Copper and Brass Limited, Montreal East; Pirelli Cables, Conduit Limited, St. Johns; and Northern Electric Company Limited, Montreal.

Prices

The price of copper in Canada fluctuated between a high of 31 cents a pound and a low of 28.5 cents and averaged 30.244 cents a pound for the year.

As shown in the accompanying graph, copper prices in the leading markets were relatively stable in the first half. By the beginning of the third quarter increasing inventories had brought pressure to bear on the speculative price, and the London Metal Exchange price declined. In August the Canadian price was reduced, and at the beginning of the fourth quarter both the Canadian and the United States producer prices dropped.



Tariffs

Although Canada has no tariff on copper in ores and concentrates, various tariff rates are in effect for copper in bars, rods, wire, semifabricated forms, and fully processed products. The following table summarizes the Canadian tariff rates on copper and its products.

	British Preferential	Most Favored Nation	General
Ores and concentrates	free	free	free
Pigs, blocks, ingots, and cathodes	1¢ lb	1 1/2¢ lb	1 1/2¢ lb
Scrap	1¢ lb	1 1/2¢ lb	1 1/2¢ lb
Anodes	5%	7 1/2%	10%
Oxide	free	15%	15%
Bars or rods, tubing not less than 6 feet in length, unmanufactured; copper in strips, sheets, or plates, not polished, planished, or coated	5%	10%	10%
Bars and rods for the manufacture of wire and cable	free	10%	10%
Tubing not more than 1/2" in diameter and not less than 6 feet long	5%	10%	10%
Alloys of copper consisting 50% or more, by weight, of copper in sheets, plates, bars, rods, and tubes	7 1/2%	15%	25%

The United States tariff on ores, concentrates, and primary shapes is 1.7 cents a pound of copper content; on fabricated materials it goes as high as 4 1/2 cents a pound plus 1.7 cents a pound of copper content.

World Mine Production*

Copper statistics, as reported by members of the Copper Institute, show that world output of copper totalled 3,526,778 tons. This exceeded the 1959 total by 666,324 tons. These figures are the latest available, but they exclude production from Russia, Japan, Australia, Yugoslavia, Norway, Sweden, Finland, the Messina mine in the Transvaal, and the production of several other small countries from which reports are not available. Production in the United States was back to normal by the end of February; for the year it totalled 1,139,943 tons.

*Source: American Bureau of Metal Statistics.

World Production of Copper, 1960

Mine Production	Short Tons
United States	1,092,500
Northern Rhodesia	635,326
Chile	586,859
U.S.S.R.	510,000(e)
Canada	439,262
State of Katanga	332,900
Peru	200,573
Other countries	700,770
Total, world	4,498,190
Smelter Production	
United States	1,344,470
Northern Rhodesia	632,113
Chile	556,631
U.S.S.R.	510,000(e)
Canada	398,746
West Germany	336,499
State of Katanga	332,900
Japan	273,488
Peru	181,647
Other countries	496,714
Total, world	5,063,208

Source: American Bureau of Metal Statistics, 1960.
(e) Estimate.

On January 1 the Southern Peru Copper Corporation started production of blister copper at Ilo, Peru. Ore for the smelter comes from the Toquepala mine, and production is scheduled at 144,000 tons of copper a year. The production from Toquepala helped to raise Peru's copper output to 181,647 tons, or 143,623 tons over the 1959 total. Strikes at the copper mines in Chile reduced that country's copper production to 586,859 tons from the 601,209 tons produced in 1959. Copper production in Northern Rhodesia rose to 632,113 tons from the 592,716 tons produced in 1959. Production from Katanga province, of the former Belgian Congo, amounted to 332,900 tons in 1960 compared to the 310,952 tons produced in 1959.

Ten-per-cent production cuts were announced late in the year by one important producer in the United States, Noranda Mines Limited in Canada, and most of the major producing mines in Northern Rhodesia. These cuts are designed to support prices by bringing production and consumption into balance. It is expected that further production cuts will be announced by other world producers if in 1961 production continues to outstrip demand.

FELDSPAR

J.E. Reeves*

The return to only one regular producer and the continued competition of nepheline syenite for ceramic markets greatly curtailed the production of feldspar in Canada in 1960. Shipments were 23 per cent less in volume and 21 per cent less in value than those of 1959.

Exports were considerably lower. Their volume decrease was proportionately much greater than their drop in value because of the closing of the producing facilities of Spar-Mica Corporation Ltd., which had been exporting its output as lower-priced, glass-grade feldspar.

Western Canada continued to import whiteware-grade feldspar.

Producers

In 1960, the only producer of ground feldspar was International Minerals & Chemical Corporation (Canada) Limited,which obtains the mineral from a large pegmatite in Derry township, Quebec, and grinds it at a plant at Buckingham, a few miles to the south. Small amounts of crude feldspar are also yielded by other deposits in the Buckingham area.

Industrial Garnet Company Limited made a small shipment of feldspar from a deposit near River Valley, Ontario, for use in stucco.

History and Occurrences

Feldspar has been mined in Canada almost continuously since 1890, mostly in southeastern Ontario and southwestern Quebec. Each of these areas contains an abundance of very coarse grained granitic pegmatites and is well situated for markets and transportation. The wide acceptance of nepheline syenite as a substitute in the manufacture of ceramic products, particularly glass, is an important reason for the present confinement of production to

*Mineral Processing Division, Mines Branch.

Feldspar - Production, Trade and Consumption

	1960		1959	
	Short Tons	$	Short Tons	$
Production (shipments)				
Quebec	13,862	239,273	17,953	301,372
Imports (ground)				
United States	1,338	27,545	1,161	23,067
Exports				
United States	3,082	70,680	7,530	113,263
West Germany	101	3,131	-	-
Switzerland	-	-	22	1,848
Total	3,183	73,811	7,552	115,111
Consumption (available data)				
Whiteware	5,808		6,066	
Porcelain enamel	721		833	
Glass	-		40	
Soaps and cleansers.....	628		377	
Other..................	18		-	
Total	7,175		7,316	

Source: Dominion Bureau of Statistics.

Quebec, in whose Buckingham area International Minerals & Chemical Corporation, formerly Canadian Flint and Spar Company,Limited, has produced steadily for more than 30 years.

Several bulk shipments of glass-grade feldspar were exported to the northeastern United States during 1957-59 from the large, new plant of Spar-Mica Corporation Ltd. in eastern Quebec. Minor shipments were made in the early 1920's from the same area.

In 1958 and 1959, Quebec Lithium Corporation produced by-product glass-grade feldspar from spodumene-bearing pegmatites north of Val d'Or, Quebec, and shipped it to the Montreal area. During the latter year, however, this production was discontinued when the output of chemical-grade spodumene concentrate was temporarily interrupted.

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Feldspar - Production and Trade, 1950-60
(short tons)

	Production	Imports	Exports
1950	35,548	144	15,465
1951	40,749	194	19,832
1952	20,267	155	6,360
1953	21,246	336	6,848
1954	16,096	398	1,056
1955	18,152	137	1,426
1956	18,153	196	1,804
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

Source: Dominion Bureau of Statistics.

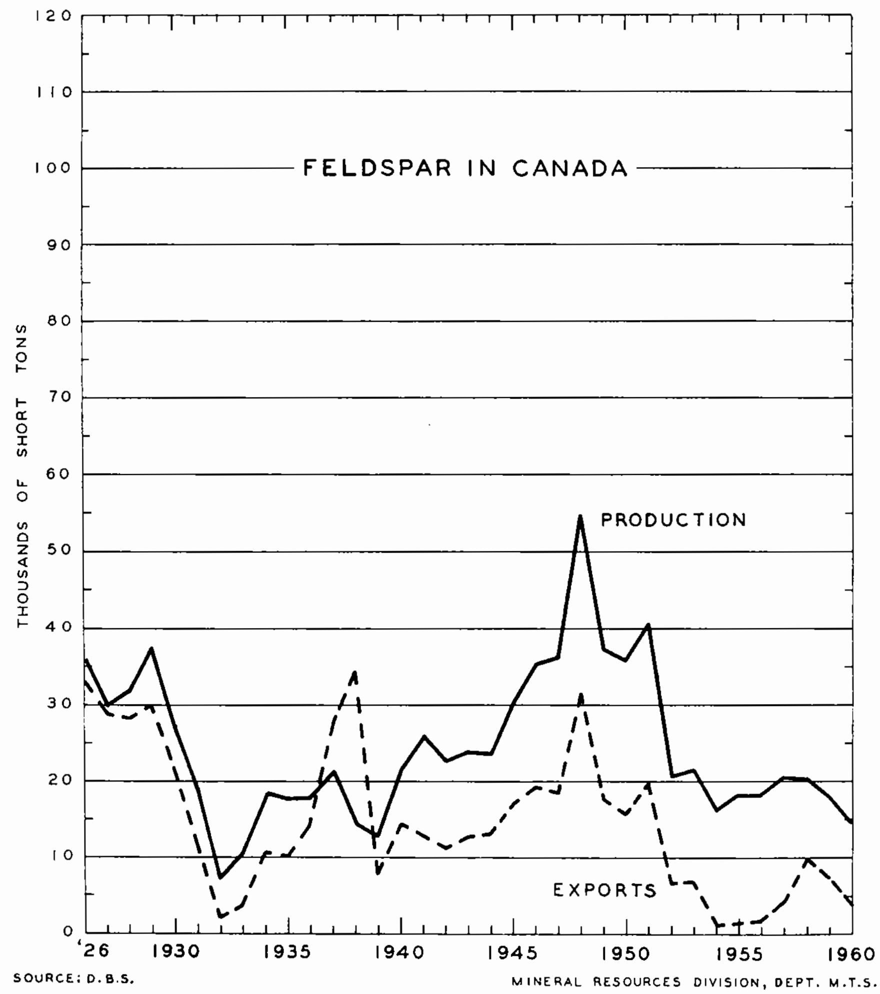
Minor quantities were produced in the 1930's near Pointe du Bois, in southeastern Manitoba. Shipments amounted to a little more than 5,000 tons. Coarse-grained pegmatites are common in this area, but it is improbable that in the future there will be any but by-product production.

Technology

Minerals of the feldspar group, which comprises aluminum silicates of potassium, sodium, and calcium, are common to many types of rock. They are found mainly as small grains closely associated with other minerals, and important natural concentrations occur only in some very coarse grained pegmatites. The potash and soda varieties have industrial applications.

Such natural concentrations have been the traditional sources of feldspar and, to a limited extent, are still important. Mining is frequently done on a relatively small scale, and the broken feldspar is hand-cobbed to remove any associated minerals. As many of the natural concentrations have become depleted, there has been a trend toward the use of pegmatitic sources in which the feldspar is more intimately mixed with quartz and other minerals and toward the concentration of the feldspar by beneficiation techniques. Such techniques, the most common of which is flotation, permit the efficient production of large volumes of a marketable product.

Feldspar is important in the ceramic industries because of its content of alumina and alkalis (potash and soda) and its relatively low firing temperature, and for certain abrasive uses because of its hardness and particle shape.



World Production of Feldspar, 1959
(short tons)

United States	562,666
West Germany	266,166
Italy	88,454
France	88,144
Norway	72,753
Japan	66,080
Sweden	49,280
Yugoslavia	31,416
Union of South Africa	17,472
Other countries	146,369
Total	1,388,800

Source: U.S. Bureau of Mines, Minerals Yearbook 1960.

Uses and Specifications

As a raw material, feldspar is important to the ceramic industry, which uses it in the manufacture of glass, whiteware, pottery, and porcelain enamel. Some select material is used in the manufacture of artificial teeth, and small amounts are employed in scouring soaps and powders and as stucco dash.

Feldspar is a source of the alumina and alkalis used in glass. Glass-grade feldspar is used in a relatively coarse, minus 20 mesh grain size to minimize the loss in the glass furnace due to fines. Its iron-oxide content should be less than 0.1 per cent.

For whiteware bodies and glazes, feldspar is used as a flux. It must be very fine ground (minus 200 mesh and finer), be essentially free of quartz and iron-bearing minerals, and contain a high potash-soda ratio. Color is of no importance providing the fired product is white.

In the manufacture of porcelain enamels potash feldspar is used as a source of alumina, potash, and silica. It must become white upon burning, have a very low iron-oxide content, and be at least minus 120 mesh.

Dental spar is a selected potash feldspar of high purity. As much as 0.1 per cent iron oxide is tolerated but no tourmaline, biotite, or other dark mineral that would leave specks in the product.

For cleansers, the material should be free of quartz and have an acceptable white color. Either potash or soda feldspar can be used.

Prices

According to E & M J Metals and Mineral Markets of December 29, 1960, prices in the United States, f.o.b. point of shipment, North Carolina, in bulk, per short ton, were as follows:

200-mesh	\$17.00 to \$20.50
325-mesh	\$20.50 " \$23.50
40-mesh, glass	\$13.50
20-mesh, semigranular	\$ 9.00

Tariffs

Canadian and United States feldspar tariffs in effect at the time of writing were as follows:

Canada

	British Preferential	Most Favored Nation	General
Crude only	free	free	free
Ground but not further manufactured	"	15%	30%

United States

Crude	12 1/2¢ per long ton
Ground	7 1/2¢ ad valorem

FLUORSPAR

C.M. Bartley*

At $1,921,820, the value of Canadian fluorspar production showed a 4-per-cent increase in 1960. Its 1959 value was $1,850,497. Consumption of fluorspar in Canada reached an all-time high of 111,835 short tons in 1960. The rate of operation of the aluminum and steel industries, Canada's leading fluorspar consumers, was high, and markets for hydrofluoric acid, although small, continued to expand. At one Newfoundland mine, the year's production was interrupted for brief periods so that a radiation hazard could be identified and controlled and mining methods changed. A shipment of crystal fluorspar from Ontario's Madoc area brought a comparatively higher price than the industrial grades.

Production and Trade

More than 90 per cent of Canada's 1960 fluorspar output came from Newfoundland. Most of the rest was produced in Ontario. A small tonnage of by-product fluorspar was shipped by a silica producer in British Columbia. The Newfoundland fluorspar shipped is largely of submetallurgical or metallurgical grade, although one operator has facilities to produce acid-grade fluorspar and prefers to market it.

Another company ships submetallurgical-grade concentrate to its own plant at Arvida, Quebec, for further processing.

At 10,310 tons, exports to the United States, all from Newfoundland, were almost three times as great as in 1959. Canada's fluorspar imports, mainly from Mexico, increased substantially to an all-time high of almost 60,000 tons. Most of this material was consumed in Canada, in steelmaking and similar fluxing operations, but part was required for aluminum production and other industrial uses.

Imports of cryolite, used in the production of aluminum, reached a three-year high of more than 8,000 tons. Natural cryolite (Na_3AlF_6) is mined in Greenland; artificial cryolite is manufactured from fluorspar.

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*Mineral Processing Division, Mines Branch.

Fluorspar - Production, Trade and Consumption

	1960		1959	
	Short Tons	$	Short Tons	$
Production (shipments) (1)				
Newfoundland..........		1,820,769		1,749,903
Ontario................		100,811		100,594
British Columbia		240		-
Total..................		1,921,820		1,850,497
Exports (2)				
United States...........	10,310	262,114	3,774	73,078
United Kingdom (3)	2	49,875	-	-
Total..................	10,312	311,989	3,774	73,078
Imports				
Mexico	51,359	1,241,772	24,709	633,182
Union of South Africa....	6,826	175,093	-	-
United States...........	925	46,834	1,519	72,466
United Kingdom.........	580	22,408	360	13,126
Total..................	59,690	1,486,107	26,588	718,774

	1960	1959
Consumption		
Metallurgical flux	25,784	20,752
Glass	628	3,116
Other (including aluminum production)..	85,423	72,148
Total..................	111,835	96,016

Source: Dominion Bureau of Statistics.

(1) Tonnage not available for publication after 1957.
(2) Exports for 1959 and 1960 are as recorded in Trade of Canada.
(3) Shipment of clear crystal fluorite as mineralogical specimens and for optical use.

Fluorspar - Production, Trade and Consumption
(short tons)

	Production(1)	Exports(2)	Imports	Consumption
1950	64,213	14,238	1,572	52,137
1951	74,211	21,461	8,188	57,526
1952	82,187	18,675	22,714	68,748
1953	88,569	22,079	20,161	83,116
1954	118,969	34,756	16,240	80,610
1955	128,114	58,390	21,774	87,927
1956	140,071	78,380	28,148	96,126
1957	66,245	23,630	14,547	70,761
1958	1,542,589(3)	7	30,408	89,933
1959	1,850,497(3)	3,774	26,588	96,016
1960	1,921,820(3)	10,312	59,690	111,835

Source: Dominion Bureau of Statistics except where otherwise indicated.
(1) Producers' shipments. Only the dollar value was reported after 1957.
(2) Exports for 1950 to 1954, inclusive, to the United States are recorded in United States import statistics but are not shown in the official Canadian export statistics. The export figures for the years after 1954 are as recorded in Trade of Canada.
(3) According to the United States Bureau of Mines Mineral Market Report MHS No. 3261, tonnages for 1958, 1959 and 1960 are estimated as 62,000,74,000 and 78,000.

In 1960 The British American Oil Company Limited built a hydrofluoric-acid alkylation unit at its Clarkson, Ontario, refinery. Five hydrofluoric-acid alkylation units are now operating in Canada to manufacture high-octane gasolines, which they can produce at the rate of 6,600 barrels a day. Hydrofluoric acid is also used in Canada in the making of fluorinated hydrocarbons for refrigerants and propellants and in the production of uranium metal.

Hydrofluoric acid is produced in Canada by two companies, both in Quebec - Aluminum Company of Canada, Limited, at Arvida, for captive use, and Nichols Chemical Company Limited, at Valleyfield, for general trade.

Producing Companies

The fluorspar mines of Newfoundland are on the Burin Peninsula, where two companies have produced for many years. Numerous veins and ore zones have been found and several have yielded substantial quantities. The ore occurs in a granitic rock, and the silica content makes it difficult to meet metallurgical fluorspar-grade specifications. The ore, however, is a satisfactory source of acid-grade concentrate, and most of it is used for this purpose. The reserves are not accurately known but are obviously large. The mines are wet and the pumping of large volumes of water adds considerably to operating costs but does not seriously affect production.

Newfoundland Fluorspar Limited, a subsidiary of Aluminum Company of Canada, Limited, and currently the largest producer, ships submetallurgical-grade concentrate to the parent company, at Arvida, Quebec. Here it is further concentrated to acid grade and made into hydrofluoric acid, which is used to produce artificial cryolite for the manufacture of aluminum. The company operates one large mine, the Director, which is one of the world's best sources of fluorspar. Shipments were slightly higher in 1960 than in 1959 in spite of interruptions due to a change-over from shrinkage to cut-and-fill stoping and to local problems. A radiation hazard discovered and investigated by the Department of National Health and Welfare was controlled by an increase in underground ventilation. Radiation of a similar nature has been encountered in uranium and other types of mines in Canada, the United States, and Europe.

The company installed a hydraulic backfill system and made plans to deepen the shaft by 400 feet to a total of 950 feet. These changes will improve efficiency and permit substantially increased production during 1961.

Before being shipped to Arvida, the ore is concentrated in a heavy-media plant with a rated capacity of 30 tons an hour.

St. Lawrence Corporation of Newfoundland Limited has operated fluorspar mines on the Burin Peninsula almost continuously since 1933. In 1956 it produced more than 72,000 tons. In 1957, on completion of a contract with the General Services Administration of the United States, the company found it difficult to compete with Mexican and European fluorspar in United States markets; during the latter part of that year and throughout 1958, it did not produce. Resumed in 1959 on a small scale, production increased substantially in 1960. Shipments, mostly to the United States, totalled more than 7,000 tons and were about equally divided between acid- and metallurgical-grade concentrate.

The company has produced more than 500,000 tons of fluorspar concentrate and has operated mines on several veins and zones. For many years, the Iron Springs mine was a large producer. The Blue Beach vein or zone, the main source of ore at present, is reported to be 1.5 miles in length and up to 70 feet in width. In 1960 a new vein, known as the Valley vein, was explored and developed by means of a shaft. Widths of 10 feet of better-than-average grade have been reported and the structure has been traced for more than 1,000 feet.

The company expects to increase production in 1961, perhaps to 20,000 tons of acid-grade concentrate; and rather than make metallurgical sales, it will try to increase acid-grade sales in the United States, where the consumption of this material is growing.

Ore from various mines operated by the company is concentrated by heavy-media methods. The product is then treated by grinding and flotation to produce acid-grade concentrate. The plant where the grinding and flotation take place has a capacity of 100 tons a day.

Huntingdon Fluorspar Mines Limited, at Madoc, in eastern Ontario, has produced metallurgical-grade fluorspar for many years. Mines in the Madoc area have been in operation for more than 40 years, but the output has varied widely - from nothing in 1926-28 to more than 11,000 tons in 1948. In recent years as much as 2,000 tons a year has been shipped to Canadian steel mills. During 1960 production was obtained from two mines - the Perry and the Coe.

In 1960, in addition, the company made a shipment of clear crystal fluorspar to the United Kingdom. Fluorspar of this type, which is comparatively rare, may be used for optical purposes. It commands a much higher price than the industrial grades.

Pacific Silica Limited, which operates a silica quarry at Oliver, British Columbia, occasionally recovers metallurgical-grade fluorspar as a by-product. It has shipped fluorspar to foundries in Vancouver.

Other Occurrences

A large number of fluorspar occurrences are known to exist in Canada from Labrador to Yukon Territory, but most are only of mineralogical interest. Some will probably be of value in the future, and one or two are of such a size and grade that with the solution of processing problems or the lowering of transportation costs they might become interesting immediately.

Fluorspar and barite occur together near Lake Ainslie, Nova Scotia, but the low grade has limited production to a few tons obtained during wartime. An occasional small shipment has been made from the Wilberforce area of Ontario and from western Quebec, but the occurrences have not been capable of sustained production. Numerous small occurrences of fluorspar found along the north shore of Lake Superior are of interest but are not of importance at present.

In British Columbia, considerable amounts of fluorspar were produced in past years from the Rock Candy mine of The Consolidated Mining and Smelting Company of Canada Limited. This mine is reported to have produced more than 42,000 tons between 1918 and 1942, inclusive, and its reserves are believed to be still large. Fluorspar occurs at the property of Rexspar Minerals & Chemicals Limited, near Birch Island, British Columbia. The mineral is finely disseminated and, although the tonnage is large, no economic method of recovering the fluorpar has yet been found. Research on this problem was in progress during 1960.

A large deposit of fluorspar, barite, and witherite discovered in northern British Columbia is of interest. Because of its remoteness, however, it is at present of little value.

World Review

Fluorspar is used mainly in the large, highly industrialized countries, where, because of the growing needs of the steel, aluminum, and chemical

World Production of Fluorspar
(short tons)

	1960	1959
Mexico	399,859	362,456
China	275,000(e)	220,000
United States	229,782(1)	185,091
U.S.S.R.	210,000(e)	190,000
Italy	167,454	174,091
West Germany	133,403	126,280
France	132,277	99,208
Spain	119,036	98,318
Other countries	493,189	399,556
Total	2,160,000	1,855,000

Source: U.S. Bureau of Mines, Minerals Yearbook, 1960.
(e) Estimated.
(1) Shipments.

industries, its consumption is steadily growing. Although the smaller nations individually use relatively minor quantities, their combined consumption is becoming significant. The large countries that are less developed industrially but are making determined efforts to modernize will probably use increasing amounts. Among them are China, India, and several lands in South America and Africa, in all of which fluorspar undoubtedly occurs. Only China, however, is known to have supplies available for immediate use.

While the demand for fluorspar for primary metallurgical uses is expected to increase, the more highly developed countries need additional supplies for chemical purposes. The demand for fluorine chemicals for aerosols, refrigerants, and noncorrosive plastics is rapidly rising in the United States. Canada, Europe, and Latin America, and has begun to develop in other countries.

Recognizing these trends, the large aluminum and fluorine-chemical producers have felt concern for their future supplies of fluorspar. The result has been active exploration for fluorspar in the United States and Mexico and efforts to encourage production in other countries. In 1960 the United States Bureau of Mines scheduled several research projects on fluorspar and fluorine compounds ranging from efforts to beneficiate complex ores to attempts to produce cryolite and other fluorine compounds directly from low-grade or complex fluorine-bearing materials.

At 229,782 tons, production in the United States in 1960 was higher than in 1959 but considerably below the output of 1958 and earlier years. Imports totalled 534,020 tons, and consumption, at 643,759 tons, was the highest on record. The consumption of acid-grade fluorspar for fluorine chemicals continued to increase.

Interest in the fluorspar deposits of Mexico is growing, and United States, Canadian, and native companies are expanding their operations in that country. As 1960 ended, foreign companies were awaiting the announcement of the 'Mexicanization' of the mining industry. They expected the new laws to increase Mexican participation in operating companies but not to limit or discourage production, since most of Mexico's fluorspar output is exported.

In 1960, the Mexican output totalled about 399,859 tons. The greater part of it was exported to the United States and Canada, but shipments were also made to several other countries. Production is drawn from several large mines (some of which can produce as much as 70,000 tons a year) operated by major mining and chemical companies and from many smaller mines operated on a short-term or intermittent basis by local Mexican companies. Most of the fluorspar-mining areas are in the north-central part of the country, between the city of San Luis Potosí and the United States border, although there are large deposits farther south and west.

The Las Cuevas mine, near San Luis Potosí, is owned by a group of Canadian mining companies including Waite Amulet Mines, Limited; and Aluminium Limited has a mine and mill in the State of Sonora.

Late in 1960, the Dow Chemical Company mill in northern Coahuila made its first shipment of acid-grade concentrate. New plants were reported to be operating at two other locations, a third was being doubled in size, and the building of another large one was being planned for 1961. All will produce acid-grade fluorspar concentrate. General Chemical Division of Allied Chemical Corporation, New York, announced it would provide Mexican interests with technical information for the establishment of Celulosa y Derivados, S. A., which will produce hydrofluoric acid and fluorinated hydrocarbons for Latin America.

The United Kingdom and France increased their fluorspar production. These countries and West Germany are producing and marketing fluorine chemicals. A French company reported the sale of more than 3 million cooking utensils lined with a fluorocarbon plastic (Teflon) for fatless cooking, some of which were exported to the United States. The United States also received 204,000 tons of fluorspar from Italy and Spain, which produce it in substantial quantities.

The Union of South Africa is the only important African producer. Its 1960 output totalled 113,550 tons, about 111,488 of which were exported, mostly (58,790) to Japan.

In the whole of Asia, fluorspar production is apparently limited to China and the Asiatic part of the Union of Soviet Socialist Republics, where substantial tonnages have been mined in recent years, and to Japan and Korea, where the output is small and variable. Other Asiatic countries undoubtedly have deposits, which will be developed when growing industrial activity requires them. An example is India, where imports satisfy present needs (some 12,000 tons a year) but where domestic deposits are being opened to obtain metallurgical-grade fluorspar for the native steel industry.

Information on fluorspar production and consumption in Communist-bloc countries is limited, but there is evidence that the output is relatively large and is increasing. The bulk comes from China, the U.S.S.R., and East Germany, and smaller amounts are recovered in Bulgaria. The U.S.S.R. also probably recovers fluorides in the processing of nepheline-apatite rock at a plant on the Kola Peninsula.

The world consumption of fluorspar is hard to estimate. In 1960, it probably totalled 1,500,000 tons. In the approximate order of their importance the main consumers are the United States, the U.S.S.R., West Germany, France, the United Kingdom, Canada, East Germany, and Japan.

Technology

Two developments in the use of fluorspar as a flux are of interest and may be significant.

In the United States, fluorspar fines have been made into bricks or briquettes for metallurgical use and have been accepted by some consumers. Previous attempts to serve the metallurgical market with briquetted fines were generally unsuccessful because of impurities introduced by binders, insufficiency of output and consequent unreliability of supply, and the availability of natural lump fluorspar. Competition from Mexico and Europe has since reduced the production of metallurgical-grade fluorspar in the United States, and the use of the manufactured brick now provides an alternative to complete reliance on foreign sources. Deposits unsuitable as sources of the metallurgical lump grade and plants not equipped to produce it may nevertheless be used for the manufacture of bricks made of fines. If the consumers are satisfied, the producers can operate more efficiently and turn out larger quantities to serve both the acid-grade and the metallurgical markets.

During 1960 Quebec Iron and Titanium Corporation produced a slag-thinner called 'Sorelflux.' This material is a by-product of the ilmenite-processing operation and can be marketed at about one third the cost of metallurgical-grade fluorspar. Described as a complex calcium-magnesium-aluminum silicate with titanium oxide, it has been tested in Canadian steel plants and foundries and appears to serve the same purpose as fluorspar, particularly in high-temperature basic-steel furnaces. Its acceptance as an alternative to metallurgical fluorspar would reduce fluorspar imports, lower production costs in steel plants, provide additional markets for products of the ilmenite-processing industry, and conserve fluorspar supplies for more essential uses in aluminum and chemical production.

Uses and Specifications

Fluorspar is consumed in two general ways - as a metallurgical and ceramic flux and as the source material for hydrofluoric acid, fluorine gas, and the fluorine chemical compounds made from them. For metallurgical purposes, the mineral is used in its natural state after concentration and elimination of associated waste. When it is a source material for chemicals, preparation of the raw material is more detailed and the specifications are strict.

In the steel industry, fluorspar is used as a flux to assist in the melting of the ore charge and to improve the separation of metal and slag. Other materials have been used, but few are comparable to fluorspar in efficiency. Fluorspar for metallurgical purposes must be in coarse sizes (2 inches to 3/8 inch), since fine material would float on the surface of the melt or be carried up the stack by draft.

For ceramic purposes, a finer-grained and purer concentrate is used as a flux in glass and in enamel melts.

Large amounts of fluorspar are consumed in aluminum production, and no adequate substitute is known. Fluorspar is processed to acid-grade purity and made into hydrofluoric acid, which is then used to make cryolite. Aluminum metal is produced by the Hall electrolytic process from a molten solution of alumina and cryolite.

Fluosilicic acid and sodium fluoride are used to fluoridate public water supplies to reduce children's dental cavities. Recently, natural calcium fluoride (fluorspar) has also come to be used for this purpose.

The amount of fluorspar used by the fluorine-chemical industry is increasing each year. The materials consumed are of two general classes - fluorine materials for industrial processes such as uranium-processing, the alkylation of gasoline, ore treatment, and production of high-energy missile fuels; and fluorine and hydrofluoric acid for the manufacture of refrigerants, propellent gases, chemicals, and the numerous fluorocarbon-plastic intermediates and fluorocarbon-plastic consumer articles. It has been estimated that fluorspar requirements for chemical purposes will more than double in the next 10 years. For these various uses, the following three grades of fluorspar are marketed.

Standard-fluxing-gravel or lump grade - Used for metallurgical purposes, this is usually sold on a specification of a minumum of 85 per cent CaF_2 (fluorspar) and maxima of 5 per cent SiO_2 (silica) and 0.3 per cent sulphur. Fines should not exceed 15 per cent.

Ceramic, glass, or enamel grade - This calls for not less than 94 per cent CaF_2 with maxima of 3.5 per cent $CaCO_3$ (calcium carbonate), 3 per cent SiO_2, and 0.1 per cent Fe_2O_3 (ferric oxide). The material must be in mesh sizes ranging from coarse to extra-fine.

Acid grade - This has the most rigid specifications. It must be more than 97 per cent CaF_2 and not more than 1 per cent SiO_2. Like the ceramic grade, it is used in powdered form.

Prices

Canada

Ceramic grade, 94% CaF_2, coarse, Aluminum Company of Canada, Limited, per net ton f.o.b. Arvida, Quebec	$61.50		
Acid grade, Mexican, offered Canadian trade at U.S. price minus $8.50 U.S. import duty, per ton, in Canadian funds, approximately	$36.00		

United States (per short ton as reported in E & M J Metal and Mineral Markets of Dec. 29, 1960)

Metallurgical grade, f.o.b. Kentucky and Illinois			
Effective CaF_2 content 72 1/2%	$37.00	to	$41.00
" CaF_2 " 70%	$36.00	"	$40.00
" CaF_2 " 60%	$33.00	"	$36.00
Acid-grade concentrates, dry, bulk, carload, f.o.b. Kentucky, Illinois, and Colorado			
Spot	$49.00	to	$50.00
Contracts	$45.00		
Pellets	$55.00		
Bags	$ 3.00 extra		
Ceramic grade			
95% CaF_2	$45.00	to	$48.00
93-94% CaF_2, calcite and silica variable, Fe_2O_3 0.14%,bulk, f.o.b. Kentucky and Illinois	$43.00	"	$45.00
In 100-lb paper bags	$ 3.00 extra		
European, c.i.f. U.S. ports, duty paid			
Metallurgical, effective CaF_2 72 1/2%			
Spot	$33.00	to	$34.00
Contracts	$32.00	"	$34.00
Acid grade			
Spot	$51.00		
Contracts	$50.00		
Mexican, f.o.b. border, effective CaF_2 72 1/2%			
All rail, duty paid	$26.50	to	$28.50
Barge, Brownsville, Tex.	$28.50	"	$30.50

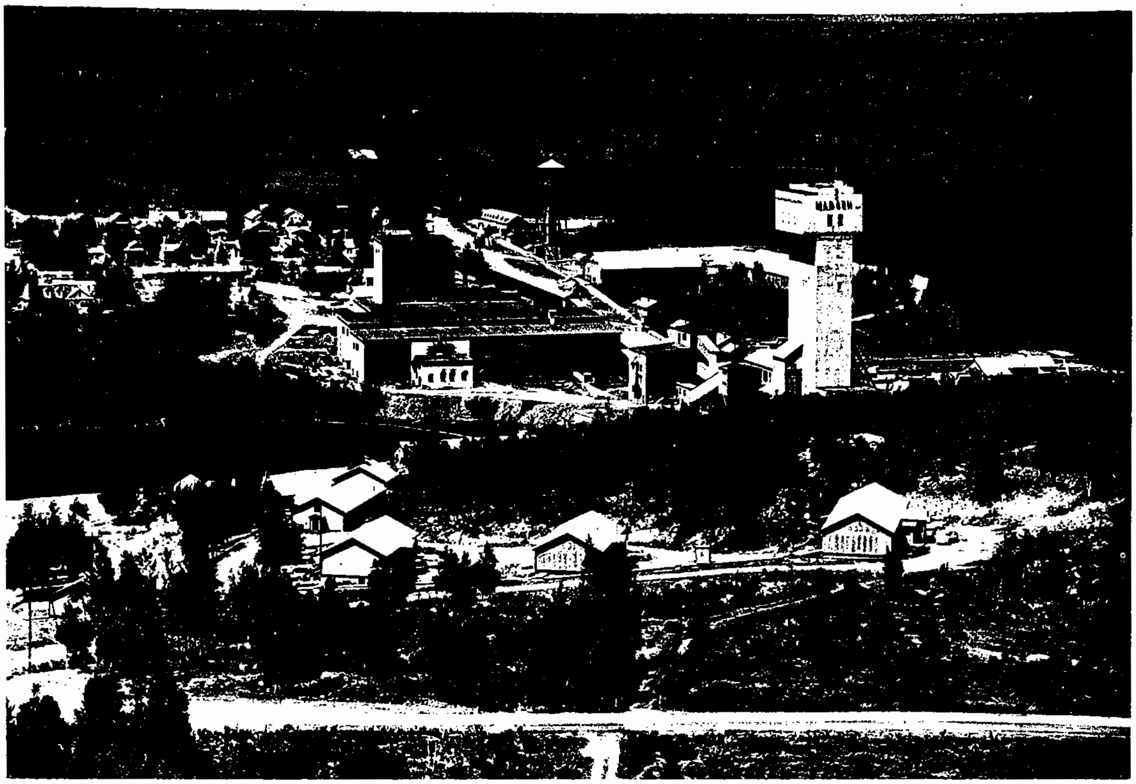
Tariffs

Canada

Fluorspar	free

United States

Fluorspar containing not more than 97% CaF_2, per long ton	$ 8.40
Fluorspar containing more than 97% CaF_2, per long ton	$ 2.10



Madsen Red Lake Gold Mines Limited in the Red Lake district of northwestern Ontario.

GOLD

T.W. Verity*

Conditions throughout the gold-mining industry in 1960 were more favorable than in the preceding year, with the result that gold production increased. Prices also rose, the Royal Canadian Mint annual average being 38 cents a fine troy ounce higher than in 1959. An upswing in the price of gold that occurred late in the year on international markets brought an increase in the earnings of gold mines selling on the open market.

A 1958 amendment to the Emergency Gold Mining Assistance Act had raised cost assistance to qualifying mines by 25 per cent, and an additional amendment, passed in 1960, extended these benefits for three years - to the end of 1963. To obtain cost assistance under the Act, Canadian gold mines must sell directly to the Royal Canadian Mint in Ottawa. Of the 54 lode-gold mines in operation during the year, 42 received this cost assistance. The others, because their costs were lower, did not qualify. Most of the non-qualifying lode-gold mines sold on the open market, where about half of Canada's 1960 gold production was available for sale.

Labor costs were higher, but the rise caused in the Mint price by the decline in the value of the Canadian dollar in relation to the United States dollar helped the industry to meet them. Material and power costs were also higher. Had it not been for the increase in the Mint price of gold and in the cost assistance provided for in the Emergency Gold Mining Assistance Act, many older mines, faced with a decline in ore reserves and having access only to lower-grade ore, would have been unable to continue operations. Three mines were closed during 1960, and two new mines began operations.

The Dominion Bureau of Statistics places the year's gold production at 4,628,911 fine troy ounces valued at $157,151,527. The final total for 1959 was 4,483,416 fine ounces valued at $150,508,275. In 1960, the volume produced was the highest since 1942 and the value was the highest since 1955, when an ounce of fine gold was valued at $34.52. Production increased in all producing provinces except Alberta. Ontario, with 59 per cent of the total, remained the principal producer, followed by Quebec with 22.4 per cent, the Northwest Territories with 9 per cent and British Columbia with 4.5 per cent.

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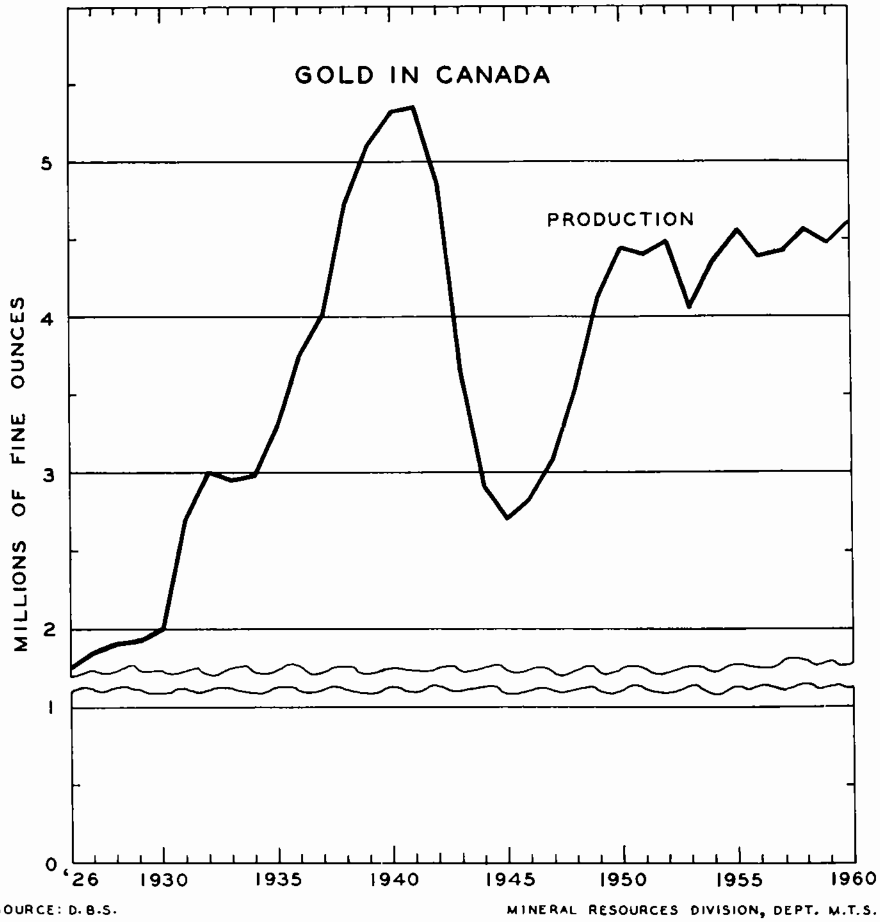
*Mineral Resources Division.

Production of Gold
(fine ounces)

		1960	1959
Nfld.	Base-metal mines...........	13,515	13,411
N.B.	Base-metal mines...........	-	-
N.S.	Auriferous quartz	3	-
Que.	Auriferous quartz		
	Cadillac-Malartic..........	298,635	294,690
	Bourlamaque-Louvicourt ...	287,156	267,048
	Noranda-Belleterre	36,489	40,828
	Chibougamau	19,043	17,537
	Miscellaneous	-	8
	Total	641,313	620,111
	Base-metal mines...........	394,601	379,277
	Total	1,035,914	999,388
Ont.	Auriferous quartz		
	Porcupine	1,084,537	1,089,699
	Larder Lake	592,244	567,304
	Patricia Portion	511,323	484,552
	Kirkland Lake	332,939	352,250
	Thunder Bay	106,358	103,228
	Sudbury..................	39,035	36,350
	Miscellaneous	97	129
	Total	2,666,533	2,633,512
	Base-metal mines...........	66,140	49,937
	Total	2,732,673	2,683,449
Man.	Auriferous quartz	31,172	29,487
	Base-metal mines...........	21,590	21,699
	Total	52,762	51,186
Sask.	Base-metal mines...........	84,775	78,588
Alta.	Placer operations	191	200
B.C.	Auriferous quartz	173,241	163,042
	Base-metal mines...........	37,120	15,456
	Placer operations	2,498	5,814
	Total	212,859	184,312
N.W.T.	Auriferous quartz	418,104	405,922
Yukon	Placer operations	78,115	66,960
Canada	Auriferous quartz	3,930,366	3,852,074
	Base-metal mines...........	617,741	558,368
	Placer operations	80,804	72,974
	Total	4,628,911	4,483,416
Canada	Total value	$157,151,527	$150,508,275
	Average value per ounce	$33.95	$33.57

Source: Dominion Bureau of Statistics.



Production from auriferous-quartz (lode-gold) mines was estimated at 3,930,366 fine ounces valued at $133,435,926. This value was 3 per cent greater than that of the 1959 output of 3,852,074 fine ounces valued at $129,314,124. Gold recovered as a by-product from base-metal ores increased by 10.6 per cent to 617,741 fine ounces from 558,368 ounces. Placer-gold production increased to 80,804 fine ounces from the 72,974 produced in 1959.

Among the minerals produced in Canada, gold maintained its position as sixth in value. It followed crude petroleum, nickel, uranium oxide, copper, and iron ore. In the Free World, Canada was second to the Union of South Africa, the chief gold-producing country. The United States Bureau of Mines reports that in 1959 South Africa produced 21,383,019 fine ounces of gold, Canada 4,628,911 the United States 1,679,800 and Australia 1,082,784. Production in the Union of Soviet Socialist Republics was estimated by the American Bureau of Metal Statistics to be 11 million ounces.

Gold Production,1950–60
(fine ounces)

Year	Auriferous-quartz Mines	%	Placer Operations	%	From Base-metal Ores	%	Total Gold Production	Total Value in Canadian Dollars	Average Value per Ounce in Canadian Funds	Gold - % of All Mineral Production Value
1950	3,764,757	84.8	108,143	2.4	568,327	12.8	4,441,227	168,988,687	38.05	16.2
1951	3,709,601	84.5	96,441	2.2	586,709	13.3	4,392,751	161,872,873	36.85	13.0
1952	3,823,747	85.5	92,843	2.1	555,135	12.4	4,471,725	153,246,016	34.27	11.9
1953	3,509,527	86.6	77,505	1.9	468,691	11.5	4,055,723	139,597,985	34.42	10.4
1954	3,738,955	85.7	89,571	2.1	537,914	12.2	4,366,440	148,764,611	34.07	10.0
1955	3,866,124	85.2	78,621	1.7	597,217	13.1	4,541,962	156,788,528	34.52	8.7
1956	3,704,870	84.5	74,919	1.7	604,074	13.8	4,383,863	151,024,080	34.45	7.2
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

Source: Dominion Bureau of Statistics.

Operations at Producing Mines

Newfoundland

Gold was recovered as a by-product from the lead-zinc ores of American Smelting and Refining Company, Buchans Unit, in the central part of the province, and the copper ores of the Tilt Cove operation of Maritimes Maritimes Mining Corporation Limited, on the northeast coast. The gold-production total was slightly higher than in 1959.

Maritime Provinces

No gold production was reported from New Brunswick and only three ounces were recovered from an old lode-gold mine in Nova Scotia.

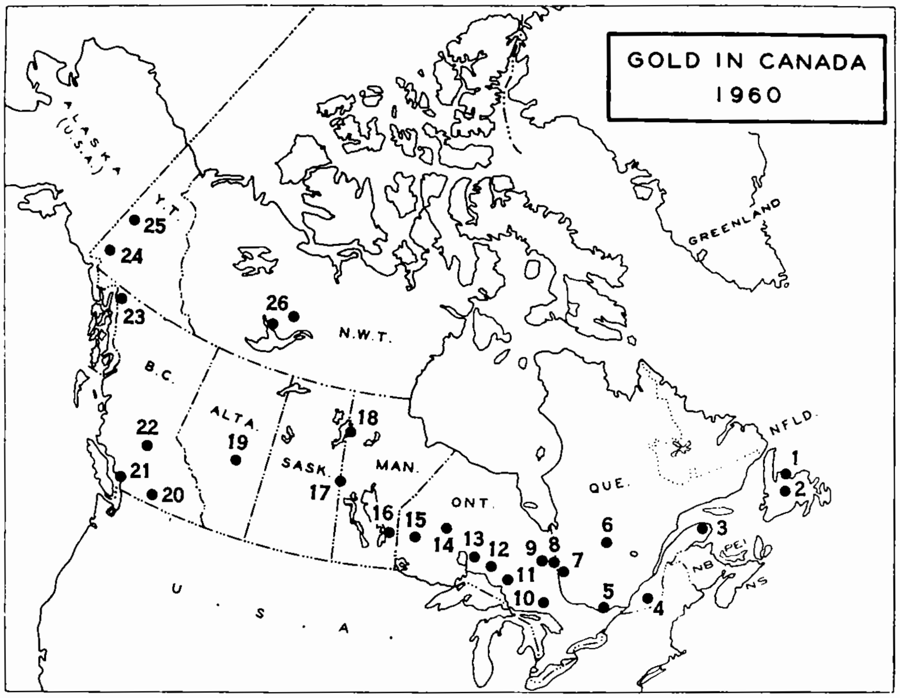
Quebec

Thirteen auriferous-quartz mines operated in 1960. One new mine started to operate in the Louvicourt area, and one mine closed in the Chibougamau district. Gold production from all sources increased by 3.7 per cent. That from auriferous-quartz mines increased by 3.4 per cent, while gold recovery from base-metal mines increased by 4.0 per cent. Gold from base-metal mines was 38 per cent of the total, the same as in 1959.

Auriferous-quartz Mines

Cadillac-Malartic District

Five lode-gold mines continued to operate in the district, and gold production increased slightly. Barnat Mines Ltd. began stoping operations in its porphyry-ore zone and increased its daily tonnage by nearly 100 per cent and its gold production by 75 per cent. Canadian Malartic Gold Mines Limited carried out underground exploration work, but results were disappointing. East Malartic Mines, Limited, Quebec's second-ranking lode-gold mine, was deepening its No. 4 shaft below the 23rd level to the 5,000-foot horizon to open seven new levels. Malartic Gold Fields Limited planned a new program of surface drilling to test the southwest corner of the property. The Gold Fields mill treated ore from the Barnat and Norlartic mines as well as its own. Norlartic Mines Limited, north of the property of Marban Gold Mines Limited, began to ship ore to the Gold Fields mill in June 1959.



MINERAL RESOURCES DIVISION, DEPT. M.T.S.

Producers and Prospective Producers

*Base metals ***Placer
**Auriferous quartz ****Prospective producer

Newfoundland
1. Maritimes Mining Corp. Ltd. (Tilt Cove)*
2. American Smelting and Refining Co. (Buchans Unit)

Quebec
3. Gaspe Copper Mines, Ltd.*
4. Chaudière River placers*** ****
5. New Calumet Mines Ltd.*
6. Chibougamau District
   Campbell Chibougamau Mines Ltd.*
   Anacon Lead Mines Ltd. (Chibougamau Operation)**
   Copper Rand Chibougamau Mines Ltd.*
   Opemiska Copper Mines (Quebec) Ltd.*
   Merrill Island Mining Corp., Ltd.*
7. Rouyn-Belleterre District
   Elder Mines and Developments Ltd.**
   Eldrich Mines Ltd.**
   Noranda Mines, Ltd.*
   Quemont Mining Corp., Ltd.*
   Waite Amulet Mines, Ltd.*
   Cadillac-Malartic District
   Barnat Mines Ltd.**
   Canadian Malartic Gold Mines Ltd.**
   East Malartic Mines Ltd.**
   Malartic Gold Fields Ltd.**
   Marban Gold Mines Ltd.** ****
   Norlartic Mines Ltd.**
   Bourlamaque-Louvicourt District
   Akasaba Gold Mines Ltd.**
   Bevcon Mines Ltd.**
   Lamaque Mining Co. Ltd.**
   Sigma Mines (Quebec) Ltd.**

Sullivan Consolidated Mines Ltd.**
East Sullivan Mines Ltd.*
Manitou-Barvue Mines Ltd.*
Duparquet District
Normetal Mining Corp., Ltd.*

Ontario

8. Larder Lake District
Kerr-Addison Gold Mines Ltd.**
Kirkland Lake District
Kirkland Minerals Corp. Ltd.**
Lake Shore Mines Ltd.**
Macassa Mines Ltd.**
Sylvanite Gold Mines, Ltd.**
Teck-Hughes Gold Mines, Ltd., The**
Upper Canada Mines Ltd.**
Wright-Hargreaves Mines, Ltd.**

9. Porcupine District
Aunor Gold Mines Ltd.**
Broulan Reef Mines Ltd.**
Coniaurum Mines Ltd.**
Delnite Mines, Ltd.**
Dome Mines Ltd.**
Hallnor Mines, Ltd.**
Hollinger Consolidated Gold Mines, Ltd.**
Hollinger Ross mine**
Hugh-Pam Porcupine Mines Ltd.**
McIntyre-Porcupine Mines, Ltd.**
Pamour Porcupine Mines, Ltd.**
Paymaster Consolidated Mines, Ltd.**
Preston Mines Ltd.**

10. Sudbury Mining Division
International Nickel Co. of Canada, Ltd., The*
Falconbridge Nickel Mines, Ltd.*

11. Renabie Mines Ltd.**

12. Port Arthur Mining Division
Geco Mines Ltd.*
Willroy Mines Ltd.*
North Coldstream Mines Ltd.*

13. Thunder Bay District
Leitch Gold Mines Ltd.**
MacLeod-Cockshutt Gold Mines Ltd.**
Consolidated Mosher Mines Ltd.** ****

14. Patricia Mining Division
Pickle Crow Gold Mines Ltd.**

15. Red Lake Mining Division
Campbell Red Lake Mines Ltd.**
Cochenour Willans Gold Mines, Ltd.**
Dickenson Mines Ltd.**
Madsen Red Lake Gold Mines Ltd.**
McKenzie Red Lake Gold Mines Ltd.**
H.G. Young Mines Ltd.**

Manitoba

16. San Antonio Gold Mines Ltd.**
Forty-Four Mines Ltd.**

17. Hudson Bay Mining and Smelting Co., Ltd.*

18. Sherritt Gordon Mines, Ltd.*

Alberta

19. Small placer operations on North Saskatchewan River***

British Columbia

20. Consolidated Mining and Smelting Co. of Canada Ltd., The (Kimberley)*
Phoenix Copper Company Ltd. (Greenwood)*
French Mines Ltd.**
Consolidated Woodgreen Mines Ltd.*

21. Howe Sound Company (Britannia Division)*

22. Bralorne Pioneer Mines Ltd. (Bralorne and Pioneer divisions)**
Cariboo Gold Quartz Mining Co. Ltd., The**
Small placer operations***

23. Small placer operations***

Yukon Territory

24. Burwash Mining Co. Ltd.***
and smaller operations***

25. Yukon Consolidated Gold Corp. Ltd., The***
Yukon Explorations Ltd.***
and smaller operations***

Northwest Territories

26. Consolidated Mining and Smelting Co. of Canada Ltd., The (Con and Rycon mines)**
Giant Yellowknife Mines Ltd.**
Consolidated Discovery Yellowknife Mines Ltd.**
Taurcanis Mines Ltd.** ****
and other small gold mines****

Bourlamaque-Louvicourt District

Five lode-gold mines operated in the district, one more than in 1959. Gold production increased by 7.5 per cent, and all the mines except Bevcon Mines Limited had an increase in gold output. Akasaba Gold Mines Limited, the new producer, began to ship ore to the Bevcon mill on March 1, 1960. Lamaque Mining Company Limited, Quebec's largest lode-gold mine, planned a new production shaft to open three levels on the southeast corner of its property. Sigma Mines (Quebec) Limited was sinking an internal shaft 1,000 feet below the 24th level to about 4,150 feet below the surface. Sullivan Consolidated Mines, Limited increased its mill rate to 750 tons a day and modified its mill circuit to provide for flotation followed by cyanidation of flotation concentrates, rather than for straight cyanidation as previously.

Noranda-Belleterre District

The only two lode-gold mines working were Elder Mines and Developments Limited and its subsidiary Eldrich Mines Limited. Both these mines continued to truck gold ore to the Noranda smelter, where it is used as a flux and the gold content is recovered as a by-product.

Chibougamau District

Anacon Lead Mines Limited (Chibougamau Operation), 40 miles west of Chibougamau, is the only mine in the district classed as an auriferous-quartz mine. This mine was closed in August 1960 for an indefinite period. Mine and mill equipment was left intact pending possible reopening.

Base-metal Mines

About 94 per cent of the gold from base-metal ores was recovered through the Noranda smelter and the Montreal East refinery of Canadian Copper Refiners Limited.

Ontario

Thirty-one auriferous-quartz mines operated, one more than in 1959. Gold production from lode-gold mines increased by 1.3 per cent and by-product gold from base-metal mines by 32 per cent. All districts except the Porcupine and Kirkland Lake camps increased their gold production. One new mine started production in the Red Lake area, but another closed at Kirkland Lake.

Auriferous-quartz Mines

Porcupine District

Thirteen lode-gold mines continued to operate in the district, which is Canada's leading gold-producing area. Milled tonnage increased, but the lower grade of the ore worked resulted in a drop of 0.5 per cent in gold production. Union agreements signed in 1959 and early 1960 resulted in higher labor costs throughout the camp. The cost of powder and other materials also increased, and many older producers had difficulty in maintaining production. None of the mines ceased operation, but Coniaurum Mines, Limited is expected to close early in 1961.

Hollinger Consolidated Gold Mines, Limited, Canada's second-ranking gold producer, increased its output by more than 7 per cent but had higher operating costs. McIntyre-Porcupine Mines, Limited had a 3 1/2-per-cent drop in production, while Dome Mines Limited increased its output by 1 per cent.

Aunor Gold Mines Limited, Broulan Reef Mines Limited, Coniaurum Mines, Limited, Hallnor Mines, Limited, Hugh-Pam Porcupine Mines Limited, Paymaster Consolidated Mines, Limited, and Preston Mines Limited, were all carrying out exploration programs to find new ore, but the lower grades of ore milled resulted in a decrease in gold production. Delnite Mines, Limited, Pamour Porcupine Mines, Limited, and the Hollinger Ross mine at Holtyre increased their milled tonnage and mined a higher grade of ore, with the result that their gold outputs were higher. Preston East Dome Mines, Limited, combined with Stanleigh Uranium Mining Corporation Limited in August 1960 to form a new company known as Preston Mines Limited.

Larder Lake District

Kerr-Addison Gold Mines Limited, Canada's leading gold producer, once again increased the tonnage milled and the volume of gold produced. Development of new levels below the 3,850-foot level was under way at the new No. 4 internal shaft.

Patricia Portion

Six lode-gold mines operated in the Red Lake mining division and one, the Pickle Crow mine, in the Patricia mining division. Gold production increased by 5.5 per cent. All mines increased their gold output. One new lode-gold mine, H.G. Young Mines Limited, started in August 1960 to truck ore 16 miles to the former Starratt Olsen mill.

Campbell Red Lake Mines Limited, the leading producer, completed the deepening of its main production shaft to 3,180 feet and was starting the developing of seven new levels. Madsen Red Lake Gold Mines Limited, the second-ranking producer, was also developing new levels. New Dickenson Mines Limited merged with Lake Cinch Mines Limited in October 1960 and formed a new company, Dickenson Mines Limited. Cochenour Willans Gold Mines, Limited, was developing its lower levels. McKenzie Red Lake Gold Mines Limited found new ore on the 1,450- and 1,600-foot levels, in the 'south' mine. Pickle Crow Gold Mines, Limited, at Pickle Lake, increased its milled tonnage and its gold production.

Kirkland Lake District

Seven lode-gold mines continued to operate, but Kirkland Minerals Corporation Limited closed in September 1960 and was cleaning up the mill circuit and salvaging mill equipment in October. Sylvanite Gold Mines, Limited, is expected to close by the summer of 1961. Gold production in the district was 5 1/2 per cent lower in 1960.

Macassa Mines Limited, the leading producer, maintained gold production close to the 1959 level. The other large producers - Lake Shore Mines, Limited and Wright-Hargreaves Mines, Limited - had a decrease in gold production. Upper Canada Mines, Limited improved its gold output, deepened its No. 1 shaft to open two new levels, and was installing a new headframe and hoist. The Teck-Hughes Gold Mines, Limited, also increased its gold production and late in 1960 acquired mining rights, at depth, on the adjoining Kirkland Minerals property.

Thunder Bay District (Port Arthur Mining Division)

MacLeod-Cockshutt Gold Mines Limited, at Geraldton, had a 2-per-cent increase in gold output and was preparing the adjoining property of Consolidated Mosher Mines Limited for stoping operations, which are expected to begin in March 1961. Leitch Gold Mines Limited, at Beardmore, started development of its new 28th and 30th levels.

Sudbury Mining Division

Renabie Mines Limited was mining its new 'N' orebody, and an improvement in mine grade resulted in an increase in gold production.

Base-metal Mines

Although it increased by 32 per cent in 1960, by-product gold from base-metal mining still amounted to less than 2 1/2 per cent of the gold production of the province. The chief sources of by-product gold were The International Nickel Company of Canada, Limited, Geco Mines Limited, Falconbridge Nickel Mines, Limited, and North Coldstream Mines Limited.

Manitoba-Saskatchewan

Two lode-gold mines continued to operate in Manitoba and gold production increased slightly. San Antonio Gold Mines Limited, in the Rice Lake area, completed the sinking of No. 5 internal shaft on the adjoining property of Forty-Four Mines,Limited and six new level stations were cut from the 26th to the 32nd level(4,864-foot horizon).Diamond-drilling was completed and cross-cutting was begun on the 30th and 31st levels. By-product gold, which was less in 1960, came from the copper-zinc ores of Hudson Bay Mining and Smelting Co., Limited, at Flin Flon, and from the nickel-copper ores of Sherritt Gordon Mines,Limited, at Lynn Lake.

All gold recovered in Saskatchewan came as a by-product from the Saskatchewan operations of the Hudson Bay Mining and Smelting Co., Limited. There was a 7.9-per-cent increase in recovery.

Alberta

A small amount of placer gold was recovered from the gravels of the North Saskatchewan River near Edmonton.

British Columbia

Gold production from auriferous-quartz mining increased by 6.3 per cent, and from base-metal mining by 140.2 per cent, while that from placer operations was less than half of the 1959 total. Four lode-gold mines continued operations, but the Pioneer mine of Bralorne Pioneer Mines Limited closed in October 1960.

The Bralorne Division of Bralorne Pioneer Mines, in the Bridge River area, was converting its flotation mill to a cyanidation mill, installing new crushing and grinding facilities,and preparing for the use of mill tailings for hydraulic backfilling in underground stoping operations. The Cariboo Gold Quartz Mining Company,Limited, in the Wells area, was driving long headings on the 3,125- and 2,850-foot levels to open up new ore in the Burnett-fault zone of the Island Mountain section of the property. A Cariboo subsidiary, French Mines Ltd. continued to operate near Hedley.

The large increase in gold recovered as a by-product resulted from increased activity in base-metal mining. The chief producers of by-product gold were The Consolidated Mining and Smelting Company of Canada Limited, the Britannia mine of Howe Sound Company, Phoenix Copper Company Limited, and Consolidated Woodgreen Mines Limited.

L.B. Roth Placers, at Williams Creek, in the old Barkerville area, did not operate, and placer production dropped in the province by more than 3,000 ounces.

Northwest Territories

All gold recovered came from lode-gold mines, and production increased by 3 per cent. In the Yellowknife district, Giant Yellowknife Gold Mines Limited, now Canada's third-ranking gold producer, amalgamated with Consolidated Sudbury Basin Mines Limited to form a new company, Giant Yellowknife Mines Limited. Three new levels were under development during the year. Production increased from the Con and Rycon mines of The Consolidated Mining and Smelting Company of Canada Limited. Consolidated Discovery Yellowknife Mines Limited, Canada's highest-grade gold mine, some 65 air miles north of Yellowknife, deepened its shaft to 4,050 feet and began the development of four new levels. Gold output, however,was lower.

Yukon Territory

Gold recovered from placer operations increased by 16.7 per cent, mainly owing to an increase in production from the dredging operations of The Yukon Consolidated Gold Corporation Limited, in the Dawson City area. Ballarat Mines Limited and Spruce Creek Placers,Limited carried out relatively large-scale hydraulic operations on benches above Dominion Creek in the Dawson area. Some 25 small placer operations worked throughout the Territory, approximately the same number as in 1959.

Developments at Other Properties

Quebec

Marban Gold Mines Limited, a gold prospect in the Malartic area, sank a three-compartment shaft to 850 feet and began development work at the 650- and 800-foot horizons. Norbeau Mines (Quebec) Limited, a gold prospect in McKenzie township in the Chibougamau district, drove a 1,000-foot adit, carried out surface and underground diamond-drilling,and was considering shaft-sinking and the construction of a 400-ton-a-day mill. In the Beauceville area of Quebec's Eastern Townships, Beauce Placer Mining Co. Ltd. has outlined, by churn-drilling in the Gilbert River basin, some 16.8 million cubic yards of placer-gold gravels, valued at about 22 1/2 cents a cubic yard. The company purchased a 6-yard dredge in 1959 and completed the stripping of a dredging area in 1960.

Ontario

In the Red Lake area, Cochenour Willans Gold Mines, Limited, was driving exploration headings into the properties of the adjoining Consolidated Marcus Gold Mines Limited and Wilmar Mines Limited. Campbell Red Lake Mines Limited was exploring from the 14th level the adjoining property of Craibbe-Fletcher Gold Mines Limited. In the Sudbury mining division, Pick Mines Limited reopened the former Cline Lake gold mine, near Lochalsh on the Canadian Pacific Railway. A 50-ton-a-day mill was being installed and a new headframe was built. Lindsay Explorations Limited was sinking a three-compartment shaft to 400 feet at a gold prospect near Sapawe, 10 miles east of

Atikokan in the Fort Frances mining division. Two levels were to be established at 175- and 350-foot depths, and a 100-ton-a-day cyanide mill was to be completed in the summer of 1961.

Manitoba

In 1959 Explorers Alliance Limited dewatered an old gold mine in the Herb Lake area and installed a 50-ton-a-day mill; in 1960 the company milled some development ore stockpiled on the surface.

British Columbia

Several gold prospects were under development in the province, and from some of them small amounts of gold were recovered. Camp McKinney Gold Mines Limited worked the former Cariboo-Amelia mine at Rock Creek, in the Greenwood mining division. Bedwell River Gold Mines Limited worked the former Musketeer mine, on Vancouver Island. Allied Mining Services Limited leased the property of Tofino Mines Limited, on Vancouver Island, and was installing a 5-ton-a-day mill; Berton Gold Mines Limited was driving an adit on a property near Herbert Arm, on Vancouver Island, and bought equipment for the construction of a 75-ton-a-day mill.

Northwest Territories

Exploration and development work continued at several gold prospects. Ruth Gold Mines Ltd., which recovered a small amount of gold from the old Ruth mine in 1959, did not operate during 1960. Taurcanis Mines Limited, in the McKay Lake-Courageous Lake area, planned to deepen its shaft to 1,265 feet and open four new levels. A mining and milling plant was bought from Rayrock Mines Limited, but milling is not to start until 1962. Salmita Consolidated Mines, Limited and Mack Lake Mining Corporation Ltd. were preparing to sink a shaft on their joint gold prospect north of the Taurcanis property. Vanguard Explorations Limited and Consolidated Northland Mines Limited were diamond-drilling on gold prospects. Beneventum Mining Co. Ltd. continued the exploration of other prospects.

Yukon Territory

Klondike Lode Gold Mines Ltd., while exploring for lode gold in the Dawson City area, uncovered a free-gold mineralized zone near Eldorado Creek. Ormsby Mines Limited was driving an adit into the old Laforma lode-gold mine in the Freegold Mountain area near Carmacks.

World Gold Production

The figures in the table on page 272, which shows world gold estimates for 1958 and 1959, are summarized from tables compiled by the Division of Minerals, Bureau of Mines, United States Department of the Interior. World estimates for 1960 are not complete, but Dr. M.A. Kriz, of the First National

World Gold Production*
(fine ounces)

	1960	1959
North America		
Canada	4,628,911	4,483,416
United States (including Alaska)	1,679,800	1,635,000
Mexico	300,256	313,663
Nicaragua	210,082	218,302
Other countries	3,951	6,619
Total	6,823,000	6,657,000
South America		
Colombia	433,947	397,929
Brazil	120,000	125,000
Peru	143,766	150,299
Chile	60,000	76,294
Other countries	134,287	134,478
Total	892,000	884,000
Europe		
U.S.S.R.	11,000,000	10,000,000
Sweden	110,000	103,000
Yugoslavia	67,517	59,640
Other countries	222,483	237,360
Total	11,400,000	10,400,000
Asia		
Philippines	410,618	402,615
Japan	262,350	261,547
Korea (including North Korea)	195,812	195,690
India	160,593	165,383
Other countries	400,627	404,765
Total	1,430,000	1,430,000
Africa		
Union of South Africa	21,383,019	20,065,515
Ghana	878,800	913,200
Southern Rhodesia	562,703	566,883
Congo, Republic of the	256,000	347,967
Other countries	209,478	206,435
Total	23,290,000	22,100,000
Oceania		
Australia	1,082,784	1,085,104
Fiji	72,203	72,565
New Guinea	45,019	46,663
Other countries	37,132	36,914
Total	1,237,138	1,241,246
Wold total (estimated)	45,000,000	42,700,000

*U.S. Department of the Interior, Bureau of Mines, Minerals Yearbook, 1960.

City Bank of New York, gives Free World production as 34.3 million fine ounces, exclusive of the output of the Union of Soviet Socialist Republics, or about 1.5 million more than in 1959. The Union of South Africa contributed 21.4 million ounces, or 62.3 per cent of this Free World total; Canada 4.6 million ounces, or 13.4 per cent; and the United States of America 1.7 million ounces, or 4.9 per cent. The U.S.S.R. does not publish its gold production, but the American Bureau of Metal Statistics estimates that the Soviet has produced 10 million ounces a year since 1956. Other estimates place Russian production as high as that of the Union of South Africa.

Uses

Throughout history, gold has been prized for its rarity, beauty, lustre, and ability to resist corrosion, and because it could be easily worked into objects of value. Today, however, it is used principally as a monetary reserve of governments and central banks to give stability to paper currencies and to settle international trade balances.

In modern jewelry, gold is used alloyed with silver, copper, nickel, zinc, or palladium to improve its hardness and wearing qualities. It is used in many forms, such as plating, goldware, foil, leaf, lace, thread, gilding, gold solutions, inserts, inlays, and lettering. Its color may vary from natural yellow through various shades of green and even white, depending on the alloying elements present.

Because gold is resistant to corrosion and oxidation and is extremely ductile and highly conductive, it has found many applications in industry. It is used in the chemical industry and in dentistry and glass-making. Gold in solution is applied like lacquer to decorate pottery. It has electronic uses in radio tubes, gold-plated printed circuits, gold-film thermometers, X-ray tubes, bolometers, transparent windows, and semiconductors. The electrical industry employs it in electrical-contact alloys, resistance alloys, heating elements, condenser plates, and thermal fuses. In the textile industry it is used in connection with spinnerets and gold thread. It has provided lining for liquid-fuel reactors. Many applications of gold and gold alloys are linked to the optical characteristics of this metal. Because in very thin sheets it is an excellent reflector of infrared radiation, it has found increasing use in modern aircraft missiles and even in earth satellites and space vehicles.

The Mines Branch of the Department of Mines and Technical Surveys, in Ottawa, in conjunction with the Canadian Metal Mining Association, has been doing research into the industrial uses of gold. An information circular entitled Physical Metallurgy and Uses of Gold, Bibliography for the Ten-Year Period 1950 to 1959 was issued in January 1960, and a further report now in preparation deals with the properties of gold and gold alloys.

Prices

The average Royal Canadian Mint value for a troy ounce of fine gold in Canadian dollars increased to $33.95 (preliminary estimate) from the 1959 average of $33.57. The price paid averaged $33.32 a fine troy ounce in the first quarter of the year, with a low of $33.26 in the first three weeks of March, but was over $34 an ounce by mid-year. The Mint price showed a marked increase after December 20, when the Supplementary Budget was presented in Parliament. From December 19 to 23 inclusive, the Mint price was $34.46 a fine ounce, but from December 26 to 30 inclusive it averaged $34.82 an ounce.

In recent history, the United States of America has controlled the greatest share of the world's supply of gold. The official United States price was established as $35 (U.S.) a troy ounce under authority of the Gold Reserve Act of 1934 and has since remained at that level. The Mint, in Ottawa, buys gold from Canadian producers and pays for it at this United States rate but in Canadian funds.

According to Bureau of Mines reports, gold reserves held by the United States Treasury at the end of 1957 had a value of $22.9 billion. By the end of 1960 they had dropped by some $5.0 billion. This loss, together with new financial regulations in Switzerland and unrest in the Belgian Congo and other parts of the world, affected the value of gold on international markets during 1960. In London, England, in the third quarter of the year, the price increased to an average of $35.23 a fine ounce. In October it was rumored that the United States was about to raise the price of gold to strengthen its dollar. Trading on the open gold market increased in volume, and the price of gold rose suddenly to a high of $41.50 a fine ounce. Subsequently, American monetary authorities denied the rumor, stating publicly that an increase in the United States purchase price of gold was not contemplated. Gold quotations dropped to $36.13 by the end of October, declined to about $35.50 by year-end, and stayed close to that level during January 1961.

GYPSUM AND ANHYDRITE

R.K. Collings*

GYPSUM

Gypsum, a hydrous calcium sulphate, is one of the more important nonmetallic minerals, chiefly because it is a major constituent of the plaster and plaster products used by the building-construction industry. It is produced in Nova Scotia, Ontario, Manitoba, British Columbia, New Brunswick, and Newfoundland. Nova Scotia, the chief producer, accounts annually for 85 to 90 per cent of the Canadian output of crude gypsum. Most of the output of the Nova Scotian quarries is exported as crude gypsum to the United States.

Canada's production of crude gypsum decreased by more than 11 per cent in 1960 - from the 1959 record of 5,878,630 short tons to 5,205,731 short tons. The decrease resulted directly from a slackening in the building-construction industry's demand for gypsum products. It is notable, however, that in 1960 the output value of crude gypsum, at $9,498,711 was more than 13 per cent greater than in 1959. This increase was due mainly to a revision in the average value of Nova Scotian crude gypsum from the 1959 price of $1.28 a short ton to $1.67 a short ton.

Exports of crude gypsum in 1960 amounted to 4,273,668 short tons, or almost 12 per cent less than in 1959. This gypsum, from Nova Scotia, was shipped to markets along the eastern seaboard of the United States. Imports of crude gypsum, mostly from Mexico, totalled 60,011 short tons in 1960.

Exports of gypsum products amounted to 33 short tons in 1960; imports totalled 12,779 short tons.

Occurrences

Gypsum deposits occur at many locations in Canada. Some are impure; others are too far from current markets to be economically important. Many however, are of good quality and are well situated with respect to transportation facilities and markets.

The largest known deposits are in the Maritime Provinces. These are flat-lying and generally are covered by 10 to 15 feet of overburden. The Newfoundland deposits are in the St. George's Bay area, in the southwestern section of the island; those in Nova Scotia occur throughout the central and northern parts of the mainland and on Cape Breton Island; in New Brunswick, the chief occurrences are near Hillsborough, in the southeastern part of the province.

*Mineral Processing Division, Mines Branch.

Gypsum - Production and Trade

	1960		1959	
	Short Tons	$	Short Tons	$
Production (shipments)				
Crude gypsum				
Nova Scotia........	4,490,427	7,515,244	5,036,411	6,462,658
Ontario	355,603	871,408	412,100	1,017,340
Manitoba..........	122,063	366,189	200,139	350,323
British Columbia ..	112,400	337,200	94,010	282,030
New Brunswick	90,892	267,002	98,250	132,735
Newfoundland......	34,346	141,668	37,720	148,617
Total	5,205,731	9,498,711	5,878,630	8,393,703
Imports				
Crude gypsum				
Mexico............	58,300	164,009	116,949	332,730
United States	1,681	29,450	833	12,469
United Kingdom....	30	1,090	48	1,597
Total	60,011	194,549	117,830	346,796
Plaster of paris, wall plaster				
United States	12,124	389,057	17,559	467,507
United Kingdom....	352	6,164	181	21,317
France...........	8	1,553	11	2,059
Italy..............	7	430	3	193
West Germany.....	3	129	3	145
Total	12,494	397,333	17,757	491,221
Wallboard and lath				
United States	285	16,267	802	41,303
Ireland	-	-	1,186	35,999
Total	285	16,267	1,988	77,302
Total imports	72,790	608,149	137,575	915,319
Exports				
Crude gypsum				
United States	4,273,668	7,053,690	4,848,576	9,844,602
Plaster of paris, wall plaster				
Bermuda	30	1,164	358	13,102
United States	2	60	15	306
Jamaica	1	277	0.3	124
Total	33	1,501	373.3	13,532
Total exports	4,273,701	7,055,191	4,848,949.3	9,858,134

Source: Dominion Bureau of Statistics.

Gypsum - Production and Trade, 1950-60
(short tons)

	Production(1)	Imports(2)	Exports(2)
1950	3,666,336	1,700	2,969,974
1951	3,802,692	848	3,028,336
1952	3,590,783	649	2,763,492
1953	3,841,457	547	2,769,990
1954	3,950,422	4,958	2,830,945
1955	4,667,901	16,104	3,039,192
1956	4,895,811	70,436	3,840,721
1957	4,577,492	92,139	3,410,684
1958	3,964,129	108,038	2,898,230
1959	5,878,630	117,830	4,848,576
1960	5,205,731	60,011	4,273,668

Source: Dominion Bureau of Statistics.
(1) Producers' shipments. These tonnage figures include both crude and calcined to the end of 1951. Beyond 1951 only crude-gypsum tonnages are included.
(2) Include crude and ground but not calcined.

Consumption of Crude Gypsum
(short tons)

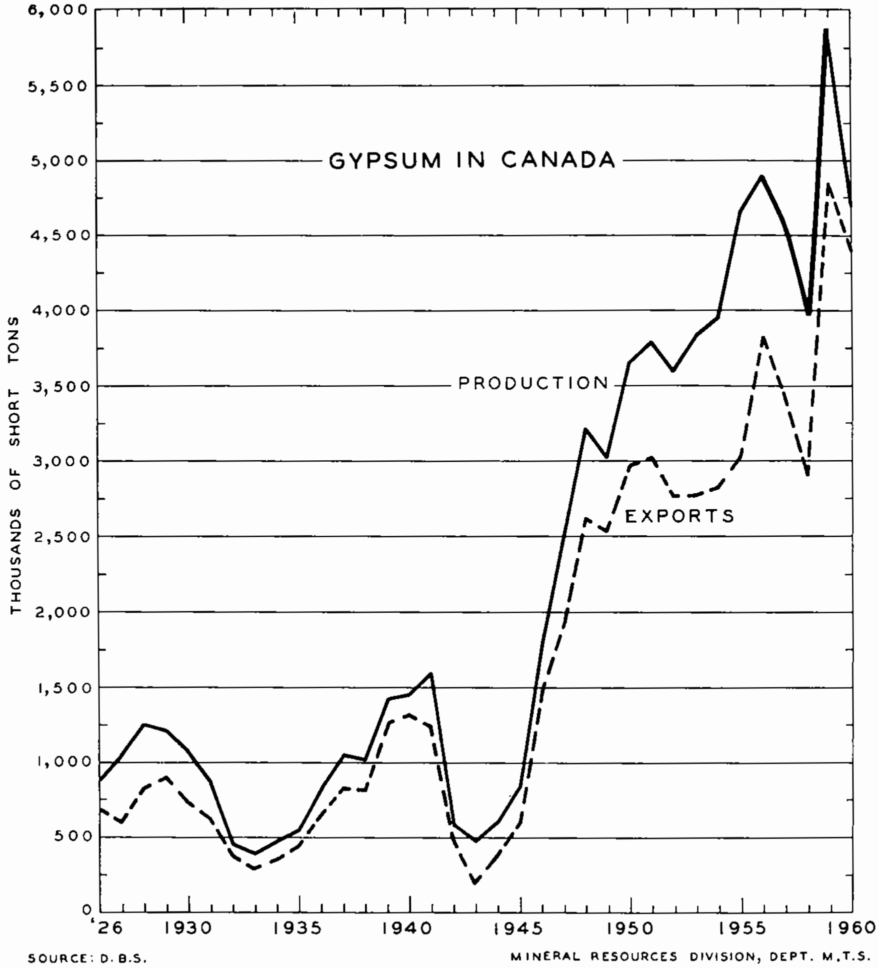
	1960	1959
In gypsum-products industry....................	617,685	954,632
In cement-manufacturing industry	262,171	278,298
Total	879,856	1,232,930

Source: Dominion Bureau of Statistics.

Gypsum in Quebec is confined to the Magdalen Islands, in the Gulf of St. Lawrence. The deposits outcrop over wide areas and are up to 50 feet or more in thickness.

The chief deposits in Ontario are in the Moose River area, in the northeast, and in the Grand River area, south and west of Hamilton. The Moose River deposits are 15 to 20 feet thick and are usually covered by 10 to 30 feet of overburden; those of the Grand River area are thin and lens-like and occur at depths up to 200 feet.

Both Manitoba and Alberta have large gypsum deposits. In Manitoba, the main occurrences are at Gypsumville, where beds 30 feet or more in thickness are exposed, and at Amaranth, where a 40-feet seam is found at a depth of 100 feet. In Alberta, the main occurrences are in Wood Buffalo Park, where gypsum is exposed along the banks of the Peace River between Peace Point and Little Rapids. Gypsum also occurs along the banks of the Slave and



World Production of Gypsum, 1960
('000 short tons)

United States	9,825
Canada	5,206
United Kingdom	4,016
France	4,134
Russia	3,860
Spain	2,360
Italy	1,320
West Germany	1,332
Other countries	9,877
Total	41,930

Source: U.S. Bureau of Mines, Mineral Trade Notes, September, 1961.

Salt rivers north and west of Fort Fitzgerald, and narrow seams of gypsum have been found interbedded with anhydrite at a depth of 500 feet at McMurray, in the northeastern part of Alberta.

In British Columbia the main deposits are at Windermere, Mayook, and Canal Flats, in the southeast, and at Falkland, near Kamloops.

Gypsum deposits have been located 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.

Producers*

Nova Scotia

Crude gypsum quarried in Nova Scotia made up 86 per cent of Canada's production in 1960. More than 96 per cent of the gypsum quarried in this province was exported to the United States.

Canadian Gypsum Company Limited, a subsidiary of United States Gypsum Company, of Chicago, Illinois, operates quarries at Wentworth and Miller Creek, near Windsor. Production from these quarries is exported to the United States.

National Gypsum (Canada) Limited, a subsidiary of National Gypsum Company of Buffalo, New York, operates a large gypsum quarry near Milford, 30 miles north of Halifax. Most of the production from this quarry is exported to the United States. Gypsum for export is also obtained from quarries at Walton and Cheverie, in Hants county.

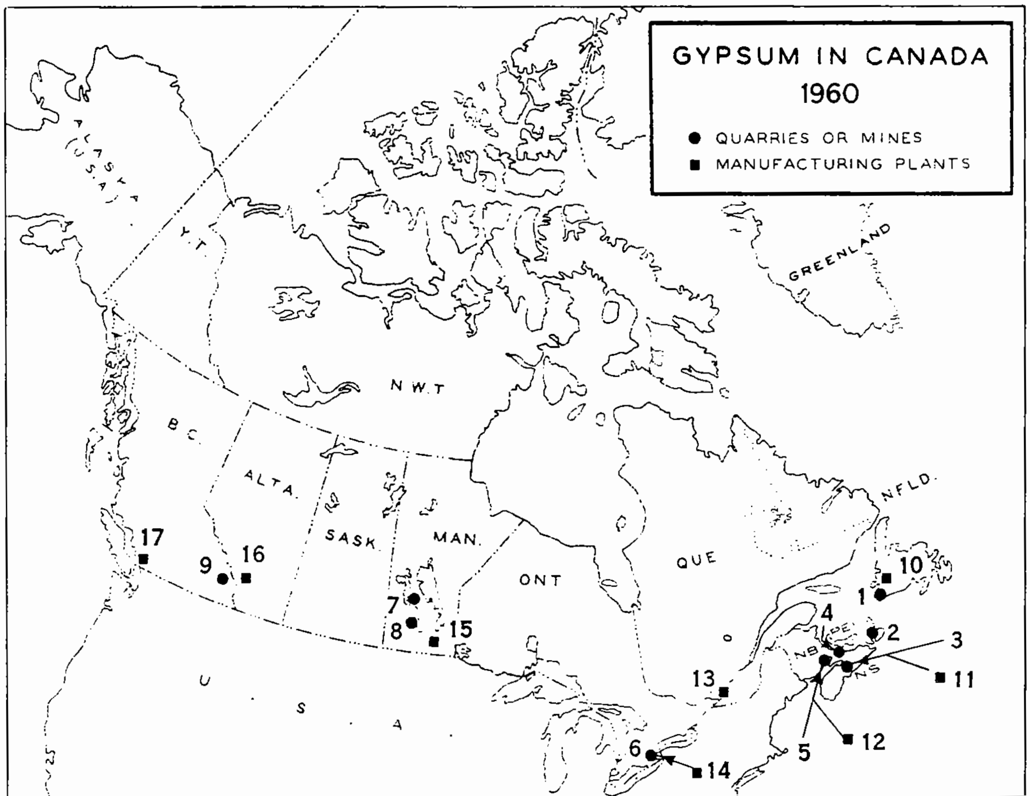
Little Narrows Gypsum Company Limited, a subsidiary of United States Gypsum Company of Chicago, Illinois, quarries gypsum at Little Narrows, on Cape Breton Island. Crude gypsum is shipped to the United States and Montreal for use in the manufacture of plaster and plaster products.

Gypsum, Lime & Alabastine Limited, with head offices in Toronto, quarries gypsum near Nappan for use in the manufacture of plaster, wallboard, and other products at a company-owned plant in Montreal. This company also operates a calcining mill at Windsor, producing plaster of paris for consumption in Nova Scotia, eastern Quebec, and Ontario. Gypsum for use in this plant is obtained from deposits at McKay Settlement, near Windsor.

Ontario

Gypsum is mined at Caledonia, near Hamilton, by Gypsum, Lime & Alabastine Limited, and at Hagersville, southwest of Caledonia, by Canadian Gypsum Company Limited. This gypsum is used in the manufacture of plaster and wallboard at company-owned plants near the respective mines.

*See map on the next page.



MINERAL RESOURCES DIVISION, DEPT. M.T.S.

<u>Quarries or Mines</u>

1. Atlantic Gypsum Limited, Flat Bay Station
2. Little Narrows Gypsum Company Limited, Little Narrows
3. Canadian Gypsum Company Limited, Wentworth and Miller Creek
   National Gypsum (Canada) Limited, Milford, Walton, and Cheverie
   Gypsum, Lime & Alabastine Limited, McKay Settlement
4. Gypsum, Lime & Alabastine Limited, Nappan
5. Canadian Gypsum Company Limited, Hillsborough
6. Canadian Gypsum Company Limited, Hagersville
   Gypsum, Lime & Alabastine Limited, Caledonia
7. Gypsum, Lime & Alabastine Limited, Gypsumville
8. Western Gypsum Products Limited, Amaranth
9. Western Gypsum Products Limited, Windermere

<u>Manufacturing Plants</u>

10. Atlantic Gypsum Limited, Humbermouth
11. Gypsum, Lime & Alabastine Limited, Windsor
12. Canadian Gypsum Company Limited, Hillsborough
13. Canadian Gypsum Company Limited, Montreal
    Gypsum, Lime & Alabastine Limited, Montreal
14. Canadian Gypsum Company Limited, Hagersville
    Gypsum, Lime & Alabastine Limited, Caledonia
15. Gypsum, Lime & Alabastine Limited, Winnipeg
    Western Gypsum Products Limited, Winnipeg
16. Gypsum, Lime & Alabastine Limited, Calgary
    Western Gypsum Products Limited, Calgary
17. Gypsum, Lime & Alabastine Limited, Port Mann
    Western Gypsum Products Limited, Vancouver

Manitobа

Gypsum is obtained from an underground deposit at Amaranth by Western Gypsum Products Limited and is shipped to Winnipeg for use in the manufacture of plaster and wallboard at a company-owned plant. Western Gypsum Products Limited is a subsidiary of British Plaster Board (Holdings) Limited, of London, England.

Gypsum is quarried at Gypsumville by Gypsum, Lime & Alabastine Limited for use in the manufacture of plaster and plaster products at company-owned plants in Winnipeg and Calgary.

British Columbia

Western Gypsum Products Limited operates a gypsum quarry near Windermere, in the southeast. This quarry supplies crude gypsum to the company's gypsum-products plants at Calgary and Vancouver and to cement plants in British Columbia and Alberta.

New Brunswick

Gypsum is quarried near Hillsborough by Canadian Gypsum Company Limited for use in the manufacture of plaster and wallboard at a company-owned plant at Hillsborough.

Canada Cement Company, Limited, obtains gypsum from a quarry near Havelock, west of Moncton, for use in the manufacture of cement at Havelock.

Newfoundland

Atlantic Gypsum Limited produces gypsum plaster and wallboard at a plant at Humbermouth, on the west coast. This plant, owned by the Government of Newfoundland, is operated by Flintkote Company of Canada Limited, Toronto, a subsidiary of Flintkote Company of New York. Crude gypsum for its operation is obtained from quarries at Flat Bay Station, 62 miles by rail southwest of Humbermouth. Flintkote Company is constructing a 6-mile aerial conveyor from the Flat Bay quarry area to deep-water shipping facilities at St. George's. Upon completion of this conveyor, crude gypsum will be exported to company-owned plants in the United States.

Other Processing Plants

Quebec

Gypsum, Lime & Alabastine Limited and Canadian Gypsum Company Limited operate gypsum-products plants in Montreal East. Crude gypsum from quarries in Nova Scotia is used by these plants in the manufacture of plaster of paris, wallboard, and other gypsum products. Atlantic Gypsum Limited manufactures a precast panel for the building-construction industry at a plant in Montreal, using plaster of paris from its Humbermouth, ,Newfoundland, plant.

Alberta

Gypsum, Lime & Alabastine Limited produces plaster and wallboard at a newly constructed plant in Calgary, using gypsum from Windermere, British Columbia, and from a company-owned quarry at Gypsumville, Manitoba. Western Gypsum Products Limited also manufactures plaster and wallboard in Calgary using gypsum from company-owned quarries at Windermere, British Columbia.

British Columbia

Gypsum, Lime & Alabastine Limited operates a plaster-and-wallboard plant at Port Mann, about 10 miles east of Vancouver. The gypsum requirements of this plant are met by imports from San Marcos Island, Mexico. Western Gypsum Products Limited completed a plant at Vancouver and began to produce plaster and wallboard early in 1960. Crude gypsum for this plant is obtained from company quarries at Windermere, British Columbia.

Uses

Calcined gypsum, or plaster of paris, is the main constituent of gypsum board and lath, gypsum tile, roof tile, and all types of industrial plasters. Gypsum plaster 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. Gypsum board and sheathing are used in the building-construction industry.

Crude uncalcined gypsum is used in the manufacture of portland cement. The gypsum, acting as a retarder, controls the set of the cement. Crude gypsum, reduced to 40-mesh or finer, is used as a filler in paint and paper. Ground gypsum is used to a limited extent as a substitute for salt cake in glass manufacture. Powdered gypsum is used as a soil conditioner to offset the effect of black alkali, as a means of restoring impervious, dispersed soil, and as a fertilizer for peanuts and other leguminous crops.

Prices

The nominal price of crude gypsum in 1960 was $3 to $5 a ton f. o. b. quarry or mine. Under large contracts with seaboard quarries, however, prices were much lower.

Tariffs

Canada

	British Preferential	Most Favored Nation	General
Gypsum, crude	free	free	free
Plaster of paris and prepared wall plaster, per 100 lb	"	11¢	12 1/2¢
Gypsum wallboard	15%	22 1/2%	35%
Gypsum lath	15%	20%	25%

United States

Gypsum, crude	free
Gypsum, ground or calcined, per long ton	$1.19
Gypsum wallboard and lath	15%

ANHYDRITE

The mineral anhydrite, which is anhydrous calcium sulphate, is commonly associated with gypsum. It is produced at one or two locations in Nova Scotia for export to the United States, where it is used as a fertilizer for peanut crops. The 1960 production, as reported in the annual report of the Department of Mines, Province of Nova Scotia, was 25,191 short tons.

Anhydrite is used to a limited extent as a soil conditioner. Gypsum and anhydrite are potential sources of sulphur compounds. As yet, however, these minerals have not been utilized for this purpose 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 by-product cement. The gases are then converted into sulphuric acid.

INDIUM

D.B. Fraser*

Indium is found in trace amounts in many lead-zinc ores and in certain tin, tungsten, and iron ores. It is usually associated with sphalerite, the common zinc mineral. Some zinc-lead ores contain as much as 1 per cent indium, but normally indium is present in much smaller amounts. The metal is produced commercially from the treatment of residues and slags derived from zinc- and lead-smelting operations.

Information on world output is vague, since the few compaines that recover indium do not publish production data. Indium is produced regularly in Canada and the United States and is reported to have been produced also in Peru, Belgium, West Germany, Japan, and Russia. The single Canadian producer of indium, The Consolidated Mining and Smelting Company of Canada Limited (Cominco), which has zinc and lead smelters and refineries at Trail, British Columbia, is one of the world's largest.

Production

The first extraction of indium at Trail was made in 1941, though the presence of indium in the lead-zinc-silver ores of Cominco's Sullivan mine, at Kimberley, British Columbia, had been known for many years. In the following year, 437 ounces were produced by laboratory methods. There followed several years of intensive research and development, and production on a commercial scale began in 1952. 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. Certain of the metallurgical operations result in slag concentrations containing 2.5 to 3.0 per cent indium. This slag is reduced electrothermally to produce bullion containing lead, tin, indium, and antimony, which is treated electrolytically to yield a high-indium (20-25 per cent) 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 (99.99 per cent) of indium or a high-purity grade (approximately 99.999 per cent). An extremely pure (99.9999 per cent) grade is also produced for electronic materials. The metal is cast in ingots varying in size from 10 ounces to 10 kilograms. Also produced are various alloys and chemical compounds of indium, and a variety of fabricated shapes such as wire, ribbon, foil and sheet, powder, and disk and spherical pellets.

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*Mineral Resources Division.

Properties and Uses

Indium is silvery white, very much like tin or platinum in appearance; chemically and physically, it resembles tin more than it does any other metal. Its chief characteristics are its extreme softness and low coefficient of sliding friction. It is easily scratched by the finger nail and can be made to adhere to other metals merely by hand-rubbing. It has a melting point of 156°C, which is relatively low, and a high boiling point of 2,000°C and is extremely resistant to atmospheric and alkaline corrosion. A rod of indium, like one of tin, 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, which is still important, was in high-speed bearing alloys, where the addition of indium to silver-lead alloys 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 engine. Standard-grade indium is satisfactory for this purpose. Indium is used also in low-melting-point alloys containing bismuth, lead, tin, and cadmium; glass-sealing alloys containing about equal amounts of tin and indium; solder alloys that require resistance to alkaline corrosion; and gold dental alloys.

A newer use, one that is probably the greatest now, is in various semiconductor devices, in which high-purity indium modifies the properties of germanium. In this application, disks or spheres of indium are alloyed into each side of a wafer of germanium. In addition to having electronic properties, indium is especially suitable because it alloys readily with germanium at low temperatures and, being soft, does not cause strains on contracting after alloying.

Discovered in 1863 but applied commercially only for the past quarter century, indium and its compounds are relatively new and their potential uses 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 because its artificial radioactivity is easily induced by neutrons of low energy. Indium compounds added to lubricants have been found to be beneficially anticorrosive. Indium anodes have been used in the cells of lightweight storage batteries.

Trade and Consumption

No statistics are available on the export, import, or domestic consumption of indium. Much of Canada's output is exported to the United States and the United Kingdom, and smaller amounts go to a number of countries in continental Europe.

Prices

The prices of indium, 99.9 per cent, quoted in E & M J Metal and Mineral Markets were as follows: in small lots, $2.25 a troy ounce throughout 1960; in lots of more than 5,000 ounces, $1.25 to $2.25 a troy ounce until February 25 and $1.35 to $2.25 a troy ounce thereafter.

IRON ORE

R.B. Elver*

Canadian producers' shipments of iron ore decreased in 1960 by 12.0 per cent - from the all-time high set in 1959 to 19,241,813 tons.# Shipments from British Columbia and Newfoundland, however, increased, as did the average value of the ore shipped from all provinces. The shipments from Alberta constituted a bulk sample for large-scale metallurgical testing in the United States.

Imports from the United States Lake Superior district for use in Ontario blast furnaces increased to a near-record level. Rather than a growing trend, the 1960 level of these imports represented a return to conditions nearer to normal than those prevailing during the general recession of 1958 and the United States steel strike of 1959. While the strike was in progress, larger amounts of Canadian iron ore were consumed domestically and the imports of Brazilian iron ore also increased. Brazil's shipments to Canada are usually of a special lump grade, but in 1960 several of them consisted of blast-furnace feed and a similar shipment of ore was received for the first time from Venezuela. Thus, two of Canada's main competitors in the United States and overseas have made small but significant inroads into the Canadian domestic market in competition with Canadian ores.

Despite an increase of more than 25 per cent in the exports to overseas customers, the export total for 1960 was 8.6 per cent below the all-time high of 1959. This decrease resulted from the slump that occurred during the year in iron-ore consumption in the United States. Canadian iron-ore exports to that country were at a high level for the first half of 1960 because of a prediction made early in the year by the United States steel industry that its production would reach a near record of 120 million net tons. As early as April, however, an unexpected production decline set in. It levelled out in July, but by the end of the year it still had not reversed itself. Thus, iron-ore stocks at United States blast-furnace sites steadily increased and caused a sharp cutback in ore receipts during the last four months of the year. Canada's exports to the United States and its iron-ore output consequently declined.

#Unless otherwise designated, the unit used throughout is the long (gross) ton (2,240 pounds). Other units that may be encountered are the short (net) ton (2,000 pounds) and the metric ton (2,205 pounds).

*Mineral Resources Division.

Iron Ore - Production, Trade and Consumption

	1960		1959	
	Long Tons	$	Long Tons	$
Production (shipments)				
Newfoundland	6,795,862	54,673,717	5,451,624	42,974,837
Quebec	6,658,903	61,752,485	10,281,401	92,497,012
Ontario	4,754,640	48,399,442	5,373,294	50,830,404
British Columbia	1,032,408	10,256,879	758,257	6,363,848
Alberta	-	-	-	-
Total	19,241,813	175,082,523	21,864,576	192,666,101
Imports				
United States	4,342,285	46,625,201	2,402,523	26,008,830
Brazil	156,901	1,606,273	97,879	1,113,251
Venezuela	15,400	137,957	-	-
Other countries	10	872	492	6,810
Total	4,514,596	48,370,303	2,500,894	27,128,891
Exports				
Crude and beneficiated iron ore				
United States	10,080,425	98,220,935	13,394,512	117,809,833
United Kingdom	3,359,919	27,721,660	2,822,240	22,427,925
Japan	1,040,563	9,424,029	653,537	5,053,579
West Germany	939,283	6,743,384	736,389	5,159,102
Netherlands (1)	912,237	7,775,700	823,393	6,480,108
Belgium	163,986	1,280,310	81,748	634,185
Italy	74,480	512,101	40,669	249,370
Total	16,570,893	151,678,119	18,552,488	157,814,102
Calcined iron ore(2)				
United States	352,819	3,682,404		
Germany	18,428	111,955		
Total	371,247	3,794,359		
Consumption (indicated)(3)	6,814,269	-	5,812,982	-

Source: Dominion Bureau of Statistics.

(1) Some 740,000 tons of the 1960 total were transshipped to West Germany.

(2) Statistics on the exports of calcined iron ore were not available separately prior to 1960.

(3) Shipments plus imports less exports, but no account is taken of changes in stocks at consuming plants.

Iron Ore - Production, Trade and Consumption, 1950-60
(long tons)

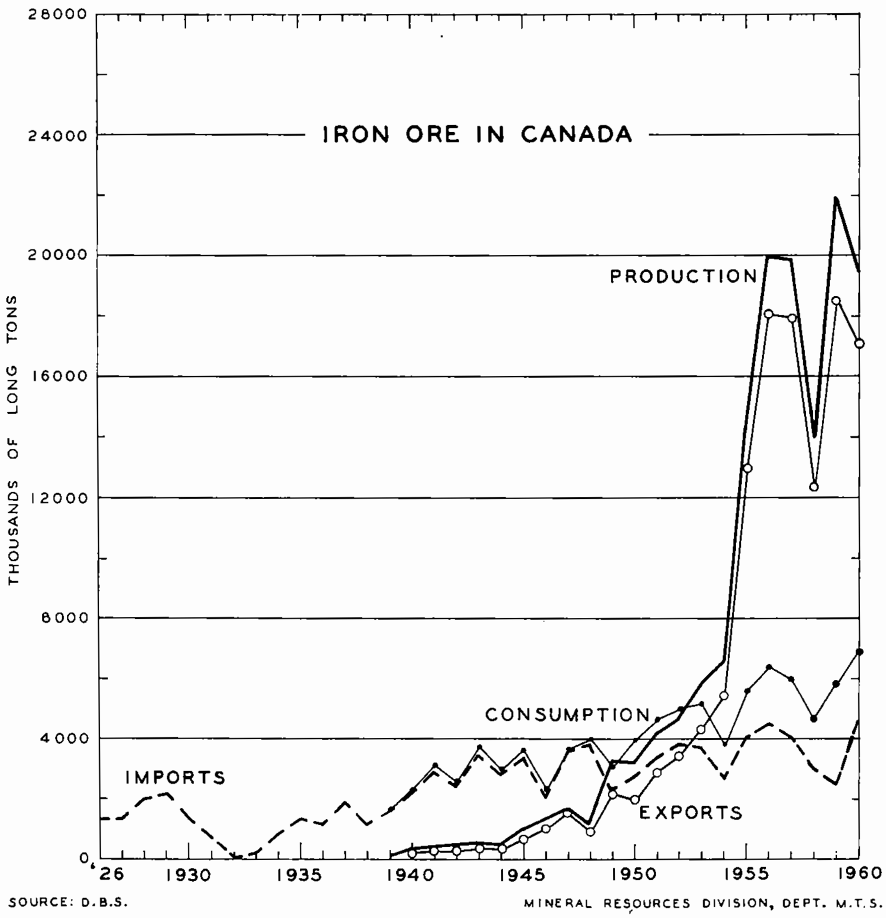
	Production (shipments)	Imports	Exports	Consumption (indicated)*
1950	3,218,983	2,741,568	1,988,817	3,971,734
1951	4,179,027	3,420,909	2,880,149	4,719,787
1952	4,707,008	3,810,409	3,434,820	5,082,597
1953	5,812,337	3,721,046	4,303,549	5,229,834
1954	6,572,855	2,709,991	5,470,480	3,812,366
1955	14,538,551	4,052,490	13,008,000	5,583,041
1956	19,953,820	4,525,768	18,094,080	6,385,508
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

Source: Dominion Bureau of Statistics.
*Shipments plus imports less exports, but no account is taken of changes in stocks at consuming plants.

It is of significance to Canadian iron-ore exporters that imports into the United States from other foreign countries increased in 1960 by more than 10 per cent. Although this can be partially explained by corporate ownership of foreign deposits and their location in relation to iron and steel plants in the United States, price and quality were probably greater factors, particularly in the overseas markets. Hence, product research on direct-shipping ores and the development of properties for the production of high-grade concentrates and agglomerates are becoming even more important in the Canadian iron-ore industry. In Labrador-Quebec, three companies are developing concentrating-grade deposits that by 1965 will raise the country's annual iron-ore-production capacity to more than 40 million tons. In addition, serious consideration is being given to the production of pellets from at least some of the concentrates to be produced.

During 1960, a new producer in Ontario started shipments and a small British Columbia company that had made initial shipments in 1959 ceased production. Thus, as in 1959, there were 12 producing operations. Direct-shipping ores make up about 61 per cent of Canada's iron-ore shipments, and concentrates and agglomerates 24 and 15 per cent respectively. About 79 per cent of the ore shipped is of the hematite-goethite variety; magnetite and sintered siderite make up respectively 13 and 8 per cent. More than 80 per cent of the shipments come from open-pit mines.

Two companies not included in normal iron-ore output statistics produce by-product iron ore. One obtains iron-oxide pellets as a coproduct in the production of nickel carbonates and sulphuric acid from the treatment of nickeliferous-pyrrhotite concentrate. This company plans to triple its



production capacity by 1963. The other obtains iron-oxide sinter and iron-oxide calcine as coproducts when it produces sulphuric acid by roasting pyrrhotite-pyrite concentrate. A third smelts ilmenite ore to produce titania slag for the manufacture of pigments and 'remelt iron,' a type of pig iron. A fourth produced by-product iron-ore pellets for smelting in its electric pig-iron furnace early in 1961.

World Production

Since 1958, the Union of Soviet Socialist Republics has been ahead of the United States in iron-ore production. While the output of the U.S.S.R. was steadily increasing, the United States experienced recessions in 1958 and 1960 and a strike in 1959. If this increase continues, the U.S.S.R. will probably remain the world's leading ore producer, since United States production is unlikely to exceed 105 million tons a year.

Reports for 1960 show France and China retaining third and fourth positions respectively as world producers. Canada dropped from fifth to sixth place, being surpassed by Sweden. The nine countries in the accompanying table account for about 72 per cent of the world's iron-ore production. Elsewhere, particularly in underindustrialized countries of South America, Africa, and Asia, production is increasing, and the increases are significantly affecting the international iron-ore market.

Production of Iron Ore, by Countries

('000 long tons)

	1960(1)	1959(2)	1958(2)
U.S.S.R.	105,407	93,007	87,397
United States	87,296	60,276	67,709
France	65,854	59,935	58,516
China	21,429	20,551	19,685
Sweden	20,980	17,997	18,304
Canada	19,242	21,865	14,041
Venezuela	19,224	16,929	15,239
West Germany	18,553	17,777	17,701
United Kingdon	17,051	14,870	14,612
Subtotal	375,036	323,207	313,204
Other countries	146,515	126,490	117,242
World total	521,551	449,697	430,446

Source: American Iron and Steel Institute, 1960.

Domestic Consumption

Iron ore is used primarily as a raw material in the making of iron and steel. Small tonnages, not normally referred to as iron ore, are used in the manufacture of paint, as heavy aggregate in concrete, as heavy media in some beneficiation plants, and for agricultural purposes. Most of the iron ore consumed is fed into blast furnaces to be made into pig iron, some of which is used by iron foundries. Most pig iron, however, along with steel scrap, goes into furnaces for the production of crude steel. Some iron ore is also used in steelmaking furnaces. The following table summarizes statistics on the consumption of iron ore in Canadian iron and steel plants.

Consumption of Iron Ore
in Canadian Iron and Steel Plants
(long tons)

	1959	1960
In blast furnaces, direct	4,891,873	4,813,358
In steel furnaces, direct	365,570	335,367
In sintering plants before ore is charged to blast or steel furnaces	1,281,203	1,266,979
Miscellaneous	70	224
Total	6,538,716	6,415,928

Source: American Iron Ore Association, Cleveland, Ohio.

Canadian Consumption of Iron Ore and
Production of Pig Iron and Crude Steel (1)

	1959 (long tons)	1960 (long tons)
Total receipts at iron and steel plants(2)	6,278,674	7,084,119
Receipts imported(2)	2,512,733	4,539,125
Receipts from domestic sources(2)	3,765,941	2,544,994
Stocks at iron and steel plants Dec. 31 of previous year(2)	2,992,084	2,738,815
Stocks at iron and steel plants Dec. 31 of year at top of column(2)	2,738,815	3,465,440
Net change in stocks	-253,269	+726,625
Consumption of iron ore(2)(3)	6,538,716	6,415,928

(table continued)

Canadian Consumption of Iron Ore and
Production of Pig Iron and Crude Steel (1)(cont'd)

	(net tons)	(net tons)
Pig-iron production(4)	4,182,775	4,278,425
Capacity at Dec. 31(4)	4,448,000	4,877,900
Steel-ingot and castings production(4)	5,901,487	5,789,570
Capacity at Dec. 31(4)	7,000,000	7,241,000

(1) Figures in this table do not correspond with those listed in the table entitled "Iron Ore - Production, Trade and Consumption".
(2) American Iron Ore Association, Cleveland, Ohio.
(3) Consumption figures are compiled from company submissions and cannot be calculated from statistics shown in this table.
(4) Dominion Bureau of Statistics, Ottawa.

Canadian Developments

This section outlines some of the more important developments concerning present and future iron-ore producers.

Newfoundland (Labrador)

Wabana Mines Division of Dominion Steel and Coal Corporation, Limited, had a year of near-record production from its submarine mines on Bell Island, Newfoundland. Detailed underground exploration and production-efficiency studies were highlights of the company's activities in 1960. In the strong western European market, which consumes more than 80 per cent of the company's output, competition has increased considerably in the last two years.

The Labrador-Quebec mining operations of Iron Ore Company of Canada in the area around Schefferville, Quebec, ceased on October 22, and the last ore shipment left Seven Islands, Quebec, on November 2. These were the earliest closing dates since 1954, when the company started to produce. In response to increasing competition from high-grade foreign sources of iron ore, the company installed an ore-drying plant at Seven Islands, and plans are well advanced for the construction of a wash plant. The drying plant, which has a daily capacity of 300 long tons, went into operation on August 10. When operating at capacity, it can process more than 1 million tons of wet ore during the eight-month shipping season. At Schefferville the company also opened a new research laboratory.

The company's $135-million Carol Lake project, in the Wabush Lake district of Labrador, is scheduled for production by mid-1962. The 42-mile rail link that connects with the main Schefferville-Seven Islands line at Mile 224 was completed during the year in collaboration with Wabush Iron Co.

(text continued on page 301)

Canadian Producers of Iron Ore during 1960

Company and Property Location	Participating Companies	Product Mined (average grade)	Product Shipped (average grade)	Shipments(1) ('000 long tons) 1959	1960
Algoma Ore Properties Division; mines and sinter plant near Wawa, Ont.	Algoma Steel Corp., Ltd., The	Siderite from open-pit and underground mines (34% Fe)	Some ore beneficiated by sink-float and nearly all sintered (50.40% Fe, 2.81% Mn)	1,935	1,439
Caland Ore Co. Ltd.; E. arm of Steep Rock Lake, N. of Atikokan, Ont.	Inland Steel Co.	Hematite and goethite from open-pit mine (53.3% Fe)	Direct-shipping ore (53.3% Fe)	-	765
Canadian Charleson, Ltd.; S. of Steep Rock Lake, near Atikokan, Ont.	Charleson Iron Mining Co.	Hematite-bearing gravels (11% Fe)	Jig and spiral concentrate (55.3% Fe)	179	112
Empire Development Co.,Ltd.; Elk River, 8 miles E. of Port Alice, Vancouver Island, B.C.	Loram Ltd., Quatsino Copper-Gold Mines Ltd.	Magnetite from open-pit mine (34.7% Fe)	Magnetite concentrate (58% Fe)	360	414
Hilton Mines, Ltd.; near Bristol, Que., 40 miles NW. of Ottawa	Steel Co. of Canada, Ltd., The, Jones & Laughlin Steel Corp., Pickands Mather & Co.	Magnetite from open-pit mine (18-20% Fe)	Iron-oxide pellets (65% Fe)	584	747

Iron Ore Company of Canada; Labrador-Quebec near Schefferville, Que.	M.A. Hanna Co., Hollinger Cons. Gold Mines Ltd., Armco Steel Corp., Bethlehem Steel Corp., Hanna Coal & Iron Corp., National Steel Corp., Republic Steel Corp., Wheeling Steel Corp., Youngston, Sheet and Tube Co.	Hematite-goethite from open-pit mines (51.6% Fe)	Direct-shipping ore (47.4-57.4% Fe)	13,059	9,809
Lowphos Ore Ltd.; Sudbury area, 20 miles N. of Capreol, Ont.	National Steel Corp., M.A. Hanna Co., The	Magnetite from open-pit mine (30.8% Fe)	Magnetite concentrate (59.2% Fe)	173	519
Marmoraton Mining Co., Ltd.; near Marmora, in southern Ont.	Bethlehem Steel Corp.	Magnetite from open-pit mine (35-37% Fe)	Iron-oxide pellets (64.3% Fe)	351	282
Nimpkish Iron Mines Ltd.; 26 miles W. of Beaver Cove, Vancouver Island, B.C.	International Iron Mines Ltd., Standard Slag Co.	Magnetite from open-pit mine (39% Fe)	Magnetite concentrate (59.2% Fe)	7	251
Steep Rock Iron Mines Ltd.; Steep Rock Lake N. of Atikokan, Ont.	Premium Iron Ores Ltd., Cleveland-Cliffs Iron Co., The, and others	Hematite-goethite from open-pit and underground mines (40.5-52.91% Fe)	Direct-shipping ores and gravity concentrate (51.9-55.1% Fe)	2,747	1,586

(table continued)

Canadian Producers of Iron Ore during 1960 (Continued)

Company and Property Location	Participating Companies	Product Mined (average grade)	Product Shipped (average grade)	Shipments[1] ('000 long tons)	
Texada Mines Ltd.; Texada Island, B.C.	Private company	Magnetite from open-pit mine (38.8% Fe)	Magnetite concentrate (61.7% Fe)	377	374
Wabana Mines Division; Bell Island, Conception Bay, E. coast of Nfld.	Dominion Steel and Coal Corp., Ltd.	Hematite-chamosite from underground mines (48.94% Fe)	Heavy-media concentrate (50.01% Fe, 0.9% P)	2,095	2,808
By-product Producers					
International Nickel Co. of Canada, Ltd., The; mines and plant in Sudbury area, Ont.	-	Pyrrhotite flotation concentrates treated	Iron-oxide pellets (68% Fe)	162	192
Noranda Mines, Ltd.; mines near Noranda, Que.; plant at Cutler, Ont.; Port Robinson, Ont., plant shut down in 1959	-	Pyrrhotite and pyrite flotation concentrates treated	Iron-oxide sinter (67-68% Fe)	142[2]	106[2]
Quebec Iron and Titanium Corp.; mine in Allard Lake area, Que.; electric smelter at Sorel, Que.	Kennecott Copper Corp., New Jersey Zinc Co., The	Ilmenite-hematite from open-pit mine (40% Fe, 35% TiO_2)	TiO_2 slag and various grades of desulphurized iron or 'remelt iron'	146 (iron)	222 (iron)

Source: Company reports, personal communications, and other sources.

(1) Statistics supplied by the companies to the Mineral Resources Division. For some companies the tonnages shown are only preliminary estimates, and provisional totals will not necessarily correspond.

(2) Production.

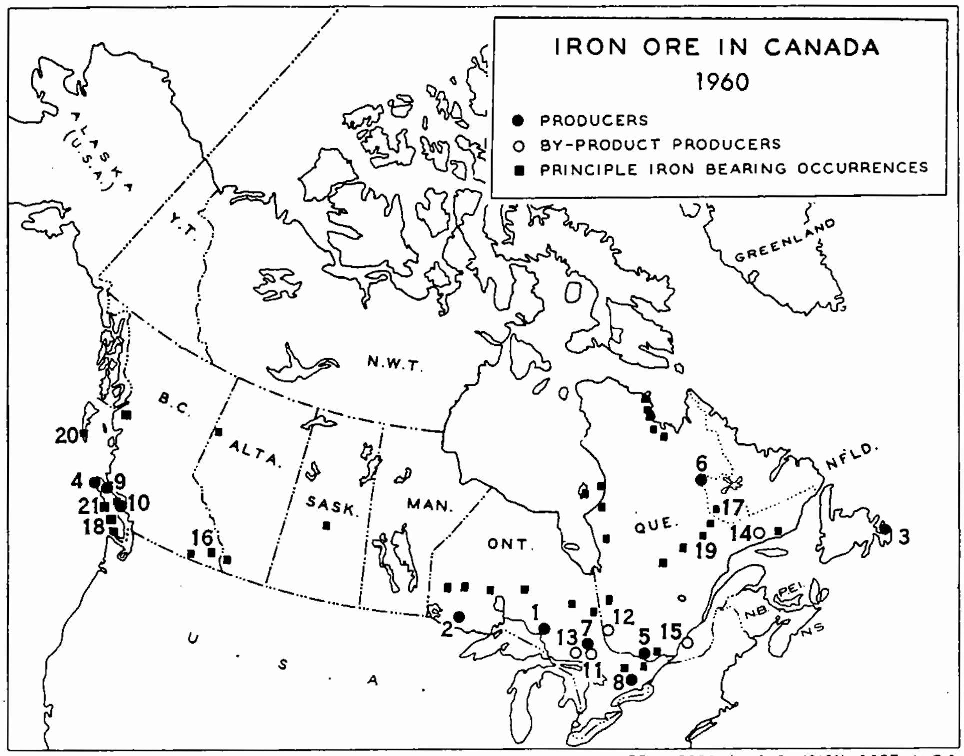
Companies under Development with Announced Plans for Production

Company and Expected Production Date	Property Location	Participating Companies	Product to Be Mined	Product to Be Shipped	Expected Annual Production
Consolidated Mining and Smelting Co. of Canada Ltd., The (early 1961)	Kimberley, B.C.	-	Pyrrhotite flotation concentrates to be roasted, ground, pelletized, and sintered before being charged into electric pig-iron furnace.	Pig iron and probably steel at later date	Sinter capacity - 100,000 long tons; initial pig iron capacity - 36,500 net tons
Iron Ore Co. of Canada (1962)	Wabush Lake, Lab., 190 miles N. of Seven Islands, Que.	As in preceding table	Specular-hematite-bearing iron formation from open-pit mines (37-38% Fe)	Concentrate (64% Fe)	7,000,000 long tons
Noranda Exploration Co. Ltd. (1962)	Kennedy Lake, W. coast of Vancouver Island, B.C.	Noranda Mines, Ltd.	Magnetite from open-pit mine (plus 50% Fe)	Magnetite concentrate (plus 60% Fe)	700,000 long tons
Quebec Cartier Mining Co. (1961)	Lac Jeannine, Mt. Reed, and Mt. Wright areas of Quebec. Lac Jeannine deposit to be first mined	United States Steel Corp.	Specular-hematite-bearing iron formation from open-pit mines (30% Fe)	Concentrate (65% Fe)	8,000,000 long tons
Silver Standard Mines Ltd. (1962)	Moresby Island, Queen Charlotte Islands, B.C.	Optioned by The Granby Mining Co. Ltd.	Magnetite from open-pit mine (51.9% Fe)	Magnetite concentrate (plus 60% Fe)	400,000 long tons

Companies under Development with Announced Plans for Production (Continued)

Company and Expected Production Date	Property Location	Participating Companies	Product to Be Mined	Product to Be Shipped	Expected Annual Production
Wabush Iron Co. Ltd. (1964-65)	Wabush Lake, Lab., 190 miles N. of Seven Islands, Que.	Steel Co. of Canada, Ltd., Pickands Mather & Co., Interlake Iron Corp., Youngstown Sheet and Tube Co., Inland Steel Co., Pittsburgh Steel Co.	Specular-hematite-bearing iron formation from open-pit mine (37% Fe)	Concentrate (64% Fe)	4,000,000 to 5,000,000 long tons
Zeballos Iron Mines Ltd. (1962)	Near Zeballos, W. coast of Vancouver Island, B.C.	International Iron Mines Ltd.	Magnetite from open-pit (48% Fe)	Magnetite concentrate (plus 60% Fe)	500,000 long tons
By-product Producers					
Falconbridge Nickel Mines, Ltd. (late 1961)	Mines and plant in Sudbury area, Ont.	-	Pyrrhotite flotation concentrates to be treated	Iron oxide (67-68% Fe)	100,000 long tons
International Nickel Co. of Canada, Ltd., The (1963)	Mines and plant in Sudbury area, Ont.	-	Pyrrhotite flotation concentrates to be treated	Iron-oxide pellets (68% Fe)	Capacity to be increased to 750,000 long tons by 1963

Sources: Company reports, personal communications, and other sources.



Producers in 1960

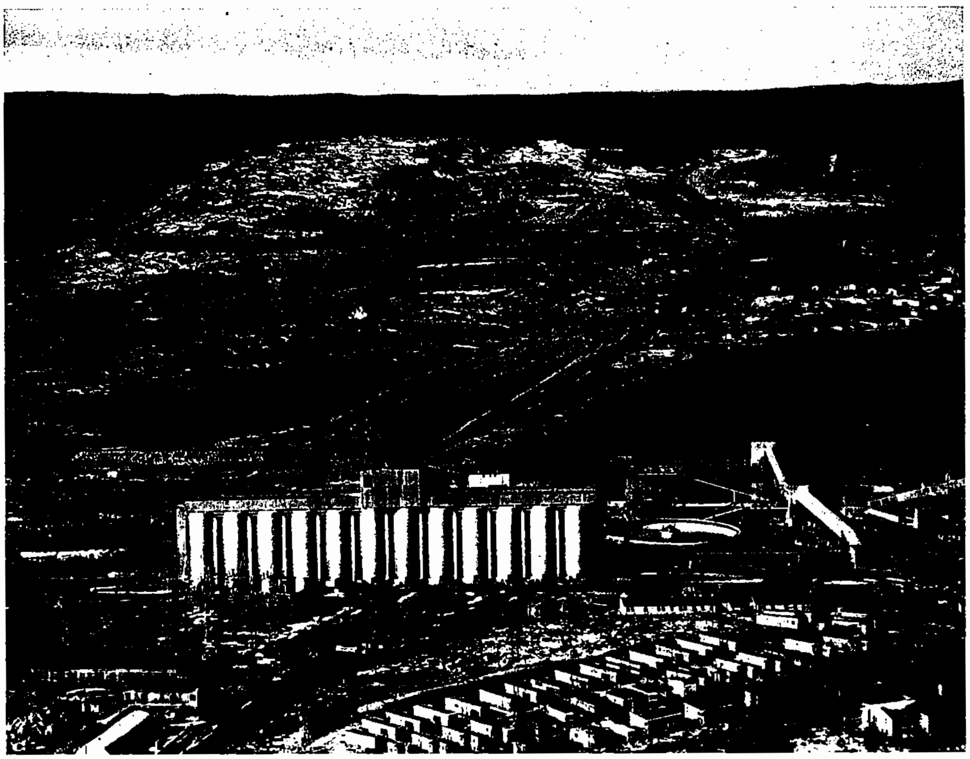
1. Algoma Steel Corporation, Limited, The (Algoma Ore Properties Division)
2. Caland Ore Company Limited
   Canadian Charleson, Limited
   Steep Rock Iron Mines Limited
3. Dominion Steel and Coal Corporation, Limited (Wabana Mines Division)
4. Empire Development Company, Limited
5. Hilton Mines, Ltd.
6. Iron Ore Company of Canada
7. Lowphos Ore Limited
8. Marmoraton Mining Company Ltd.
9. Nimpkish Iron Mines Ltd.
10. Texada Mines Ltd.

By-product Producers

11. International Nickel Company of Canada, Limited, The (mines and plant)
12. Noranda Mines, Limited (mines)
13. Noranda Mines, Limited (plant)
14. Quebec Iron and Titanium Corporation (mine)
15. Quebec Iron and Titanium Corporation (plant)

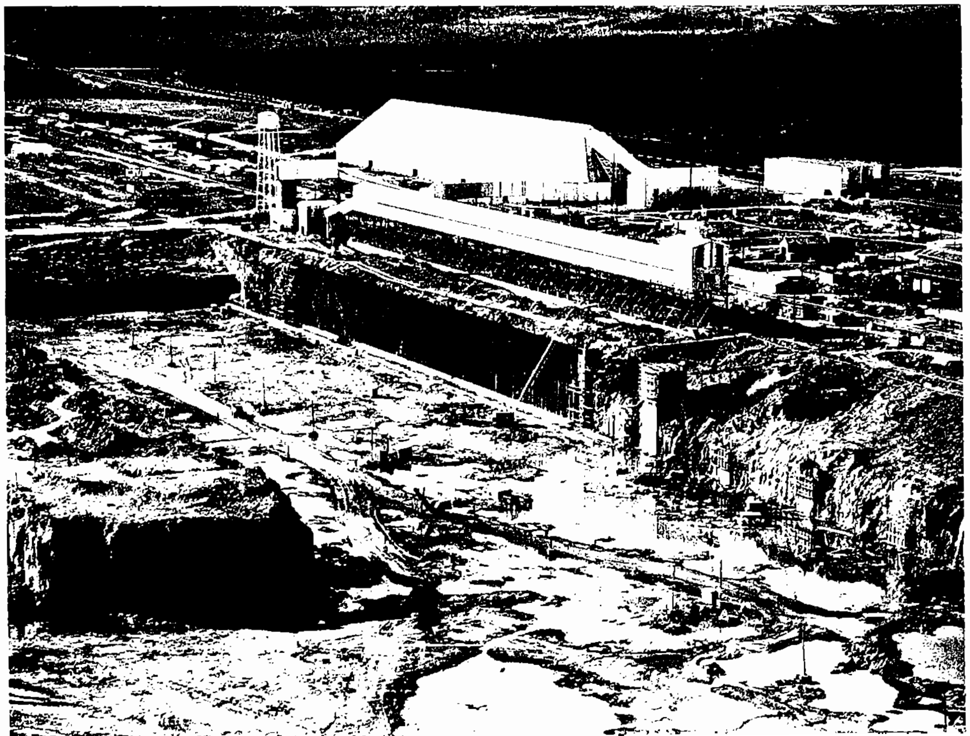
Prospective Producers (by 1965)

16. Consolidated Mining and Smelting Company of Canada Limited, The (1961)
17. Iron Ore Company of Canada (1962)
    Wabush Iron Co. Limited (1964-65)
18. Noranda Exploration Company, Limited (1962)
19. Quebec Cartier Mining Company (1961)
20. Silver Standard Mines Limited (1962)
21. Zeballos Iron Mines Limited (1962)



Quebec Cartier Mining Company's mine and mill at Gagnon, Quebec. The concentrator, which is the largest in the world, was put into operation on a trial basis late in 1960.

Harbor construction at Port Cartier, Quebec, October 1960.



Limited. Mine development, plant and town construction, and pilot-plant ore-testing proceeded on schedule. The deposit being developed is one of several held by Iron Ore Company of Canada on the west side of Wabush Lake and conservatively estimated to contain 1,500 million tons of material grading from 37 to 38 per cent iron. The beneficiation plant will have an annual capacity of 7 million tons of concentrate.

Wabush Iron Co. Limited is proceeding with a $200-million development of its 1,000-million-ton, concentrating-grade deposit on the southeast side of Wabush Lake. Production at the rate of 4 million to 5 million tons of concentrate a year is planned for 1965. A short spur connects the company's property with Iron Ore Company's Carol Lake branch line at Mile 37. Wabush Iron Co.'s new pilot plant produced 300 tons of concentrate a day for large-scale testing in furnaces of participating steel firms and for determining the most feasible flowsheet. Three shipments totalling 42,000 tons were made from Seven Islands for sintering and blast-furnace tests. Detailed exploration and engineering studies of all phases of the project continued.

In conjunction with Iron Ore Company of Canada and Wabush Iron Co. Limited, British Newfoundland Corporation Limited formed Twin Falls Power Corporation to supply power to those companies from a 120,000-horsepower hydroelectric plant 12 miles southwest of Hamilton Falls and 110 miles east of Wabush Lake. Contracts were let and the project is to be completed in 1962.

Other companies active in the Wabush Lake area include Labrador Mining and Exploration Company Limited and Canadian Javelin Limited. The companies have leased portions of their concessions to Iron Ore Company of Canada and Wabush Iron Co. Limited, respectively, but have retained extensive areas with indicated iron-ore reserves.

Quebec

Aside from Iron Ore Company of Canada, Hilton Mines, Ltd., is the only iron-ore producer in the province. In 1960, the company's pellet-plant capacity was increased to 800,000 tons a year from 600,000 tons through the balancing of crushing, grinding, concentrating, and pelletizing circuits.

The considerable improvements in the markets for titania slag and remelt iron made it possible for Quebec Iron and Titanium Corporation to operate its electric smelter at Sorel at near capacity. During the year the company initiated a $5-million modernization program in which one furnace will be rebuilt and facilities at Havre St. Pierre will be improved. In 1961, when the program is completed, the company's rated annual capacity will be 400,000 short tons of slag and 300,000 short tons of remelt iron.

Quebec Cartier Mining Company proceeded with the development of its Lac Jeannine deposit and explored several of its deposits in the Mount Reed and Mount Wright areas. Several hundred million tons of concentrating-grade material have been outlined. For the Lac Jeannine project, the 193-mile railway from Port Cartier , harbor excavations, two townsites, a hydro-electric power plant, a beneficiation plant, and open-pit mine development were completed or well advanced by the end of the year. Shipments are expected to begin in mid-1961. The operation is designed to mine 20 million tons of crude ore for the production of 8 million tons of concentrate a year. The concentration plant is one of the largest in the world.

In the Mount Reed area, where several other companies have iron-ore prospects, exploration was not particularly active during the year. Some work was done, however, primarily in geological mapping, diamond-drilling, and concentration-testing.

In the Albanel Lake area, about 100 miles northeast of Chibougamau, Albanel Minerals Limited has outlined large magnetite deposits with sufficient open-pit reserves to produce at least 200 million tons of high-grade iron pellets. The company, formed by M.J. O'Brien, Limited, of Ottawa, and The Cleveland-Cliffs Iron Company, of Cleveland, is considering a beneficiation plant to produce 3 million tons of pellets a year, although production plans have not been announced.

Ontario

Algoma Ore Properties Division of The Algoma Steel Corporation, Limited, continued to develop three new levels, to be known as the George MacLeod mine, below the present Helen and Victoria mines. The $20-million program, scheduled for completion in the fall of 1961, embraces a 2,000-foot shaft, a 1-mile aerial ropeway on a 22-degree slope to bring the ore to the surface, and an additional 2 miles of ropeway to the sinter plant. The capacity of the No. 2 heavy-media concentration plant is to be doubled to 8,000 tons of feed a day. A heavy-media cyclone plant was completed late in 1960 to treat fine ore previously stockpiled.

Shipments made from the Steep Rock Lake area, 140 miles west of Port Arthur, by Steep Rock Iron Mines Limited were the company's second lowest since 1954. Development of the Hogarth underground and 'G' open-pit mines for production in 1961 proceeded on schedule. The Hogarth open pit is expected to be depleted by 1962. Because of increasing competition from higher-grade ores, the company continued its product-research program and accelerated its evaluation of the Lake St. Joseph concentrating-grade property in northwestern Ontario.

Two miles south of Steep Rock Lake, Canadian Charleson, Limited, operated below its rated capacity of 175,000 tons of concentrate a year owing to the depressed state of the ore market.

Canada's newest producer, Caland Ore Company Limited, started production from one of its newly developed mines on the east arm of Steep Rock Lake, held under lease from Steep Rock Iron Mines Limited. Dredging of the overlying lake bottom, which began in 1955, was completed in 1960.

A second open pit will be worked in 1961 and initial underground production is scheduled for 1963.

Lowphos Ore, Limited, a new producer in 1959, operated near capacity during 1960. Shipments are made to the Detroit area through the port of Depot Harbour, on Georgian Bay.

Marmoraton Mining Company, Ltd. operated near capacity for most of the year. For six weeks beginning October 1, the plant was shut down because of the oversupply of ore and the reduced operating rate at the parent company's plant near Buffalo, New York.

The International Nickel Company of Canada, Limited, announced plans to triple the capacity of its iron-ore-recovery plant at Copper Cliff to 750,000 tons a year by the end of 1963. The plant would then treat 1,140,000 tons of nickeliferous-pyrrhotite concentrate a year.

Falconbridge Nickel Mines, Limited announced plans to produce about 100,000 tons of by-product iron ore annually from the treatment of nickeliferous pyrrhotite concentrate. The pilot plant that company has operated for several years will be altered to a commercial scale by the end of 1961.

Saskatchewan

Interprovincial Steel and Pipe Corporation Ltd. and Kelsey Lake Development Company Limited continued to explore the concentrating-grade iron formation on their properties 40 miles east of Prince Albert. The deposits are beneath 2,000 feet of younger sedimentary rocks. The companies have conducted extensive technical and economic studies on the feasibility of mining, concentrating, and smelting for the production of sponge iron for steelmaking.

Alberta

Premier Steel Mills Ltd. continued its detailed program, begun in 1959, of evaluating all aspects of the utilization of its Peace River iron-bearing deposits in northwestern Alberta. Detailed geological mapping and drilling of a portion of the extensive deposits were carried out. About 4,800 tons of material were shipped to Alabama for testing by the R-N process to determine whether a suitable charge material for electric-furnace steelmaking can be produced.

British Columbia

The Supreme Court of Canada ruled that the British Columbia Mineral Property Taxation Act of 1957 was invalid since the tax levied under the Act prohibited economic operation of iron-ore mines and specifically excluded all minerals except iron ore. The Court concluded that the Act had been passed for a purpose other than the raising of revenue and was thus ultra vires of the British Columbia legislature.

Later, the Government of British Columbia passed legislation whereby a royalty, in lieu of a 50-per-cent reserve, was placed on shipments from iron-ore properties in certain areas. The Mining Association of British Columbia said that the new regulation would be instrumental in stimulating iron-ore exploration and production.

During the year, Empire Development Company, Limited, Nimpkish Iron Mines Ltd., and Texada Mines Ltd. together shipped a record ore tonnage. The operations of Empire Development are not expected to continue past 1961 at the present level unless a new zone a quarter of a mile to the north proves economically attractive. Nimpkish Iron Mines is not likely to continue production past 1962, but the reserves of Texada Mines, the oldest producer in the province, are sufficient to last until after 1963. The Hualpai Enterprises Limited, a small new producer in 1959, went bankrupt early in 1960.

Three companies have signed contracts with Japanese interests for the sale of iron ore. Silver Standard Mines Limited has a five-year contract involving 2 million tons. Production from its Moresby Island property, in the Queen Charlotte group, is scheduled for early 1962. International Iron Mines Ltd. has signed a contract for the sale of up to 500,000 tons of magnetite concentrate a year for six years from the property of its wholly owned subsidiary, Zeballos Iron Mines Limited. Shipments will begin early in 1962. With Japanese interests Noranda Exploration Company, Limited, has negotiated a seven-year contract involving 5 million tons. Shipments are expected to begin in mid-1962. The company was active not only on its Kennedy Lake property, but also with International Iron Mines Ltd. in the Bugaboo Creek area of southern Vancouver Island.

The new 100,000-ton-a-year sinter plant of The Consolidated Mining and Smelting Company of Canada Limited and the company's 36,500-ton-a-year electric pig-iron-furnace plant, both at Kimberley, began production early in 1961. Pelletized iron-oxide calcine from the nearby sulphuric-acid plant is the source of the iron ore.

Prices and Tariffs

Traditionally, prices received by most Canadian iron-ore producers are based on the Lake Erie price - the price paid per long ton of iron ore delivered at the rail of vessel at Lower Lake ports. The Lake Erie price is based on an iron content of 51.5 per cent and is further classified as to type and phosphorous content. It is also affected by the structure of the ore and the nature of the impurities present. Ore prices in Japan and western Europe are more directly influenced by overseas market conditions than by the Lake Erie price. The Lake Erie prices in the accompanying table have been in effect since the beginning of 1957, and no increases are expected for 1961.

	$U.S. per Long Ton	
	Mesabi	Old Range
Non-Bessemer	11.45	11.70
Bessemer	11.60	11.85

Source: Cliffs Iron Ore Analyses 1961, The Cleveland-Cliffs Iron Company, Cleveland, Ohio.

Neither Canada nor any country with which it trades maintains tariffs on iron ore. In January 1959, the United States Tariff Commission held public hearings on competition and the effects of iron-ore imports on the United States iron-mining industry. At the time, no opposition to imports was voiced, but in October 1960 the Commission held public hearings to determine whether, owing to the customs treatment accorded under the General Agreement on Tariffs and Trade, iron-ore imports had seriously injured the domestic iron-mining industry. If the Commission had found evidence of 'serious injury,' it would have been bound to recommend restrictive measures against imports. Early in 1961, however, it ruled that iron-ore imports had not injured the domestic industry.

LEAD

J.W. Patterson*

Lead production in Canada during 1960, at 205,650 short tons, was 18,954 tons higher than in 1959. British Columbia accounted for 18,025 tons of this increase. Production rose also in Newfoundland and Manitoba, whose combined output increased by 2,602 tons. Decreases totalling 1,673 tons were recorded in Yukon Territory, Ontario, and Quebec, the largest decrease, which amounted to 780 tons, occurring in Ontario.

Canada's only lead smelter and electrolytic refinery, operated by The Consolidated Mining and Smelting Company of Canada Limited (Cominco) at Trail, British Columbia, raised its output of refined lead to 158,510 tons from the 135,296 tons produced in 1959.

Most of the lead concentrate from British Columbia and Yukon Territory was treated at Cominco's custom refinery at Trail. The remainder was treated at lead smelters in the United States. Lead concentrates produced in the eastern provinces were exported to smelters in Europe and the United States, most going to Europe. Exports of primary lead increased from 145,978 tons in 1959 to 147,785 tons in 1960. Of these exports, the United States received 38 per cent (51 per cent in 1959), the United Kingdom 36 per cent (31 per cent in 1959), West Germany 8 per cent (9 per cent in 1959), Belgium and Luxembourg 8 per cent (7 per cent in 1959), and Japan 8 per cent (0.02 per cent in 1959). Of the remaining 2 per cent, half went to India and Taiwan, which in 1959 did not import any lead from Canada, and half went to 11 other countries.

Lead output, exports and consumption are shown graphically on page 310.

A few mines accounted for most of the production, the most important being Cominco's Sullivan mine at Kimberley, British Columbia, which produced about 50 per cent of the total. Other important sources were the Buchans mine in Newfoundland, Cominco's Bluebell mine and the Canadian Exploration mine in southeastern British Columbia, and the Yukon mines of United Keno Hill Mines Limited. These mines, together with the Sullivan mine, produced about 193,000 tons, or close to 94 per cent of Canada's output.

In the Northwest Territories large deposits of lead-bearing ore have been outlined at Pine Point, on the south shore of Great Slave Lake. Smaller deposits in Yukon Territory have been explored on Vangorda Creek, a tributary of Pelly River, and in the Hyland River area some 40 miles north of

(text continued on page 310)

*Mineral Resources Division.

Lead --Production, Trade and Consumption

	1960		1959	
	Short Tons	$	Short Tons	$
Production				
All forms (1)				
British Columbia	166,947	35,659,900	148,922	31,601,233
Newfoundland...........	24,022	5,131,091	22,457	4,765,328
Yukon Territory.........	10,143	2,166,638	10,796	2,290,960
Quebec	2,670	570,195	2,910	617,412
Manitoba	1,037	221,574	-	-
Ontario	831	177,490	1,611	341,902
Total..................	205,650	43,926,888	186,696	39,616,835
Refined(2)...............	158,510		135,296	
Exports				
In ores and concentrates				
United States	26,895	4,928,731	30,674	6,346,922
West Germany...........	12,220	2,024,806	12,685	1,773,363
Belgium and Luxembourg.	11,446	1,970,536	10,367	1,694,631
Japan..................	775	162,666	-	-
Total	51,336	9,086,739	53,726	9,814,916
Refined				
United Kingdom	54,032	8,385,574	44,659	6,259,621
United States............	28,866	5,476,005	44,507	8,473,117
Japan	10,380	1,598,054	24	3,694
India	811	123,225	-	-
Taiwan	760	115,965	-	-
Netherlands.............	588	90,492	168	23,406
Other countries	1,012	168,779	2,894	423,439
Total..................	96,449	15,958,094	92,252	15,183,277
Scrap				
United States............	5,657	782,663	2,904	325,491
United Kingdom	943	135,204	-	-
Jamaica	52	3,120	-	-
Other countries	35	76,882	121	145,920
Total..................	6,687	997,869	3,025	471,411

Lead - Production, Trade and Consumption (cont'd)

	1960		1959	
	Short Tons	$	Short Tons	$
Lead pipe and tubing and lead manufactures				
United States		65,355		47,189
United Kingdom		6,774		4,730
Peru		5,725		2,559
Jamaica		5,568		2,200
Other countries		13,564		4,760
Total		96,986		61,438
Imports				
Lead in pigs and blocks		150,277		327,640
Lead in bars and sheets		12,066		30,581
Litharge		186,557		325,742
Lead manufactures		276,974		264,518
Miscellaneous lead products		255,396		210,322
Total		881,270		1,158,803
Consumption				
Primary lead				
Antimonial lead	256		544	
Batteries and battery oxides	12,309		14,156	
Cable covering	4,980		3,980	
Chemical uses (white lead, red lead, litharge, tetraethyl lead, etc.)	11,828		12,975	
Copper alloys (brass, bronze, etc.)	307		309	
Lead alloys				
Solders	1,562		1,737	
Other (including babbitts, type metal, etc.)	248		178	
Semifinished products (pipe, sheet, traps, bends, block for caulking, ammunition, foil, collapsible tubes, etc.)	7,779		10,695	
Other	966		1,591	
Total	40,235		46,165	

Lead - Production, Trade and Consumption (cont'd)

	1960 Short Tons	1960 $	1959 Short Tons	1959 $
Secondary lead				
Antimonial lead	19,115		7,322	
Batteries and battery oxides	349		294	
Cable covering	1,591		2,133	
Chemical uses (white lead, red lead, litharge, tetraethyl lead, etc.)	1,803		1,587	
Copper alloys (brass, bronze, etc.)	142		229	
Lead alloys ...				
Solders	1,860		1,691	
Other (including babbitts, type metal, etc.)	3,985		3,893	
Semifinished products (pipe, sheet, traps, bends, block for caulking, ammunition, foil, collapsible tubes, etc.)	1,805		1,179	
Other	1,202		1,442	
Total	31,852(3)		19,770	

Consumption summary

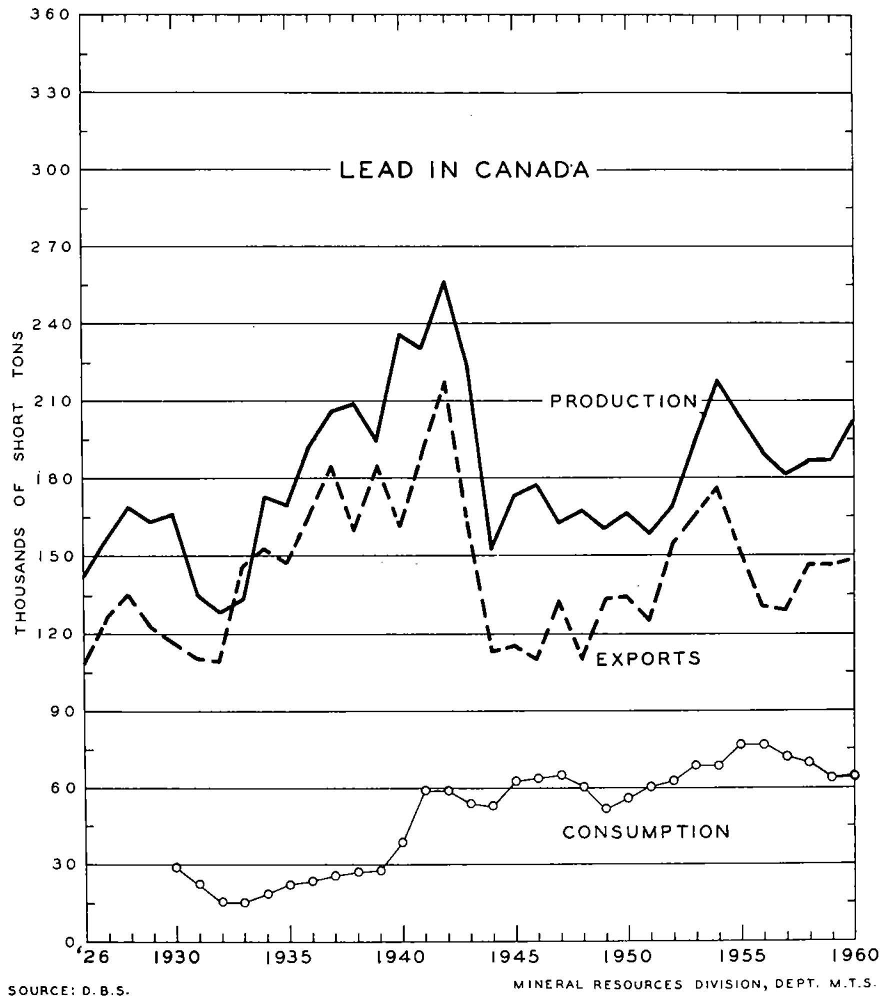
	1960 Short Tons	1960 $	1959 Short Tons	1959 $
Primary lead	40,235		46,165	
Secondary lead	31,852(3)		19,770	
Total	72,087		65,935	

Source: Dominion Bureau of Statistics.

(1) Primary lead in base bullion produced from domestic ores, plus recoverable lead in domestic ores and concentrates exported.

(2) Primary refined lead from all sources.

(3) Includes all remelt scrap lead and scrap lead used to make antimonial lead. Prior to 1960 all the scrap lead consumed was not reported.



Watson Lake. In New Brunswick, near Bathurst,several large orebodies containing appreciable quantities of lead have been outlined. In this area in 1957 and 1958 Heath Steele Mines Limited produced small amounts of lead from its large zinc-copper-lead orebody.

Since 1956, the consumption of primary refined lead has declined between 4,600 and 9,700 tons annually, the largest decline occurring in 1958. To the end of 1959 a large part of this decline was attributable to a decrease in the use of lead in cable covering. Since then, however, substantial decreases have occurred in the consumption of lead by manufacturers of batteries and battery oxides, and of such semifinished products as pipe, sheet, traps, bends, block for caulking, etc.

Lead - Production, Trade and Consumption, 1950-60
(short tons)

	Production		Exports			Imports	Consumption
	All Forms(1)	Refined(2)	In Ore and Concentrates	Refined	Total	Refined(3)	Refined(4)
1950	165,697	170,023	19,276	115,168	134,444	1,237	54,723
1951	158,231	162,000	19,648	105,736	125,384	727	60,348
1952	168,842	182,943	23,967	129,740	153,707	355	62,466
1953	193,706	165,752	61,683	102,879	164,562	255	67,718
1954	218,495	166,005	59,755	116,409	176,164	148	67,947
1955	202,763	148,811	58,164	92,704	150,868	98	76,351
1956	188,854	147,865	49,974	79,633	129,607	105	75,882
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

Source: Dominion Bureau of Statistics.
(1) Primary lead in base bullion produced from domestic ores, plus recoverable lead in domestic ores and concentrates exported.
(2) Primary refined lead from all sources.
(3) Lead in pigs and blocks.
(4) Refined lead, both primary and secondary in origin.

Lead consumption in the United States, Canada's main market, decreased from 1,091,149 tons in 1959 to 1,026,300 tons in 1960, principally beuause of a decrease in the use of lead in the manufacture of batteries, solder, and caulking materials.

United States Quotas

United States import quotas imposed on unmanufactured lead and zinc on October 1,1958, remained in effect throughout 1960. Under these quotas Canada's quarterly allotment was 6,720 tons for lead concentrates and 7,960 tons for lead metal. Owing to the prevailing practice of receiving commercial concentrate shipments in bond, the importers were able, after the imposition of the quotas, to import more lead concentrates than were needed to fill the quarterly allotments. With each succeeding quarter the excess of imports over quota allotments increased. Thus, as the accompanying table shows, the quarterly allotments were filled faster in 1960 than in the corresponding quarters of 1959. In the last quarter of 1960, however, shipments of lead concentrates to the United States decreased by some 5,000 tons from the average of the first three quarters, thus effectively reducing the excess of imports over quota allotments. Thus the allotment for the first quarter of 1961 was not filled until February 27.

Completion Dates of United States Quarterly Quotas on Lead Imports from Canada

Quarter	Year	Completion Date	
		Concentrates	Metal
First	1959	March 6	March 30
"	1960	January 4	" 29
Second	1959	May 26	June 29
"	1960	April 6	" 28
Third	1959	August 14	September 28
"	1960	July 7	August 24
Fourth	1959	November 6	December 28
"	1960	October 10	" 2

Although the shipments of metal in each quarter were less than the quarterly allotment, all the allotments were filled, the 1959 quota excess being more than enough to meet the deficiency.

International Lead and Zinc Study Group

The International Lead and Zinc Study Group, organized under United Nations sponsorship in 1959, held two meetings in Geneva during 1960. At the Group's first meeting, from January 27 to February 3, statistical analysis showed that world production of lead in 1960 would probably exceed consumption by a substantial amount; and at the second meeting, held in September, producers' stocks of lead were, in fact, found to be increasing. In July they had been at the very high level of 367,000 tons, about equally divided between the United States and the rest of the Free World. After July, Free World stocks continued to rise and by the end of the year they reached an estimated total of 381,000 tons, of which 199,000 tons were in the United States. These large stocks will undoubtedly influence discussions at the Group's next meeting, which is to be held in March 1961 and may result in some producers' voluntarily reducing their output. (In January, Cominco announced that it would keep its 1961 mine production of lead 20 per cent below its 1960 output.)

Producing Mines*

British Columbia

In 1960 The Consolidated Mining and Smelting Company of Canada Limited produced 3,242,533 tons of lead-zinc ore; in 1959 it produced 3,155,266 tons. The company mined 2,522,554 tons from its Sullivan mine at Kimberley and 719,979 tons from its other two lead-zinc producing mines, the Bluebell on the east shore of Kootenay Lake and the H.B. near Salmo.

* See sketch map on page 314.

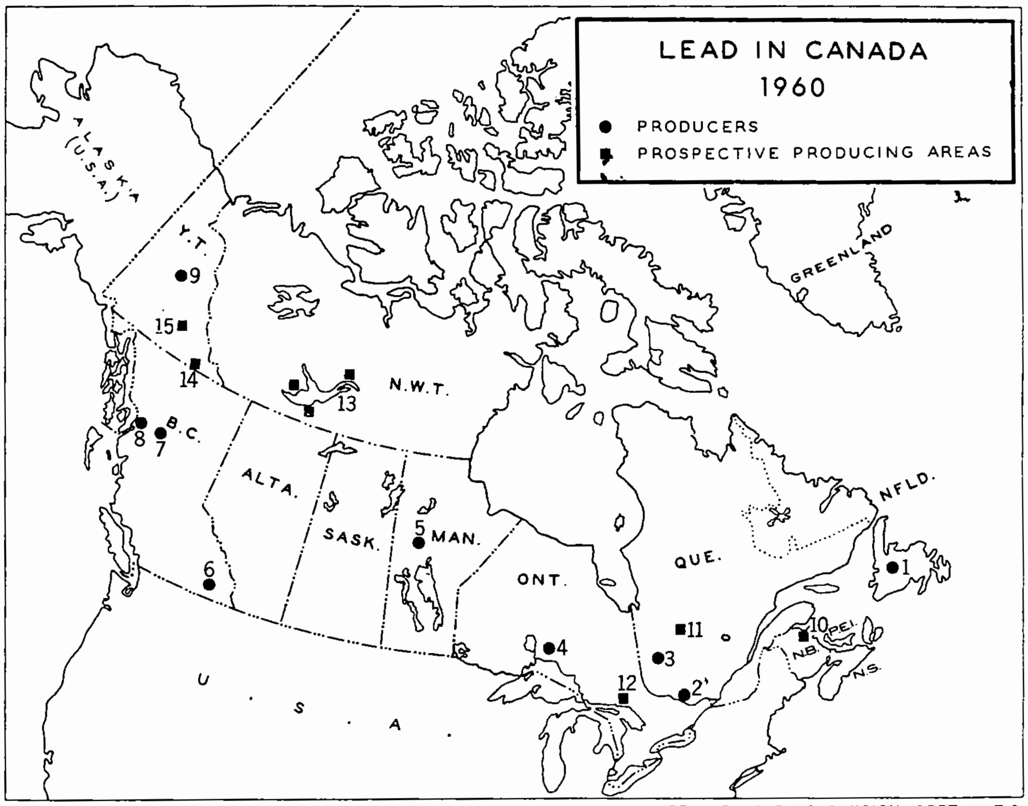
Principal Lead Producers in British Columbia, 1960

Company	Mine	Location	Mill Capacity (short tons/day)	Grade of Ore (Partial) Lead (%)	Zinc (%)	Silver (oz/ton)	Ore Produced 1960 (short tons)	Ore Produced 1959 (short tons)	Lead Produced 1960 (short tons)
Consolidated Mining and Smelting Company of Canada Limited, The	Sullivan	Kimberley	10,000	*	*	*	2,522,554	2,440,396	*
	Bluebell	Riondel	700	*	*	*	255,571	251,366	*
	H.B.	Salmo	1,200	*	*	*	464,408	463,504	*
Canadian Exploration Limited	Jersey	Salmo	1,900	2.26	4.43	*	364,424	325,564	4,832
Highland-Bell Limited	Highland-Bell	Beaverdell	70	*	*	51.70	18,204	18,029	*
Reeves MacDonald Mines Limited	Reeves MacDonald	Remac	1,000	1.15	3.59	*	411,282	421,593	1,847
Sheep Creek Mines Limited	Mineral King	Toby Creek, south-west of Invermere	500					181,495	
	Paradise	Spring Creek, south-west of Invermere		2.71 (1)	4.84 (1)	1.07 (1)	194,607 (1)		4,765 (1)
ViolaMac Mines Limited (2)	Victor	Sandon	150	5.42	9.75	15.93	6,227	6,028	337

Source: Mineral Resources Division.

(1) This is the production of the Mineral King and Paradise mines combined. (2) The ore was concentrated in the 150-ton mill owned by Carnegie Mining Corporation Limited, a ViolaMac subsidiary. The ore grade shown is based on metal recovered in concentrates.

* Not available.



MINERAL RESOURCES DIVISION, DEPT. M.T.S.

Principal Producers

1. American Smelting and Refining Company (Buchans Unit)
2. New Calumet Mines Limited
3. Manitou-Barvue Mines Limited
4. Willroy Mines Limited
5. Hudson Bay Mining and Smelting Co., Limited (Chisel Lake mine)
6. Canadian Exploration Limited
   Consolidated Mining and Smelting Company of Canada Limited, The (also lead smelter and lead refinery)
   Bluebell mine
   H.B. mine
   Sullivan mine
   Highland-Bell Limited
   Lajo Mines Limited
   Reeves MacDonald Mines Limited
   Sheep Creek Mines Limited
   Silver Ridge Mining Company Limited
   Violamac Mines Limited
   Western Mines Limited
   Yale Lead & Zinc Mines Limited
   Yukon Western Mining Company Limited
7. New Cronin Babine Mines Limited
8. Bermah Mines Ltd.
9. United Keno Hill Mines Limited

Prospective Producing Areas

10. Bathurst
11. Bachelor Lake
12. Sudbury basin
13. Great Slave Lake
14. Watson Lake
15. Pelly River

Cominco's smelting facilities at Trail were used to treat the lead concentrates produced at its three mines as well as purchased and custom concentrates obtained principally from mines in British Columbia and Yukon Territory. Output from all souces, including some metal sold in unrefined products, was 160,079 tons in 1960; in 1959 it was 140,881 tons. The production total for lead and zinc combined was 355,068 tons (335,380 tons in 1959). Of this total, about 67 per cent (64 per cent in 1959) was derived from Sullivan concentrates, 14 per cent (14 per cent in 1959) from Bluebell and H.B. concentrates, 9 per cent (11 per cent in 1959) from purchased ores and concentrates, and 10 per cent (11 per cent in 1959) from the retreatment of stockpiles of zinc-plant residues and lead-blast-furnace slag.

The output of Cominco and other principal producers is summarized in the table on page 313. Other producers in 1960 were: Yale Lead & Zinc Mines Limited, which, in its 250-ton mill at Ainsworth, treated custom ores mined by leasers principally from Yale's own mines and the Kootenay Florence mine of Western Mines Limited; Bermah Mines Ltd., near Stewart; New Cronin Babine Mines Limited, near Smithers; Silver Ridge Mining Company Limited and Yukon Western Mining & Prospecting Co. Ltd., both in the Slocan area; and Lajo Mines Limited, West of Kaslo.

Manitoba

Hudson Bay Mining and Smelting Co., Limited, began to produce zinc-lead-copper ore from the Chisel Lake mine at Snow Lake on September 1 at about 1,000 tons a calendar day. The ore is transported some 70 miles by rail to Flin Flon, where it is concentrated in the company's 6,000-ton mill.

Ontario

Willroy Mines Limited, at Manitouwadge, milled 429,309 tons of zinc-copper-lead ore, from which lead concentrate containing 800 tons of lead was produced.

Quebec

In its fiscal year ended on September 30, 1960, New Calumet Mines Limited produced 1,775 tons of lead in concentrate at its zinc-lead-silver-gold mine on Calumet Island, in the Ottawa River about 70 miles northwest of Ottawa.

Manitou-Barvue Mines Limited, 8 miles east of Val d'Or, produced 931 tons of lead in lead concentrate derived from 164,690 tons of zinc-lead ore. The ore was treated in a split-circuit mill together with 292,065 tons of copper ore.

Newfoundland

As in previous years American Smelting and Refining Company (Buchans Unit) produced zinc, lead, and copper concentrates. These concentrates, derived from 386,000 tons of ore, were estimated to contain 27,311 tons of recoverable lead.

Yukon Territory

United Keno Hill Mines Limited, Mayo district, during the fiscal year ended on September 30, 1960, produced 10,993 tons of lead in lead and zinc concentrates. The concentrates were derived from 176,745 tons of silver-lead zinc ore, of which 58.7 per cent was mined from the Calumet mine, 20.9 per cent from the Hector mine, 19.3 per cent from the Elsa mine, and the rest from development in the Keno mine, from dumps, and from development and clean-up in the Galkeno mine.

Other Developments

British Columbia

Cominco continued to explore and develop the Duncan lead-zinc property, near Duncan Lake, in the Lardeau district, in the southeastern section of the province.

Quebec

To treat tailings from lead-zinc ore left by previous operators, Ghislau Mining Corporation Ltd. rehabilitated a mill in Portneuf county, northwest of Quebec City, that was formerly operated by Anacon Lead Mines Limited.

Atlantic Provinces

Brunswick Mining and Smelting Corporation Limited announced in March 1960 that it had reached agreement in principle with Sogemines Limited, a Canadian subsidiary of a Belgian firm, on the development of Brunswick's mining property near Bathurst, New Brunswick. Other potential lead-and-zinc producers active in the same area were Anacon Lead Mines Limited, Heath Steele Mines Limited and The New Jersey Zinc Company.

Northwest Territories

The Royal Commission on the Great Slave Lake Railway, appointed in June 1959, reported on the respective merits of the western and eastern routes to Pine Point on Great Slave Lake, the site of important lead-zinc deposits. As announced on November 17 in the Speech from the Throne, the federal government intends to provide funds for a detailed survey of a railway route from Grimshaw, in northwestern Alberta, to Great Slave Lake.

Uses and Consumption

The main industrial applications and the tonnages used in each are shown on pages 308 and 309.

The most valued properties of lead are its resistance to corrosion, its low melting point, its malleability, and its high specific gravity. Because of these properties, lead is used extensively in the manufacture of corrosive-liquid containers, batteries, various types of lead-base babbitts, solders and type metals, plumbing equipment such as pipes, drains and bends, caulking materials, ammunition, etc. Lead is also used in large amounts in the manufacture of paints and tetraethyl lead.

Among more recent developments is the use of lead in reactor installations as shielding against nuclear radiation, in containers for storing and shipping radioactive substances, in jet liners to reduce noise, in air-conditioning systems to control sound and vibration, in the construction of skyscraper foundations to absorb vibrations, and in lead-alloy anodes in impressed-current cathodic systems for the protection of bridges, piers,and ships' hulls against corrosion.

In 1960, domestic consumption equalled 35 per cent of Canada's production of primary lead. A large part of this consumption, however, was not of primary lead but of secondary lead and such alloys as antimonial lead,which were produced from scrap materials and re-used in the manufacture of battery plates, bearing metal, solder, and type metal. Prior to 1960, the scrap used in antimonial-lead manufacture was not all reported; hence, the secondary-lead consumption figures of past years are not comparable with those of 1960.

Among the principal consumers of lead in Canada are: Canadian Industries Limited, Electric Storage Battery Company (Canada) Limited; Prest-O-Lite Battery Co., Limited; Hart Battery Company (1957) Limited; The Canada Metal Co., Limited; Federated Metals Canada Limited; The Steel Company of Canada Limited; Ethyl Corporation of Canada Limited; Northern Electric Company, Limited; Canada Wire and Cable Company Limited; and Carter White Lead Co. of Canada Limited.

World Production of Lead

The countries in the following table are the world's leading producers of refined lead as reported by the American Bureau of Metal Statistics. Omitted are the countries of the Soviet bloc, which in 1960 produced an estimated 570,300 tons.

Production of Refined Lead, by Principal Producing Countries*
(short tons)

	1960	1959
United States(1)	409,258	364,250
Australia	268,152	273,516
West Germany(2)	227,330	211,993
Mexico	183,701	208,283
Canada	158,510	135,296
France	121,096	112,330
Belgium(3)	102,189	97,489
Yugoslavia	98,262	94,131
Japan(2)	81,783	70,891
Peru	80,353	62,551
Spain	78,262	75,543
Sweden	49,112	40,619
Italy	48,056	49,417
Morocco	33,870	31,368
Argentina	32,400	37,600
Tunisia	21,215	23,860
Northern Rhodesia	16,419	16,128
Burma	14,740	22,341
Austria	12,900	10,965
Total	2,037,598	1,938,571

(1) Includes metal derived from imported ores and base bullion, and metal derived from scrap at primary refineries.
(2) Includes some metal derived from scrap.
(3) Reported as a moving average covering three months.
* Excluding Soviet bloc.
Source: American Bureau of Metal Statistics, 1960.

Prices

The price of lead in 1960 was 10.75 cents a pound until April 12,when it increased to 11 cents. Subsequently, it dropped half a cent on July 5 and half a cent on December 29, to a year-end price of 10 cents.

Tariffs

Canadian tariffs on ore and concentrates and certain semifabricated forms were as follows:

	British Preferential	Most Favored Nation	General
Lead ores and concentrates	free	free	free
Pig-lead scrap and blocks (per pound)	3/4¢	1¢	1¢
Lead bars and sheets	15%	22 1/2%	25%
Babbitt metal and type metal in blocks, bars, plates, and sheet	10%	20%	20%

The United States tariff on the lead content of ores and concentrates was 0.75 cent a pound. On pig lead, lead bullion, scrap lead,and various lead alloys, it was 1.0625 cents a pound on the lead content. Varying tariffs were applied to imports of lead in other forms.

LIME

J.S. Ross*

The shipments made by the lime industry during 1960 were notably smaller than those of the record year 1959. The output decreased mainly because less lime was demanded by the uranium, pulp-and-paper, and alkali and calcium-carbide industries. Although plant capacity exceeded national requirements, two new rotary lime kilns were put in operation at established plants in Ontario and Quebec. One veteran producer did not operate but made small shipments.

Production in 1960 amounted to 1,213,597 tons of high-calcium and dolomitic quicklime and 315,971 tons of hydrated lime, with a total value of 19 million. This tonnage was 9 per cent less than that of 1959, the bulk of the decrease being in quicklime. The most notable change in volume took place in Ontario, where production dropped by 139,967 tons, or 12 per cent.

Lime is imported in small amounts for a few smaller markets more favorably situated in relation to United States lime plants. In addition, minor quantities of special types not produced in Canada are imported. Exports are less than imports and go mainly to the United States.

Production

A product of the calcination of limestone, lime is marketed in either the oxide or the hydroxide form. In general, two types of quicklime (the oxide) are produced in Canada. These are classified as high-calcium, which contains 90 per cent or more available calcium oxide and up to 5 per cent available magnesia, and dolomitic, which contains 25 to 45 per cent free magnesia. The hydrated counterparts are also produced. The bulk of the domestic output is of high-calcium quicklime.

Lime is manufactured in all provinces except Prince Edward Island, Nova Scotia, Newfoundland, and Saskatchewan. It is produced mainly in or near the more populated regions. Limestone deposits of suitable quality occur in all provinces except Prince Edward Island. During 1960, 2,669,574 tons of limestone were used for the production of lime.

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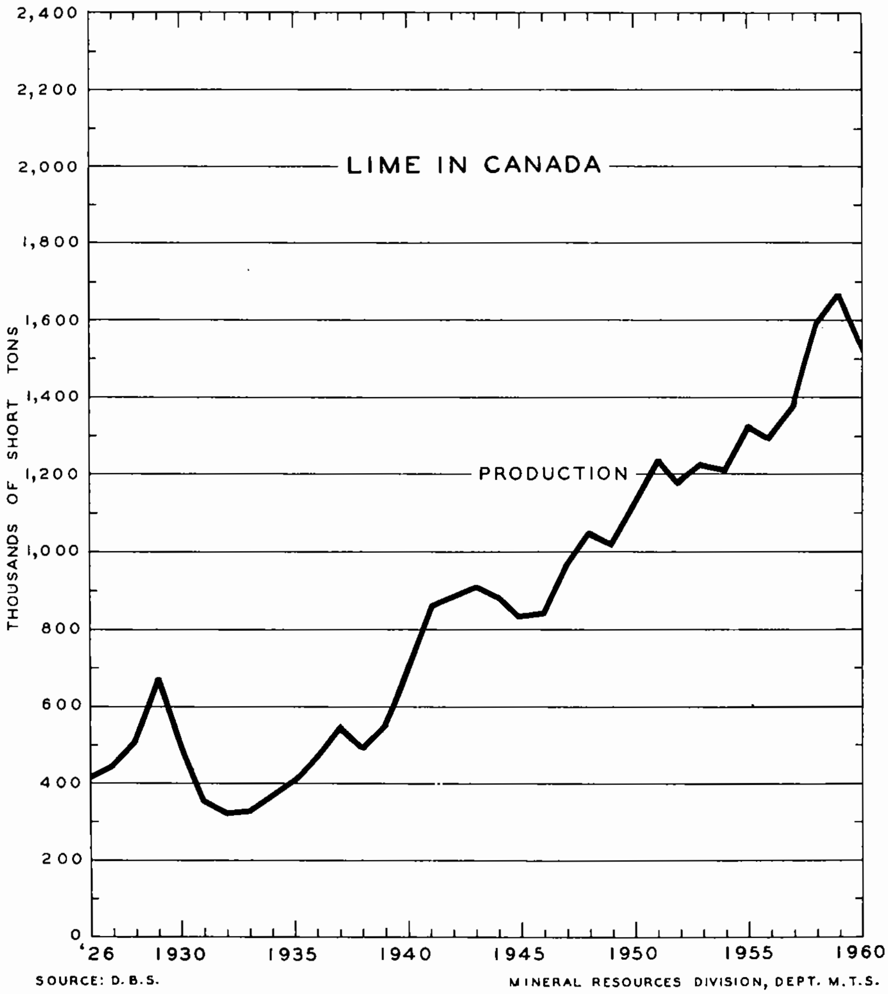
*Mineral Processing Division, Mines Branch.

Lime - Production and Trade

	1960		1959	
	Short Tons	$	Short Tons	$
Production				
By product				
Quicklime	1,213,597	15,609,573	1,359,666	17,255,903
Hydrated lime	315,971	3,692,217	326,059	4,048,118
Total	1,529,568	19,301,790	1,685,725	21,304,021
By province				
Ontario	990,088	12,278,630	1,130,055	14,006,532
Quebec	399,874	4,449,164	404,060	4,568,694
Manitoba	48,383	834,698	60,503	1,022,953
Alberta	43,731	756,499	43,709	741,837
British Columbia	30,765	603,541	29,167	547,190
New Brunswick	16,727	379,258	18,231	416,815
Total	1,529,568	19,301,790	1,685,725	21,304,021
Imports				
United States	33,437	425,559	30,548	379,237
United Kingdom	383	4,053	868	8,958
Denmark	-	-	7	84
Total	33,820	429,612	31,423	388,279
Exports				
United States	18,802	399,941	24,609	428,178
British Guiana	2,800	22,882		
Bermuda	55	2,464	25	1,450
St. Pierre	11	348	3	114
Netherlands Antilles	-	-	4	156
Total	21,668	425,635	24,641	429,898

Source: Dominion Bureau of Statistics.

High-calcium lime is shipped from all producing provinces and dolomitic lime from Manitoba, Ontario, and New Brunswick. Plants in Ontario and Quebec supply 90 per cent of the requirements. Thirty-five plants equipped with 118 vertical kilns and 27 rotary kilns and having a total rated capacity of 8,010 tons of primary quicklime a day were in operation in 1960. Two separate hydrating plants were operated in Manitoba. In addition, a number of pulp and paper plants throughout Canada produce a large, although undetermined, amount of secondary lime from by-product calcium-carbonate sludges. Statistics concerning the number and output of these reclaiming plants are not available.



Developments

Despite a noteworthy excess of rated plant output, the capacity of the domestic lime industry continued to expand during 1960. At the end of the year, it was 36 per cent greater than the 1960 shipments. At Joliette, Quebec, Standard Lime Company, Limited completed construction of a rotary-kiln plant with a daily-output capacity of 200 tons. Cobo Minerals Limited installed a rotary kiln at its lime plant at Coboconk, Ontario. This kiln has a capacity of 170 tons a day.

Neither the Milton, Ontario, plant of Gypsum, Lime & Alabastine Limited nor the Trottier plant at St. Marc des Carrieres produced lime. Similarly, the Wallaceburg, Ontario plant of Canada Dominion Sugar Co. Ltd. was idle.

The coal-gas producers at the Lime Ridge, Quebec, plant of Dominion Lime Limited were replaced by oil-gas producers. This is the only Canadian lime operation that employs this technique.

Ontario Building Materials Limited began to produce lime putty at a plant in Toronto.

Lime Producers, 1960

Name of Firm	Plant Location	Type of Quicklime	Hydrator
New Brunswick			
Bathurst Power & Paper Company Limited	Bathurst	High-calcium	
Snowflake Lime Limited	Saint John	High-calcium and dolomitic	Hydrator
Quebec			
Aluminum Company of Canada, Limited	Wakefield	Magnesian	"
Bousquet, Adrien	St. Dominique	High-calcium	
Dominion Lime Limited	Lime Ridge	"	"
Lamothe, N.	Pont Rouge	"	
Raffinerie de Sucre de Québec	St. Hilaire	"	
Shawinigan Chemicals Limited	Shawinigan	"	
Standard Lime Company Limited	Joliette	"	"
	St. Marc des Carrières	"	
Ontario			
Bonnechere Lime Limited	Grattan tp.	"	
Brunner Mond Canada, Limited	Anderdon tp.	"	
Canada & Dominion Sugar Co. Ltd.	Chatham	"	
		"	
Canadian Gypsum Company Limited	Guelph tp.	Dolomitic	"
Carleton Lime Products Co.	Carleton Place	High-calcium	
Chemical Lime Limited	Beachville	"	
Cobo Minerals Limited	Coboconk	"	
Cyanamid of Canada Limited	Niagara Falls	"	
	Ingersoll	"	
Dominion Magnesium Limited	Haley Station	Dolomitic	
Gypsum, Lime & Alabastine Limited	Hespeler	"	"
	Beachville	High-calcium	"
Rockwood Lime Company, Ltd.	Rockwood	Dolomitic	"

Lime Producers, 1960 (cont'd)

Name of Firm	Plant Location	Type of Quicklime	Hydrator
Manitoba			
Building Products and Coal Co. Ltd.	Inwood	Dolomitic	Hydrator
Manitoba Sugar Company Limited, The	Fort Garry	High-calcium	
Winnipeg Supply & Fuel Company Limited, The	Spearhill	"	
	Stonewall	Dolomitic	
Alberta			
Canadian Sugar Factories Limited	Raymond	High-calcium	
	Picture Butte	"	
	Taber	"	
Loder's Lime Co. Limited	Kananaskis	"	"
Summit Lime Works Limited	Crowsnest	"	"
British Columbia			
Crown Zellerbach Canada Limited	Ocean Falls	"	
Gypsum, Lime & Alabastine Limited	Blubber Bay	"	"
	Granville Island	"	

Consumption and Uses

Lime, the most common alkali, has numerous direct or indirect uses in most industries. In many applications it has no substitute. Lime is used by four main groups of consumers, as indicated in the table on the following page.

Eighty-eight per cent of the lime consumed in Canada in 1960 was used by the chemical, metallurgical, and similar industries. Of this group, the classification 'other industries' is the largest and includes lime produced for the manufacture of calcium carbide and other alkali compounds. High-calcium lime is utilized in the Canadian uranium industry to neutralize waste sludges. In the pulp-and-paper industry lime is used in the preparation of dissolving fluids for the sulphite, sulphate, and soda processes. It serves as a flux and in the neutralization of waste pickling liquors in steel plants and may be put to the same use in the smelting of nonferrous ores. In the refining of beet sugar, high-calcium lime is utilized to precipitate impurities from sucrate solutions. It acts as a depressant in ore-flotation processes and provides pH control in the recovery of minerals by the cyanidation process. Dolomitic and high-calcium varieties are used in the production of glass. Lime is also used in the manufacture of magnesia, magnesium, fertilizer, insecticides, paint pigments, varnish, glue, calcium cyanamide, acetylene, soda ash, precipitated calcium carbonate, calcium chloride, calcium hydroxide, sodium bicarbonate, and other organic and inorganic compounds.

Consumption of Lime
(producers' shipments, by usage)

Uses	1960		1959	
	Short Tons	$	Short Tons	$
Chemical and other industrial				
Uranium mills	214,626	2,589,930	286,738	3,464,612
Pulp and paper mills	166,527	2,195,109	185,524	2,482,283
Nonferrous smelters	138,662	739,947	130,054	714,147
Iron and steel plants	173,711	2,079,593	162,244	1,904,349
Sugar refineries	31,086	471,966	34,324	451,419
Glass works	19,539	236,380	21,075	252,719
Cyanide and flotation mills	20,023	240,069	31,828	370,065
Tanneries	4,689	61,106	4,986	60,351
Fertilizer plants	7,406	52,340	1,754	19,071
Insecticides, fungicides	1,522	27,262	1,202	23,522
Other industries	574,681	7,360,143	615,019	7,735,492
Building-trade				
Mason's lime	58,630	987,529	78,963	1,283,591
Finishing lime	74,576	1,682,635	94,464	2,066,517
Sand-lime brick	12,336	138,746	16,070	181,192
Agricultural	7,731	102,301	8,515	86,224
Other	23,823	336,734	12,965	208,467
Total	1,529,568	19,301,790	1,685,725	21,304,021

Source: Dominion Bureau of Statistics.

The second main consuming group is the construction industry, which uses 9.5 per cent of Canada's lime output as a constituent of plaster, stucco, mortar, brick, artificial stone, and asphalt paving. In token amounts, lime also serves in Canada as a soil stabilizer.

In agriculture, lime is used as a fertilizer, in the manufacture of fertilizers, and in insecticides and fungicides.

The 'other' category includes lime used in water and sewage treatment.

Prices

Quicklime is marketed in Canada in bulk as lump, pebble, and pulverized and in bags as pulverized lime. Hydrated lime is sold in bulk or in bags. Prices vary according to the type and form of product, the sale tonnage, and the location. During 1960 the average production value of quicklime and hydrated lime was $13.06 and $12.42 a ton respectively at the plants.

LIMESTONE

J. S. Ross*

Although the production of limestone remained at a high level during 1960, it was below that of 1959, the record production year. Shipments for purposes other than the production of cement and lime amounted to 36.5 million tons valued at $45.4 million, as compared with 36.7 million tons valued at $46 million in 1959. A small amount of marble and marl was included in these shipments. In addition, 10.6 million tons of limestone were quarried for the production of cement and lime. The quarries in operation, numbering about 450, were situated in all provinces except Saskatchewan and Prince Edward Island. During 1960, the output of limestone for non-cement and non-lime purposes decreased in Quebec, Ontario, and Alberta. In British Columbia it increased notably but amounted to less than half the output of 1956, the peak year. Quebec remains the leading producer of this type of stove.

Canadian trade statistics on limestone, as such, are not available. The trade in all types of crushed stone between the United States and Canada is large for such a low-priced commodity. Statistics provided by the United States indicate that in 1960 Canada imported 905,102 short tons of broken, crushed, and ground limestone from that country and exported to it 121,449 short tons of the same material. In general, the trade in this product between the two countries was less than in 1959. Chemical-grade limestone is exported mainly from British Columbia, Alberta, and Ontario and imported chiefly into Ontario and British Columbia. The bulk of the trade is in crushed limestone for construction purposes and is mainly between Ontario and the United States. Several provinces trade small amounts of building, ornamental, and monumental limestone with foreign countries.

During the year the usual renovations and expansions were carried out at some plants, and a few new plants and quarries were put in operation. The larger expansions included the commencement of the construction of a new crushing-and-screening plant at the Bamberton, British Columbia, operations of British Columbia Cement Company Limited. A modern pulverizing plant was constructed by Shawinigan Chemicals Limited at its limestone operations near Bedford, Quebec.

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*Mineral Processing Division, Mines Branch.

Limestone - Production, Trade and Consumption

	1960*		1959	
	Short Tons	$	Short Tons	$
Production				
By province[1]				
Newfoundland.......	380,273	641,738	352,127	582,815
Nova Scotia	171,384	422,884	70,156	187,828
New Brunswick......	299,046	495,981	139,180	425,593
Quebec	17,784,980	21,925,129	18,168,512	22,629,885
Ontario	16,158,994	19,138,844	16,373,511	19,691,087
Manitoba...........	636,510	1,012,819	526,679	771,091
Alberta	70,173	235,175	279,584	459,359
British Columbia....	974,011	1,541,253	782,055	1,290,657
Total	36,475,371	45,413,823	36,691,804	46,038,315
By use				
Structural[2]	68,035	1,880,220	91,275	2,131,647
Metallurgical........	2,009,913	2,298,017	1,916,215	2,227,304
Glass-making	46,662	160,204	46,582	154,826
Sugar-refining.......	27,924	55,968	38,756	77,672
Pulp-and-paper	437,614	1,403,734	375,823	1,169,780
Other chemical uses	323,664	271,737	445,397	414,656
Pulverized for agricultural and fertilizer uses	896,377	2,270,512	727,142	1,966,332
Pulverized for other uses	219,302	738,992	253,986	869,166
Rubble and riprap....	1,074,913	978,014	830,201	1,057,125
Concrete aggregate ..	7,947,937	9,022,705	7,476,397	8,716,154
Road metal..........	19,375,150	21,398,317	20,230,873	22,003,778
Railroad ballast	729,475	728,311	1,135,524	1,159,421
Other uses	3,318,405	4,207,092	3,123,633	4,090,454
Total	36,475,371	45,413,823	36,691,804	46,038,315
Exports				
Total crushed stone to United States	715,544	1,130,248	588,757	557,733
Crushed, ground, and broken limestone imported by United States from Canada[3]...........	121,449	269,435	285,560	522,486

Limestone - Production, Trade and Consumption (cont'd)

	1960		1959	
	Short Tons	$	Short Tons	$
Imports				
Total crushed stone from United States...	940,330	1,321,675	1,055,588	1,408,228
Crushed, ground, and broken limestone exported by United States to Canada(4) ..	905,102	1,630,285	1,066,760	1,817,673
Consumption				
In production of cement.............	7,965,872		8,175,733	
In production of lime...............	2,669,574		3,062,152	
Miscellaneous	36,475,371		36,691,804	
Total	47,110,817		47,929,689	

Source: Dominion Bureau of Statistics.

(1) Does not include limestone produced for the lime and cement industries, but includes small amounts of marl and marble.

(2) Includes building, monumental, and ornamental stone, flagstone, and curbstone.

(3) United States import statistics. Report No. F.T. 110.

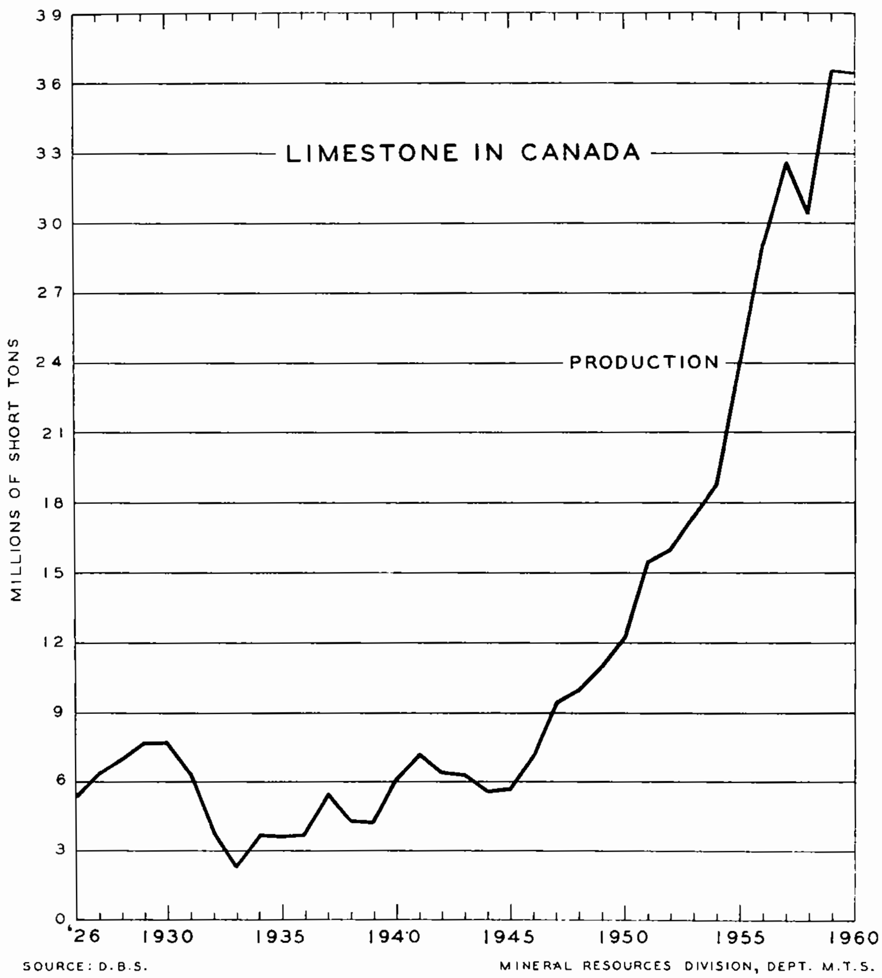
(4) United States export statistics. Report F.T. 410, Part 1.

Occurrence

In general, Canada is fortunate in having excellent occurrences of suitable types of limestone in the more populated regions. More than 90 per cent of the limestone quarried in Canada comes from southern Ontario and the southern part of Quebec. Easily accessible limestone of standard quality does not occur in central or eastern Alberta, southern Saskatchewan, northwestern Ontario, or Prince Edward Island.

Uses

In industry, the term 'limestone' includes rocks that are composed at least 50 per cent of carbonate minerals, such as calcite and dolomite. Owing to the numerous possible variations in chemical composition and geological history, this rock may be classified into many categories. Varieties such as brucitic limestone and dolomitic magnesite originate from the partial replace-



ment of a limestone by brucite or magnesite, respectively. In this review, marble is regarded as recrystallized limestone and marl as an unconsolidated form of limestone.

Limestone is a commodity of low unit value. Commonly, the most important factor determining the extent of use of a particular limestone is the distance to markets. Other factors include the chemical composition, accessibility, texture, hardness, and color of the rock as well as the thickness and extent of the beds and the formation.

Limestone is used extensively in the construction, metallurgical, chemical, and agricultural industries. It is also consumed by many other industries. This rock may be used in large pieces as rubble and riprap, flagstone, curbstone, or building, monumental, or ornamental stone. For most other purposes, it is crushed or ground and then sized to particles ranging from 6 inches to minus 325 mesh.

Canadian limestone is used mainly for construction purposes - as road metal; in the production of cement; as concrete aggregate, rubble and riprap, railroad ballast, structural and ornamental stone, terrazzo chips, stucco dash, and artificial stone; as a filler in asphalt products; and in the production of lime. Except when limestone is used in the production of cement or lime, the physical properties that make it suitable for construction are its most important characteristics.

The limestones used for their chemical content are normally high-calcium or high-dolomite varieties. For the production of portland cement, the limestone is commonly of the calcium variety that contains minor amounts of magnesia.

High-calcium limestones, which are commonly desired for most purposes, are the source of high-calcium lime. They are used as fluxes in the smelting of ferrous and nonferrous ores and are employed by the pulp-and-paper industry in the preparation of calcium-bisulphite dissolving liquor. They also go into the production of glass and other ceramic products and serve as fillers in the manufacture of such materials as paint, rubber, floor tile, plastics, and asphalt products. For some of these purposes it is used as whiting substitute.

Dolomitic limestone containing low impurities is sometimes used in iron production as a flux, in the manufacture of glass and pulp and paper, and in the production of lime employed mainly for construction purposes.

Canadian Refractories Limited mines dolomitic magnesite at Kilmar, Quebec, for use in the manufacture of basic-refractory products. Dolomite is dead-burned by Steetley of Canada Limited near Dundas, Ontario, for use as a refractory material in open-hearth furnaces.

Near Wakefield, Quebec, Aluminum Company of Canada, Limited, quarries brucitic limestone and processes it as a source of magnesia and lime. Dolomite is the main raw material used by Dominion Magnesium Limited, near Haley, Ontario, in the production of magnesium.

To control acidity and serve as a source of calcium and magnesium, pulverized limestone is used as a natural fertilizer and as a constituent of manufactured fertilizer. It is also a constituent of certain stock foods. Marl is recovered as a fertilizer in Quebec, New Brunswick, Nova Scotia, and British Columbia.

Prices and Tariffs

Prices of limestone products vary according to the location, local supply, quantity of sale, type, quality, and degree of preparation of the product. Normally, limestone for chemical purposes is more costly than limestone for other uses. Transportation costs often make up a large part of the final prices.

There is no tariff on crushed limestone entering Canada. There is however, an import duty of 1 1/4 cents per 100 pounds on crude or crushed limestone entering the United States.

LITHIUM MINERALS

J.E. Reeves*

The most notable development in the Canadian lithium-mineral industry in 1960 was the start of production at Quebec Lithium Corporation's new lithium-chemical plant, which is adjacent to the company's mine and mill near Barraute, Quebec. Production of lithium carbonate from stockpiled chemical-grade spodumene concentrate began near the end of the year. The plant will reach a daily output of 12,000 pounds of lithium carbonate from an input of about 50 tons of spodumene concentrate.

Late in 1960 the company resumed the mining and milling of spodumene ore after an interruption of a little more than a year. The mill was reported to be operating at a rate of 300 tons a day, only a small fraction of the mill's capacity, and was yielding chemical-grade spodumene concentrate with an Li_2O(lithia) content of 6.15 per cent.

Chemalloy Minerals Limited conducted a development program on its lithium-minerals and pollucite property in southeastern Manitoba.

Elsewhere in Canada, interest in lithium minerals showed a slight increase. The Lithium Corporation of Canada, Limited, started a new diamond-drilling program at its property adjacent to that of Chemalloy to investigate the lithium-mineral and pollucite content. In Quebec, about 80 miles northwest of Chibougamau and to the northwest of Assinica Lake, Sirmac Mines Limited made a surface examination of a deposit that was discovered in 1959 and has an unusually high content of spodumene.

Production and Trade

Quebec Lithium Corporation's 1960 shipments of spodumene concentrate were very small: the Li_2O content, which in 1959 amounted to 2,756,280 pounds and in 1957, the peak year, totalled 5,140,257 pounds, was down to about 204,666 pounds. The shipments, consisting solely of ceramic-grade concentrate containing nearly 6 1/2 per cent Li_2O but very little iron, were exported to the United States for use in television-tube glass. They came from a stockpile of ceramic-grade spodumene concentrate accumulated before the suspension, late in 1959, of mining and milling operations.

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*Mineral Processing Division, Mines Branch.

Canada continued to import its lithium chemicals from the United States. They consisted mainly of lithium hydroxide monohydrate and lithium carbonate and lesser amounts of lithium hydroxide, lithium bromide, and lithium chloride. The reported value of these imports has been steadily increasing. In 1958 it amounted to $66,000 and in 1959 to more than $85,000. In addition, sizable quantities of lithium greases are imported from the United States.

Lithium-bearing Minerals

Numerous minerals contain lithium, but only four have had any economic importance. In addition, zinnwaldite and lithiophilite occur as accessory lithium minerals. The lithium content of these minerals has been replaced to some extent by other alkali metals, with the result that the composition is variable. In the following table, the lithium minerals appear in the order of their commercial importance.

Mineral	Simplified Formula	Theoretical Li_2O Percentage	Actual Range Li_2O Percentage
Spodumene	$LiAlSi_2O_6$	8.03	4 to 7.5
Lepidolite	$KLi_2AlSi_4O_{10}F_2$	7.65	3 " 5
Amblygonite	$LiAlFPO_4$	10.10	7.5 " 9
Petalite	$LiAlSi_4O_{10}$	4.89	3 " 4.5
Zinnwaldite	$LiKFeAl_2F_2Si_3O_{10}$	3.40	2 " 3
Lithiophilite-triphylite	$Li(MnFe)PO_4$	9.52	2 " 6

Occurrences in Canada

Quebec

Diamond-drilling on the property of Quebec Lithium Corporation in Lacorne township north of Val d'Or has indicated one of the largest spodumene deposits in the world. The deposit consists of a number of large pegmatite dikes and many associated smaller ones, constituting a family of parallel dikes that extends for several miles. The company has reported reserves in excess of 20 million tons containing 1.15 per cent Li_2O.

Lithium-bearing pegmatites occur in other parts of Lacorne township and in the neighboring Figuery and Landrienne townships. They are associated with the contact of a large granitic intrusive mass known as the Lacorne batholith. Spodumene is the main lithium mineral in this area, although small amounts of lepidolite and lithiophilite occur.

Canada's most recent lithium-mineral discovery, the already mentioned Assinica Lake property of Sirmac Mines Limited, is of interest because of a relatively high concentration of spodumene crystals. Surface examination has indicated a considerable area with an Li_2O content averaging 2.7 per cent.

Manitoba

Numerous lithium-bearing pegmatites occur in the Winnipeg River-Cat Lake area, in the southeastern part of the province. The most significant occurrence at present is that of Chemalloy Minerals Limited, on the north shore of Bernic Lake. Its flat dip and unusual mineral assemblages make it notably different from other Canadian deposits. Zones containing large quantities of spodumene, lepidolite, and amblygonite and an unusual concentration of the cesium mineral, pollucite, make this deposit one of considerable interest. Lithium-mineral reserves have been estimated at about 9 million tons containing 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 Beardmore area, near Lake Nipigon. In the Northwest Territories, to the north and east of Yellowknife, pegmatites containing spodumene, to a much lesser extent amblygonite, and minor amounts of other lithium minerals have been described. Beryl and columbite-tantalite are also relatively common in the Northwest Territories.

World Resources and Production

The United States is the leading producer of lithium compounds, metal, and alloys. It fills many of its own spodumene requirements - mostly from North Carolina and, to a lesser extent, from South Dakota - but imports lepidolite, amblygonite, and petalite, mainly from Southern Rhodesia. The United States also produces dilithium sodium phosphate from the vast brine deposits of Searles Lake, California.

In December 1960, the last contract between the United States Atomic Energy Commission and the lithium industry expired, and there remained only commercial markets. The United States lithium industry's main problem is greatly excessive production capacity, which will be relieved only with the development of new markets and the expansion of existing ones.

Southern Rhodesia has been an important world source of lithium minerals, particularly those other than spodumene. Its most important variety is lepidolite, followed by petalite, spodumene, and amblygonite.

The decline in the consumption of lithium-mineral concentrates in the United States - particularly spodumene and lepidolite - has resulted in a considerable reduction in the world output of concentrates.

Technology

Lithium is not uncommon as a constituent of the earth's crust, but commercial concentrations occur mainly in granitic pegmatites in certain areas.

Lithium-mineral concentrates may be used directly in manufacturing processes or may be converted first to various lithium compounds. A very large part of the concentrates is converted to lithium carbonate or lithium hydroxide monohydrate and, to a lesser degree, to other compounds before being used in manufacturing. Only a small amount of lithium metal is produced.

Lithium compounds, whose many properties have resulted in the development of a wide range of markets, have a promising future despite current production reversals. Some of the most important of their properties are mentioned in the following section.

Uses and Specifications

Lithium compounds are used chiefly in ceramics and 'multipurpose' lubricating greases.

The carbonate and fluoride compounds have become important ceramic raw materials. Concentrates of spodumene, lepidolite, and petalite are also used, but much less extensively. In ceramics, lithium is primarily important as a flux, permitting the development of low-temperature bodies with the attendant benefits of lower refractory and fuel costs and wider color use. Lithium compounds reduce the maturing temperature and increase the fluidity and gloss of glass, glazes, and enamels, facilitate the production of glasses of high electrical, chemical, and shock resistance, make possible the production of glass transparent to ultraviolet light for use in germicidal lamps, and in various other ways have resulted in improved ceramic products.

Lithium stearate and other lithium soaps, which are derived from lithium hydroxide monohydrate, allow lubricating greases to be effective over a wide range of temperatures - from -60°F to +320°F - and make them highly insoluble in water.

Other common applications include the use of lithium hydroxide monohydrate as a constituent of the electrolyte in alkaline storage batteries; of lithium chloride (for water absorption) and lithium bromide (for gas absorption) in air-conditioning units and refrigeration systems; of lithium chloride or fluoride as a flux in the welding and brazing of aluminum and magnesium; of lithium fluoride as the analyzing crystal in X-ray spectrographs; of compounds in the control of reactions leading to the formation of alkyd resins for paints; and of lithium chloride or bromide in the manufacture of dry-cell batteries that will function at extremely low temperatures where normal cells are inoperative.

Lithium metal has so far had limited application. It is used as a scavenger of gases in nonferrous metallurgy, as a reducing agent in organic synthesis, notably in the production of vitamin A, as a catalyst in the production of synthetic rubber, and in the preparation of certain compounds such as lithium hydride. The use of lithium to form alloys with aluminum, copper, and zinc is under investigation.

Standard specifications for lithium-mineral concentrates have not been established. Specifications for any particular contract have been negotiated between supplier and user.

Prices

Published prices of lithium-mineral concentrates are nominal and roughly vary between $5 and $10 per unit of Li_2O (1 short-ton equals 20 pounds).

According to the Oil, Paint and Drug Reporter of December 26, 1960, prices of the important lithium compounds, per pound, are as follows:

Lithium carbonate	$0.67	
Lithium hydroxide monohydrate	$0.72	
Lithium chloride	$0.87	
Lithium bromide	$2.60	
Lithium fluoride	$1.75	to $1.90
Lithium stearate	$0.47 1/2	

E & M J Metal and Mineral Markets of December 29, 1960, gives the selling price of lithium metal, 99.5 per cent, as $9 to $11 a pound.

MAGNESITE AND BRUCITE

J.S. Ross*

In Canada, dolomitic magnesite and brucitic limestone are the only industrial minerals that are being mined primarily as raw materials for high-magnesia products. Throughout the world, the main raw materials for these products - hereafter termed 'magnesia' (MgO) to distinguish them from dolomitic lime and dead-burned dolomite - are brines, sea-water bitterns, and sea water, as well as magnesite and brucite. Magnesia is used principally in the manufacture of basic refractories.

During 1960, the value of production, which included brucitic magnesia and dead-burned dolomitic magnesite, reached the record high of $3,279,021 This was 7 per cent over the value for 1959, the previous peak year. The rise occurred because the metallurgical industry was more active and increased its use of basic refractories containing magnesia.

World production of magnesite was estimated at 7,100,000 short tons for 1960. Austria, the United States, and Yugoslavia, in that descending order, supplied more than one third of the total, and Canada contributed a minor amount.

Magnesia products are traded widely throughout the world. Canada exports calcined and dead-burned magnesia, mainly to the United States and the United Kingdom. United States import statistics indicate that 678 tons of dead-burned magnesite valued at $108,098 and magnesite brick and shapes and refractory material of magnesia and lime with a total value of $3,053,043 were imported from Canada in 1960.

Canadian imports of calcined and dead-burned magnesia amounted to 27,029 tons valued at $1,941,635. Imports also include magnesium carbonate, oxide, sulphate, and other magnesium compounds. The United States and the United Kingdom are the chief suppliers.

Production

Magnesite (magnesium carbonate) and brucite (magnesium hydroxide) are mined at separate locations in southern Quebec. Deposits containing brucite occur in Ontario and British Columbia, as well as elsewhere in Quebec, and magnesite deposits have been discovered in British Columbia, the Northwest Territories, Saskatchewan, Ontario, Quebec, Nova Scotia, and Newfoundland.

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*Mineral Processing Division, Mines Branch.

Magnesite and Brucite - Production and Trade

	1960		1959	
	Short Tons	$	Short Tons	$
Production[1]				
Dolomitic magnesite and brucite.............		3,279,021		3,050,779
Imports				
Magnesite, dead-burned and sintered				
United States	18,438	1,422,808	14,305	1,172,469
Yugoslavia	5,531	299,446	3,306	159,294
United Kingdom.........	210	17,323	3	327
West Germany..........	-	-	27	1,649
Total	24,179	1,739,577	17,641	1,333,739
Magnesite, caustic calcined				
United States	2,836	199,841	2,418	165,708
India	12	1,966	25	3,943
Other countries.........	2	251	28	1,707
Total	2,850	202,058	2,471	171,358
Magnesitic firebrick				
United States		323,682		230,319
West Germany..........		202,860		141,575
United Kingdom.........		159,385		65,473
Total		685,927		437,367
Magnesium carbonate and magnesium oxide				
United States	1,097	119,994	2,043	221,755
United Kingdom.........	272	41,591	359	51,332
Total	1,369	161,585	2,402	273,077
Magnesium salts or compounds				
United States	1,137	254,692	2,121	286,206
United Kingdom.........	132	59,526	103	49,315
West Germany..........	33	1,724	11	630
Total	1,302	315,942	2,235	336,151

Magnesite and Brucite - Production and Trade (cont'd)

	1960		1959	
	Short Tons	$	Short Tons	$
Imports (cont'd)				
Magnesium sulphate, or Epsom salts				
West Germany..........	1,733	32,551	1,797	31,467
United States	667	27,867	862	35,566
United Kingdom.........	34	3,580	37	3,071
Netherlands	-	-	25	593
Total	2,434	63,998	2,721	70,697
Magnesia pipe covering				
United States		27,488		40,953
Exports				
Dolomite and brucite				
United States		64,748		64,237
United States imports from Canada(2)				
Magnesite, dead-burned	678	108,098	1,052	245,023
Refractory material of magnesia and lime(3).	12,911	549,837	8,468	495,952
Magnesite brick and shapes	15,589	2,503,206	16,786	2,770,063

Source: Dominion Bureau of Statistics except where otherwise indicated.

(1) Includes the value of brucitic magnesia shipped, and of dead-burned dolomitic magnesite and a small quantity of serpentine used or shipped.

(2) Not recorded separately in the official Canadian trade statistics. The figures shown are reported in United States import statistics. These materials are shipped to other countries, but the quantities are not available.

(3) Probably includes the Canadian dolomite and brucite exports mentioned above.

Brucitic limestone is quarried at Farm Point,near Wakefield, Quebec, by Aluminum Company of Canada, Limited. This material, which contains about 30 per cent brucite, is calcined, hydrated, and then separated into magnesia and lime. The magnesia is graded into various types according to the magnesia content and is sold for use in the manufacture of high-magnesia basic refractories and for agricultural and other chemical and industrial purposes.

Dolomitic magnesite is mined by underground methods at Kilmar, Quebec, by Canadian Refractories Limited, a subsidiary of the United States firm, Harbison-Walker Refractories Company. The rock, which contains magnesite, dolomite, and magnesium silicates, is concentrated in a heavy-media separation plant before being dead-burned in a rotary kiln. The resulting clinker is either consumed nearby at the company's Marelan plant or it is exported, mainly to the United States. In addition, the clinker is employed in high-temperature refractory cements, as hearth clinker, and in ramming mixtures. At Marelan, the dead-burned magnesite is used in the manufacture of various basic-refractory bricks and other refractory products. Brucitic magnesia is also an ingredient of some of these products.

Besides the Marelan plant, two others, both in Ontario, produce basic refractories from imported high-quality, dead-burned magnesia. They are General Refractories Company of Canada Limited, which manufactures dry-pressed shapes at Smithville, and Refractories Engineering and Supplies Limited, which produces four types of basic ramming mixes at Bronte, primarily for the use of the steel industry.

At Chippawa, Ontario, Norton Company produces crude fused magnesia from imported magnesia.

Developments

In addition to the attainment of record production, there were two developments of note during 1960.

One was the installation of Refractories Engineering and Supplies Limited at its Bronte ceramics plant, of the facilities for the production of the high-purity ramming mixes already mentioned. Although the company imports the basic ingredients, it now produces these mixes in Canada.

The other was the completion, late in 1960, of the first phase of a modernization program being carried out at the Kilmar dead-burning plant of Canadian Refractories Limited. Two 1,050-ton-capacity concrete silos were erected for the air blending of ground dolomitic magnesite and other kiln feed.

Technology

Magnesia may be produced from magnesite or brucite, which theoretically contain 47.6 and 69.0 per cent magnesia, respectively. When pure, both minerals may be transformed to magnesia by calcination.

Since 1952, the utilization of sea water and well bitterns as sources of magnesia has been increasing rapidly. Sea water usually contains 0.2 per cent magnesia. The United States Bureau of Mines reports that two thirds of the

United States 1959 output of magnesia was obtained in this way. The recovery of magnesia from these raw materials normally involves the precipitation of magnesium hydroxide by lime followed by the calcination of the precipitate to magnesia.

Caustic calcined magnesia, a chemically active commodity, is a product of mild calcination. Dead-burned magnesia is chemically inactive and is produced by intense calcination. In industry, the term 'periclase' refers to the dead-burned product containing minor amounts of iron and a minimum of 92 per cent magnesia.

Consumption and Uses

Magnesia is consumed mainly in the dead-burned form. Dead-burned magnesia is used almost entirely as a constituent of refractories. Its prime characteristic is its ability to withstand high-temperature basic slags.

Caustic calcined magnesia is used by the pulp industry in the preparation of magnesium-bisulphite dissolving liquor. It may also be employed as a constituent of kiln feed for the production of dead-burned magnesite. Calcined magnesia may serve in the production of metallic magnesium and magnesium-oxychloride and magnesium-oxysulphate cements. It is also used for the control of acidity and as a constituent in the manufacture of fertilizer, insulation, heating elements, rayon, rubber, petrochemicals, magnesium chemicals, abrasives, and welding-rod coatings.

Prices and Tariffs

E & M J Metal and Mineral Markets of December 29, 1960, quotes the following United States prices for magnesite:

Crude	Per short ton, bulk, carload lots	$27.50
Calcined	Per short ton, pebble	$37.50
Dead-burned	Per short ton, grain, f.o.b. Chewelah, Wash.	
	In bulk	$46.00
	In bags	$52.00

Canadian tariffs on magnesium oxide were under study during 1960 but remained unchanged pending the outcome. The Canadian import duty on dead-burned and caustic calcined magnesite of a type or kind manufactured in Canada is as follows: British preferential, 15 per cent; most favored nation, 15 per cent; and general, 30 per cent. Crude magnesite may be imported free of duty.

MAGNESIUM

W. H. Jackson*

A decided improvement in the demand for magnesium on world markets was reflected in an increase in Canadian production if not in prices. Output rose from the 1959 level of 6,102 short tons to a total of 7,289 short tons for 1960. Exports continued to provide the main outlet, although their value as reported in Trade of Canada for the same two years, declined from $3.8 million to $3.2 million.

A change in the pattern of trade occurred during the year as 70.8 per cent of Canadian exports,on a dollar basis, went to the United Kingdom and only 2.7 per cent to West Germany. In 1959 the United Kingdom absorbed 45.9 per cent of magnesium exports and West Germany 37 per cent. Canada's main competitors on world markets are Norway, the United States, Italy, and France. As an exporting nation, Norway is geographically in a favorable position with respect to European markets.

Tariffs, transportation costs, and the convertibility of foreign exchange as elements of a competitive-price structure determine the position of Canadian magnesium in a particular market. The United Kingdom, unlike other European countries, provides a preferential tariff. The admission of the small amount of magnesium now entering the United States from Canada in the form of castings is due to an agreement between the two countries permitting the sharing of defence contracts. Owing to the tariff structure, competitive sales of ingot are not feasible in the United States.

Magnesium ingot consumed in Canada rose to 2,199 short tons, gaining its main increases as an alloying agent with aluminum and in the production of magnesium castings. Imports by Canadian manufacturers consist mainly of sheet or plate and extrusions. Owing to the limited market there are no domestic rolling mills, and extrusion presses currently using magnesium alloys do not produce extruded shapes more than 6 inches in cross section.

Production

Dominion Magnesium Limited, a major supplier of high-purity magnesium on world markets, is the only producer of primary magnesium in Canada. The 8,000-ton-a-year reduction plant at Haley, Ontario, in which the ferrosilicon process is used, is an important source of employment in the Renfrew area. Six reduction furnaces were in operation at the beginning of 1960. By March 18, the plant was working at full capacity - with 10 furnaces

*Mineral Resources Division.

Magnesium - Production, Trade and Consumption

	1960*		1959	
	Short Tons	$	Short Tons	$
Production (metal)				
Ontario	7,289	4,313,987	4,072	2,202,392
Quebec	-	-	2,030	977,123
Total	7,289	4,313,987	6,102	3,179,515
Imports (alloys)				
United States		193,063		258,401
United Kingdom		143,485		2,413
West Germany		-		12,207
Total		336,548		273,021
Exports (metal)				
United Kingdom		2,290,382		1,779,079
United States		264,716		86,155
China (mainland)		198,761		63,701
France		189,612		183,096
West Germany		87,047		1,451,157
Hungary		70,425		-
Czechoslovakia		35,768		-
Other countries		96,094		316,400
Total		3,232,805		3,879,588
Consumption (metal)				
Castings	158		86	
Extrusions (structural shapes, tubing)	230		50	
Aluminum alloys	1,339		1,136	
All other products	472		396	
Total	2,199		1,668	

Source: Dominion Bureau of Statistics.

in operation. A typical analysis of the metal produced at Haley is 99.97 per cent magnesium. The raw material used in the process is dolomite that is Pre-cambrian in age and of exceptional purity and averages 21 per cent magnesium oxide (MgO). Ore reserves are adequate for any foreseeable need. The deposit, located near the plant, is worked by quarrying. The company also produces calcium, thorium, and zirconium.

Magnesium - Production, Trade and Consumption, 1950-60

	Production (1) (short tons)	Imports (2) ($)	Exports (3) ($)	Consumption (short tons)
1950		61,033		537
1951		113,391		1,332
1952		136,742		1,119
1953		144,253		1,414
1954		99,944		1,308
1955		186,034	4,887,980	833
1956	9,606	366,837	5,153,509	1,003
1957	8,385	276,742	4,535,570	840
1958	6,796	255,768	2,871,991	711
1959	6,102	273,021	3,879,588	1,668 (4)
1960	7,289	336,548	3,232,805	2,199

Source: Dominion Bureau of Statistics.

(1) Production statistics for 1950 to 1955 inclusive are not available for publication.

(2) Magnesium alloys.

(3) Statistics for 1950 to 1954 are not separately available.

(4) This figure is larger because the consumption survey from which it is derived was more comprehensive than the surveys of previous years.

The plant at Arvida, Quebec, formerly operated by Aluminum Company of Canada, Limited, ceased operations in October 1959.

World Developments

The United States Bureau of Mines estimates that world production amounted to 104,000 tons in 1960 and 82,200 tons in 1959. Details are shown in the following table.

World Production of Magnesium
(short tons)

	1958	1959	1960
United States	30,096	31,033	40,070
U.S.S.R.	19,400	22,000	27,600
Norway	10,132	10,633	13,200
Canada	6,796	6,102	7,289
Italy	4,607	4,960	5,500
United Kingdom	2,691	2,458	4,200
France	1,897	1,938	2,300
Japan	1,106	1,724	2,400
China	1,100	1,100	1,100
W. Germany	660	550	330
Total	78,500	82,500	104,600

Source: Mineral Trade Notes, June, 1961.

After two years of output curtailment, the demand for new production has increased, although markets are still extremely competitive. In addition to production cutbacks, the influences resulting from inventories accumulated during the market decline of 1958 and sales from the United Kingdom stockpile have been overcome.

An increase in production is expected from two major European producers. In 1960, the plant of Norsk Hydro-Elektrisk Kvaelstofaktieselskab, at Heroya (near Porsgrunn), Norway, was expanded to 15,000-ton capacity. That of Società Italiana per il Magnesio e Leghe di Magnesio S.P.A., at Bolzano, Italy, will expand from 4,400 to 7,700 tons. The Bitterfield plant in East Germany, reported to be under reconstruction, may have a capacity of 7,000 tons a year by 1965.

Uses

Magnesium is used as a reducing agent in the production of such other metals as titanium, uranium, zirconium, beryllium, and platinum. Other uses include the cathodic protection of steel structures by magnesium anodes, pyrotechnics, and the production of nodular cast iron.

Foundries can produce intricate and high-quality castings that fully utilize the high strength-to-weight ratio and excellent machinability of magnesium. Alloys containing aluminum with small quantities of zinc and manganese are used in castings and extrusions. For high-temperature and high-strength applications, a series of alloys containing zirconium and thorium has been developed. Magnesium sheet, on being heated, can be deep-drawn in one operation to a greater depth than any other light alloy.

Magnesium is a constituent of aluminum alloys that have high strength and resistance to salt-water corrosion. In Canada, a larger tonnage goes into this use than into any other.

Prices

In 1960, representative base prices for magnesium were as follows: Canada, f.o.b. Haley, 30 cents a pound; United States, in 5-ton lots, f.o.b. Velasco, Texas, for consumption in the United States, 35.25 cents a pound; United Kingdom, delivered, 2s. 3d. a pound.

Tariffs

Canada

	British Preferential	Most Favored Nation	General
Sheet or plate of magnesium or alloys of magnesium, plain, corrugated, pebbled, or with a raised surface pattern for use in Canadian manufacturing	free	free	free
Alloys of magnesium, viz ingots, pigs, sheets, plates, strips, bars, rods, and tubes	5%	10%	25%
Magnesium scrap	free	free	free

United States

Metallic magnesium and metallic magnesium scrap (duty on scrap suspended until June 30, 1961)	50%
Magnesium alloys, powder, ribbons, sheets, tubing, wire, and all other articles of magnesium not specifically provided for	20¢ per lb on magnesium content plus 10% ad valorem
Other magnesium alloys, magnesium content	17¢ per lb plus 8 1/2% ad valorem

United Kingdom

	Commonwealth	Most Favored Nation
Unwrought magnesium	free	10%

MANGANESE

V.B. Schneider*

Manganese-ore imports in 1960 dropped to 56,350 tons from the 118,454 imported in 1959. This decline was due to an increase in the imports of ferromanganese from 2,334 tons in 1959 to 15,495 tons in 1960, a decrease in manganese ore inventories from 52,360 tons to 36,405 tons, and a slight decrease in steel production. In addition, technical developments in the production of pig iron and steel have tended to reduce the ratio of manganese ore used per ton of steel produced.

No manganese ore is produced in Canada, although in past years small amounts have been mined from bog deposits in New Brunswick, Nova Scotia, and British Columbia.

In November, the United States Department of Agriculture issued a revised list of materials eligible for the supplemental stockpile. The list included chemical-grade manganese (grades A and B), which had previously been omitted. Barter agreements concluded during the year involved the exchange of surplus United States agricultural products for metallurgical-grade manganese ore from Brazil and Ghana, battery-grade manganese ore from Greece, and ferromanganese from India.

Canadian Occurrences and Development

Canada has no known commercial manganese deposits, nor are any likely to be found that will be commercial by present standards, because there is no evidence of the special environment necessary for the formation of the large residual-type deposits.

Large low-grade deposits have been found, and technological advances may, in time, give some of them economic importance. The most notable of these large-tonnage low-grade deposits is near Woodstock, New Brunswick. This deposit has been estimated to contain more than 50 million tons grading 11 per cent manganese and 14 per cent iron.

Strategic Materials Corporation, through its subsidiary, Stratmat Limited, owns the Woodstock deposit, and Strategic-Udy Metallurgical & Chemical Processes Limited, controlled by Stratmat, has been conducting research to find a method of processing the ore economically. In 1959 Strategic-Udy produced some 97 tons of ferromanganese and 60 tons of highly phosphorous pig. The ferromanganese was sold in the open market, and the pig was refined in an electric steel-refining furnace to SAE** 1010-20-30 grades. The steels so produced were rolled and processed in numerous ways and are reported to have shown excellent mechanical properties.

*Mineral Resources Division.
**Society of Automotive Engineers.

Manganese - Trade and Consumption

	1960 Short Tons	1960 $	1959 Short Tons	1959 $
Imports				
Manganese ore				
Ghana	22,399	811,363	66,246	2,273,401
Republic of the Congo	17,032	704,012	5,777	243,044
Brazil	6,522	253,701	20,115	848,199
Union of South Africa	5,488	142,331	-	-
United States	4,345	613,390	13,887	1,243,679
Mexico	512	3,918	-	-
United Kingdom	44	12,614	111	26,077
Japan	4	1,733	3	1,216
France	4	701	1	159
India	-	-	12,314	381,337
Total	56,350	2,543,763	118,454	5,017,112
Ferromanganese under 1% silicon				
Union of South Africa	10,113	1,310,580	-	-
United States	2,460	467,365	822	180,698
France	1,843	335,063	52	10,636
Japan	982	257,455	919	223,675
United Kingdom	97	15,938	-	-
Chile	-	-	541	105,201
Total	15,495	2,386,401	2,334	520,210
Silicomanganese over 1% silicon				
United States	1,493	340,358	1,660	471,376
Japan	700	115,933	1,283	342,473
Norway	122	15,900	46	6,468
Chile	51	10,348	-	-
Total	2,366	482,539	2,989	820,317
Exports				
Ferromanganese				
United States	668	269,566	169	60,692
Mexico	58	11,513	-	-
Colombia	1	125	21	4,913
Other countries	2	637	3	604
Total	729	281,841	193	66,209
Consumption				
Manganese ore				
Metallurgical grade	70,652		86,413	
Battery and chemical grade	2,367		3,898	
Total	73,019		90,311	

Source: Dominion Bureau of Statistics.

This was the first time that ore from Woodstock, New Brunswick, was smelted to produce ferromanganese and finished steel products.

World Mine Production and Trade

World mine production in 1960 at 14,832,000 tons represents an all-time high. Russia maintained its traditional position as the world's leading producer. However, China, which as recent as 1955 ranked 6th with about 5.1 per cent of the world's production, moved to 2nd position in 1960, with about 9.3 per cent. India, which ranked 2nd in 1959, dropped to fourth position with the Union of South Africa occupying the 3rd position. Brazil and India were the only major producing countries to produce less in 1960 than in 1959. Brazilian ore came mainly from the Amapá mine, situated in the Serra do Navio district of the State of Amapá and owned jointly by Indústria e Comérico de Minésios, S.A., and Bethlehem Steel Corporation.

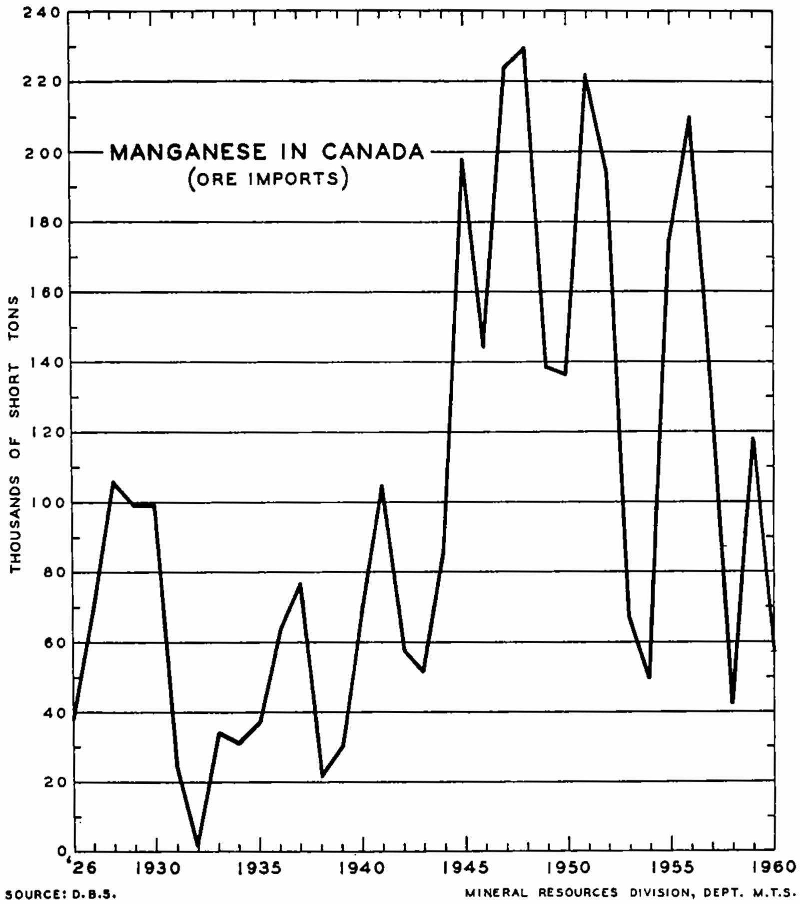
Manganese - Trade and Consumption, 1950-60
(short tons)

	Imports			Exports	Consumption
	Manganese Ore	Manganese Alloys		Ferro-manganese	Ore
		Under 1% Silicon	Over 1% Silicon		
1950	135,698	1,017	82	26,571	123,096
1951	222,082	292	338	67,508	223,328
1952	194,405	1,629	153	31,290	169,560
1953	66,682	1,044	18	683	69,533
1954	48,962	8,527	19	3,639	66,052
1955	175,282	3,945	272	29,404	113,075
1956	207,977	2,191	1,130	59,445	219,141
1957	131,318	743	2,257	46,733	195,088
1958	42,060	2,483	2,185	225	46,143
1959	118,454	2,334	2,989	193	90,311
1960	56,350	15,495	2,366	729	73,019

Source: Dominion Bureau of Statistics.

The United States, which is the leading consumer and importer of manganese ore, imported 2,582,970 tons in 1960. The four main suppliers were Brazil (874,808 tons), India (513,808), Ghana (328,657), and the Union of South Africa (277,357).

During the year, the expansion of ferromanganese production facilities outside Europe and the United States continued. Programs to increase output were announced in South Africa, India, Australia, Japan, and Southern Rhodesia.



The appearance in Europe of ferromanganese from the Communist countries, together with the claims of the Russian and Chinese that their steel industries have expanded, seems to indicate that ferromanganese production facilities behind the Iron Curtain are more than adequate.

These developments mean that traditional suppliers of ferromanganese are meeting severe competition. Even in the United Kingdom, which has always supported its domestic ferromanganese producers, it is expected that a much greater proportion of its requirements will soon be met by imports.

Consumption, Uses, and Specifications

About 95 per cent of the world's output of manganese ore is used by the steel industry.The dry-battery industry accounts for 3 per cent and the chemical industry for the remaining 2 per cent.

World Production, 1960
(short tons)

Russia	6,393,400
China	1,380,000
Union of South Africa	1,316,124
India	1,267,657
Brazil	942,205
Ghana	600,261
French Morocco	532,508
Other countries	2,399,845
Total	14,832,000

Source: U.S. Bureau of Mines, Mineral Trade Notes, September 1961.

U.S. Bureau of Mines, Manganese Report No. 178, March 23, 1961.

The importance of manganese is due principally to its scavenging action in steelmaking furnaces, which makes it the cheapest material known for desulphurization and dephosphorization. In the proportion of 1 or 2 per cent, it increases strength and toughness in steel. In proportions of 12 to 14 per cent, it greatly increases toughness and resistance to wear and abrasion.

Electrolytic manganese, made in an electrolytic cell, where the manganese is deposited on an electrode and stripped off as thin plates, is used in place of low-carbon ferromanganese to reduce the carbon content of stainless steels and thus to eliminate the need for a carbon stabilizer. It is also used by the manufacturers of nonferrous products, particularly the aluminum and brass industries. It serves the aluminum industry in the production of high-purity aluminum 'hardener' alloys; in brass mills it is added either as metal or as a 30-70 manganese-copper master alloy in the production of manganese bronzes.

Metallurgical-grade Manganese

Most of the manganese consumed by the steel industry is in the form of high-carbon ferromanganese. The remainder is in the form of low- and medium-carbon ferromanganese and of silicomanganese, spiegeleisen, manganese metal, and ore, in the order given.

For the making of ferromanganese, the manganese-iron ratio should be 7:1 or more because the production capacity of the ferro-plant is handicapped as this ratio drops. High silica is undesirable because it increases the quantity of slag, which is attended by a manganese loss. In preparing their furnace charges, ferromanganese producers prefer to blend commercial ores to their own specifications. Since no single ore is generally considered ideal, consumers usually purchase ores from more than one source.

General specifications for metallurgical-grade manganese ore are as follows: a minimum of 48 per cent manganese; 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.

Battery-grade Manganese

Manganese ore for dry-cell use must be manganese-dioxide (pyrolusite) ore of not less than 75 per cent MnO_2 and not more than 1.5 per cent iron, and should be very low in such metals as arsenic, copper, zinc, nickel, and cobalt. The physical properties of the oxide are also important. The material should be porous and moderately hard.

Chemical-grade Manganese

Chemical-grade manganese ore should contain at least 35 per cent manganese. It is used to make manganese-sulphate fertilizer and in the production of other salts for use in the glass, dye, paint, varnish, and photographic industries.

Canadian Consumers

Union Carbide Canada Limited, Metals and Carbon Division, uses metallurgical-grade ore to manufacture silicomanganese and high- and low-carbon ferromanganese at its Welland, Ontario, plant. Chromium Mining & Smelting Corporation, Limited, produces manganese alloys at its Beauharnois, Quebec, plant.

The main consumers of ferromanganese are: The Algoma Steel Corporation, Limited, at Sault Ste. Marie, Ontario; Dominion Steel and Coal Corporation, Limited, at Sydney, Nova Scotia; The Steel Company of Canada, Limited, and Dominion Foundries and Steel, Limited, both at Hamilton, Ontario; and Atlas Steels Limited, at Welland, Ontario.

Electrolytic manganese metal imported from the United States is used at Atlas Steels Limited, Welland, Ontario, in making 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 & M J Metal and Mineral Markets of December 29, 1960, were as follows:

Manganese ore	Per long-ton unit, 46-48% Mn, c.i.f. U.S. ports, import duty extra	
	Indian (Al+Si 13%)	87.00¢ to 90.00¢ (nominal)
	South African (Al+Si7%, As 2%)	91.00¢ (")
Manganese metal	Per lb, 95 1/2%, delivered, carload	
	Bulk	45.00¢
	Packed	45.75¢
	Per lb, 99.9% electrolytic, f.o.b. shipping point, freight allowed east of Mississippi, carload	33.75¢
	Premium per lb for hydrogen removed	00.75¢
Ferromanganese	Per lb contained Mn, carload lots, lump	
	Standard (74-76% Mn), f.o.b. shipping point	11.00¢
	Medium-carbon (80-85% Mn, 1 1/4-1 1/2%C), f.o.b. U.S.	24.00¢
	Low-carbon (85-90% Mn, max. 0.07% C), basis as for medium-carbon	35.10¢
Silicomanganese	Per lb carload lots, lump, f.o.b. shipping point	
	1.5% C max., 18-20% Si	11.60¢
	2% C max., 15-17 1/2% Si	11.30¢
	3% C max., 12-14 1/2% Si	11.10¢
Spiegeleisen	Per gross ton, carload lots, lumps, f.o.b. Palmerton, Pa.	
	3% max. Si, 16-19% Mn	$ 98.00 to $100.50
	3% max. Si, 19-21% Mn	$100.00 to $102.50
	3% max. Si, 21-23% Mn	$102.50 to $105.00

Tariffs

	British Preferential	Most Favored Nation	General
Canada			
Manganese ore	free	free	free
Ferromanganese (on Mn content)	"	1¢ per lb	1 1/4¢ per lb
Silicomanganese (on Mn content)	"	1 1/2¢ per lb	1 3/4¢ per lb

United States	
Manganese ore	1/4¢ per lb on Mn content
Ferromanganese*	
Not over 1% C	0.8¢ per lb on Mn content and 6% ad valorem
Over 1% C but under 4% C	15/16¢ per lb on Mn content
4% or more C	5/8¢ per lb on Mn content
Spiegeleisen	
Over 1% C	75¢ per long ton
Less than 1% C	0.8¢ per lb on Mn content and 6% ad valorem
Manganese metal	1 7/8¢ per lb on Mn content and 15% ad valorem

*These classes must contain 30% or more Mn.

MERCURY

J. W. Patterson*

There has been no mine production of mercury in Canada since 1944, when the Pinchi Lake and Takla mines, in British Columbia, were closed. Of these two, the Pinchi Lake mine, operated by The Consolidated Mining and Smelting Company of Canada Limited, was by far the more important source. During the years of its operation, from 1940 to 1944 inclusive, it yielded more than 4 million pounds of mercury. In 1943 and 1944, Bralorne Mines Limited (now Bralorne Pioneer Mines Limited) produced from the Takla mine, but its output was much smaller. The principal mercury mineral was cinnabar (HgS).

These mines are on the same geological break in an area north of Fort St. James, in northern British Columbia. The Pinchi Lake mine is on the north side of the lake of the same name, about 15 miles northwest of Fort St. James, and the Takla is some 80 miles northwest of the lake on Silver Creek, near the summit of the divide between the watersheds of the Omineca and Nation rivers.

In southern British Columbia, small mines to the east and north of Bralorne and in the vicinity of Kamloops Lake have sporadically yielded mercury, more than 11,000 pounds being produced in the latter area between 1895 and 1927. To date no mercury has been obtained from any Canadian mine outside of the west-coast province.

World Production

World production in 1960, at its highest level since 1942, is estimated at 254,000 flasks,# the principal producers being Spain (56,000 flasks), Italy (55,492), the United States (32,223), and China (an estimated 23,000).

At 33,223 flasks, the United States primary output was 6 per cent higher than in 1959. Its secondary output, 5,350 flasks, was 8 per cent higher. California, Nevada, Alaska, Idaho, and Oregon, in that order, accounted for virtually all of the primary production. United States consumption for 1960 was 51,167 flasks, 7 per cent less than 1959. The mercury imported to meet consumption requirements totalled 19,515 flasks, or 36 per cent less than in 1959, and was the lowest since 1947. Of this quantity, Spain supplied 12,444 flasks, Italy 3,447, Mexico 2,459, Yugoslavia 910, and Chile, Peru, New Zealand, and Canada together 255.

#In one flask there are 76 pounds of mercury.

*Mineral Resources Division.

Mercury - Trade and Consumption

	1960 Pounds	1960 $	1959 Pounds	1959 $
Exports*				
Metal				
United States	1,279	3,377	10,458	25,072
United Kingdom	639	500	-	-
Total	1,918	3,877	10,458	25,072
Imports				
Metal				
Spain	121,600	285,114	38,000	95,390
Italy	36,666	88,105	-	-
Mexico	33,382	79,724	11,089	29,975
United States	32,429	90,233	21,221	62,581
Chile	17,404	46,271	6,605	17,799
United Kingdom	1,610	4,000	3,800	10,328
Peru	-	-	39,984	97,587
Netherlands	-	-	20,520	50,018
Total	243,091	593,447	141,219	363,678
Salts				
United Kingdom		6,316		3,564
United States		599		2,573
Total		6,915		6,137
Consumption				
Metal				
Heavy chemicals	119,399		143,373	
Pharmaceuticals and fine chemicals	11,888		10,319	
Electrical apparatus	2,962		4,211	
Gold recovery	4,904		3,628	
Miscellaneous	474		456	
Total	139,627		161,987	

Source: Dominion Bureau of Statistics.

* Scrap mercury.

Mercury - Production, Trade and Consumption, 1950-60

	Production	Imports		Exports	Consumption
	Metal	Metal	Salts	Metal	Metal
	(pounds)	(pounds)	($)	(pounds)	(pounds)
1950	-	614,005	4,366	8,100	166,716
1951	-	308,172	12,448	58,235	289,980
1952	-	144,439	27,043	1,500	280,632
1953	-	196,412	34,155	7,018	211,852
1954	-	244,783	18,472	6,310	203,756
1955	75	555,526	11,258	3,781	416,632
1956	-	450,006	1,819	5,953	212,800
1957	-	400,710	24,225	1,425	215,344
1958	-	197,073	10,918	2,830	151,021
1959	-	141,219	6,137	10,458	161,987
1960	-	243,091	6,915	1,918	139,627

Source: Dominion Bureau of Statistics.

Uses

In Canada in 1960, mercury was used principally in the production of such heavy chemicals as chlorine and caustic soda. Lesser amounts are used in the manufacture of pharmaceuticals, fine chemicals, and electrical apparatus and in gold recovery. Although large quantities of mercury are required for the installation that precedes the application of the heavy-chemical-manufacturing process, little mercury is employed in the process itself. In the United States, more mercury was used in the construction of electrical apparatus than for any other purpose. Substantial amounts also went into the production of protective paints, pulp and paper, and industrial and control instruments.

Other applications practised in both Canada and the United States included the use of mercury in gold amalgamation, the manufacture of dental preparations, and general laboratory work.

Prices

According to E & M J Metal and Mineral Markets, the 1960 monthly price average per flask of mercury f.o.b. New York varied from a high of $214 in March to a low of $209 from August to December inclusive. The average price for the year was $210.76 a flask, $16.72 less than in 1959. This was the lowest since 1953.

Tariffs

Canada Nil

United States 25 cents a pound ($19 a flask)

MICA

J. E. Reeves*

In recent years mica production in Canada has been far less than in earlier periods. In the 1920's, Canada was a leading supplier of phlogopite; and in the 1940's, the stimulus of World War II and the immediate postwar period, together with the availability of the unusual Purdy muscovite, raised the annual output as high as 8.7 million pounds. The production of 1960, although relatively low, was considerably above that of 1959, a year of unusually low output.

Imports of unmanufactured mica have increased about eightfold since first reported in 1954, but a decrease in the imports of the higher-priced Indian-muscovite splittings has made the total import value decline for most of this period.

Exports of unmanufactured mica were about 15 per cent higher than in 1959. They consisted largely of rough and trimmed small-sheet phlogopite shipped to Japan and selected phlogopite scrap shipped to Belgium. Because of these relatively high-priced grades of mica the export value was doubled in 1960.

Products

Most of the mica produced in 1960 was phlogopite that originated from several small operations in southwestern Quebec within a few miles of Ottawa. Blackburn Brothers,Limited mined sheet phlogopite and dry-ground scrap phlogopite near Cantley, in Hull township.

Ontario provided a small amount of phlogopite. Most of it was scrap from the Perth area and from a new deposit opened in Loughborough township, where there was extensive mining many years ago. A few tons of scrap muscovite, for use as punch mica, were recovered from a dump near the Purdy mine, west of Mattawa.

An interesting development took place near Albreda, British Columbia, when Georgian Mineral Industries Ltd. started to mine and dry-grind muscovite schist. In November, it made its first shipment, consisting of relatively coarse ground mica used as a dusting agent on pipeline wrapping. The company announced that in 1961 it would install fine-grinding equipment.

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*Mineral Processing Division, Mines Branch.

Mica - Production, Trade and Consumption

	1960		1959	
	Pounds	$	Pounds	$
Production				
By shipments				
Trimmed	28,862	35,011	16,336	21,407
Sold for mechanical splittings	27,900	8,370	23,250	6,495
Splittings	-	-	-	-
Rough, mine-run, or rifted	118,407	5,103	8,641	601
Ground or powdered	791,994	35,257	591,356	29,953
Scrap and unclassified	735,442	10,462	174,251	4,548
Total	1,702,605	94,203	813,834	63,004
Imports				
Unmanufactured				
United States	1,698,000	112,660	1,074,300	67,058
India	92,400	31,271	225,600	90,401
United Kingdom	43,200	1,775	21,600	1,455
Brazil	5,200	2,141	18,900	2,395
Total	1,838,800	147,847	1,340,400	161,309
Manufactured				
United States		310,360		404,772
United Kingdom		10,938		22,610
Mexico		961		706
Total		322,259		428,088
Exports				
Unmanufactured				
Rough				
Japan	30,200	9,000	15,100	4,613
United States	-	-	92,000	1,380
Total	30,200	9,000	107,100	5,993
Trimmed				
Japan	67,000	67,397	24,200	23,154
Scrap				
Belgium and Luxembourg	340,800	13,448	160,000	6,340
United States	26,800	689	64,200	302
Japan	-	-	22,300	6,420
Total	367,600	14,137	246,500	13,062

Mica - Production, Trade and Consumption (cont'd)

	1960		1959	
	Pounds	$	Pounds	$
Exports (cont'd)				
Ground				
United States............	24,000	1,380	46,000	2,760
Total unmanufactured.....	488,800	91,914	423,800	44,969
Manufactured				
United States............		50		70
Brazil..................		-		8,500
Total..................		50		8,570
Consumption (available data)				
Paints and wall-joint sealing compounds	2,210,000		2,266,000	
Electrical apparatus	124,000		312,000	
Rubber	520,000		516,000	
Roofing..................	204,000		200,000	
Paper	198,000		104,000	
Other	192,000		224,000	
Total....................	3,448,000		3,622,000	

Source: Dominion Bureau of Statistics.

World Review

World trade in mica is considerable because many consuming nations either have inadequate resources or lack low-cost, experienced labor. India and Brazil are prominent as sources of high-quality muscovite. Canada imports Indian ruby-muscovite splittings for use in the manufacture of built-up sheet. Madagascar is an important world source of high-quality phlogopite.

Technology

The importance of mica in industry is due to its unusual electrical and other physical characteristics. It has consistent and relatively high dielectrical 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.

Mica - Production, Trade and Consumption, 1950-60
(pounds)

	Production(1)	Imports(2)	Exports(2)	Consumption
1950	3,879,209		1,975,100	3,886,222
1951	4,961,508		2,432,800	4,124,876
1952	2,014,941		1,562,300	3,424,071
1953	2,265,128		1,994,600	3,786,321
1954	1,706,770	232,700	771,200	3,429,848
1955	1,640,708	198,900	362,800	3,356,904
1956	1,843,811	324,900	277,800	4,524,810
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

Source: Dominion Bureau of Statistics.
(1) Producers' shipments.
(2) Unmanufactured mica.

High-quality muscovite, which possesses the best dielectric properties of all types of mica, is used extensively for insulation at high frequencies and voltages and in capacitors. Its high strength and transparency make it of minor value for glazing. It may be colorless, ruby-colored, green, or brown and is found in granitic pegmatites.

World Production of Mica, 1960
('000 pounds)

United States	240,437
India	65,514
Union of South Africa	7,286
Norway	6,614
Brazil	2,645
Madagascar	2,229
Canada	1,702
Australia	1,170
Other countries	82,403
Total	410,000

Source: U.S. Bureau of Mines, Mineral Trade Notes, November 1961.

Phlogopite, or amber mica, varies considerably in dielectric strength, hardness, structural strength, and other properties, but its thermal resistance, which is higher than that of muscovite, gives it a certain limited value. It is found in parts of southwestern Quebec and southeastern Ontario, frequently in irregular veins with green apatite and pink calcite. Its properties vary with the wide variation in its composition, and it may range from an almost complete lack of color to a deep brown.

When ground to a fine powder, mica maintains its flaky particle shape, which is advantageous in the many uses to which it is put as a filler and dusting agent.

Uses

Mica is used in three forms - natural sheet, splittings, and ground mica.

Natural-sheet mica is used for electrical insulation in a wide variety of electrical and electronic equipment and appliances for industrial and household purposes. In lesser 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.

Mica splittings are used in the manufacture of built-up sheet and mica tape and cloth. To make built-up sheet, the splittings are bonded with a suitable resin and the product is baked and pressed into sheets of required size. Built-up sheet is used, within the limits of its dielectric characteristics, in place of natural sheet, and may be cut or moulded into washers, tubes, and other forms. More than 90 per cent of the splittings used are muscovite.

In recent years a mica paper has been developed as a substitute for built-up sheet. It is produced by grinding clean scrap and bonding it into a paper-like sheet.

Phlogopite and muscovite, frequently of lower quality, are dry-ground for use as dusting powder on asphalt roofing and other products and for use in the manufacture of moulded electrical insulators. Dry-ground mica serves also in certain protective coatings, lubricants, wall-joint sealing compounds, and drilling muds and as a dusting agent for rubber tires and tubes. The wet-grinding of high-quality muscovite yields a polished, well-delaminated white powder used mainly 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, as a means of decorating wallpaper.

Specifications

Natural Block Muscovite

Block muscovite is graded for size and quality according to Designation D351-57T of the American Society for Testing Materials. For grading size, this classification utilizes the area of minimum rectangle and the minimum dimension of one side; for grading visual quality, it utilizes the degree of staining by included impurities.

Natural Phlogopite Sheet

In Canada, phlogopite sheet is graded in terms of its linear dimensions (in inches), the following grades being in common use: 1 x 1, 1 x 2, 1 x 3, 2 x 3, 2 x 4, 3 x 5, 4 x 6, 5 x 8, and larger.

No formal quality-grading that applies specifically to phlogopite has been established, but the soft, light-colored varieties are generally regarded as having the best electrical qualities. These grade down to the darker, more brittle varieties.

Ground Mica

Mica is ground to meet the user's requirements, the only formal specification being for mica pigment. For this, a well-delaminated product with a low bulk density is required, and A.S.T.M. Designation D607-42 specifies a maximum of 10 pounds to a cubic foot.

Dry-ground mica is sold in a wide range of particle sizes, from as coarse as minus 20 mesh for use by some roofing companies to as fine as minus 200 mesh for other purposes. Wet-ground mica is generally at least minus 200 mesh, but there is a trend toward the greater use of finer grades.

Markets

The following Canadian companies buy mica: all grades - Walter C. Cross & Co., 209 Eddy Street, Hull, Quebec; block and sheet - Mica Company of Canada Ltd., 4 Lois Street, Hull, Quebec; scrap - Blackburn Brothers, Limited, 85 Sparks Street, Ottawa, Ontario.

There is currently a limited demand for high-quality small phlogopite sheet and for clean phlogopite scrap.

Prices

Prices offered by Canadian purchasers for sheet phlogopite vary with the quality and with the degree of trimming and grading. Prices for well-graded good-quality small sheet are approximately as follows:

Size (inches)	Value ($ per lb)
1 x 1	0.30 to 0.70
1 x 2	0.50 " 0.80
1 x 3	0.75 " 0.85

Prices for larger sheet, from 2 x 3 to 5 x 8, may be obtained from the buyer.

Clean scrap phlogopite sells for as much as $25 a ton delivered at the plant.

Prices for mica in the United States, according to E & M J Metal and Mineral Markets of December 29, 1960, included:

Punch mica, per lb	\$ 0.07 to \$ 0.12
Wet-ground mica, per short ton	\$140.00 to \$155.00
Dry-ground mica, per short ton	\$ 30.00 to \$ 55.00
Scrap mica, per short ton	\$ 20.00 to \$ 30.00

Prices of North Carolina muscovite sheet and Madagascar phlogopite sheet are also quoted periodically in this journal.

64374-2—24

MINERAL PIGMENTS AND FILLERS

J. S. Ross*

Mineral pigments are derived from insoluble, inert, natural mineral products and are used to impart color or opacity to nonmetallic materials. Iron oxide and ground marble are the only natural mineral pigments produced in Canada. Both have wide application in industry, but the total consumed is small relative to that of most other industrial minerals.

Mineral fillers are industrial minerals that generally, as employed, show a relative chemical inertness. They are used mainly because of their physical properties, which impart certain characteristics and take the place of more expensive materials in industrial products. The mineral fillers produced in Canada include limestone, whiting substitute, asbestos, various clays, talc, cement, silica, pyrophyllite, nepheline syenite, barite, mica, and diatomite. Theoretically, aggregates for concrete and masonry products are fillers.

Whiting, used both as a pigment and as a filler, is the only filler dealt with in detail in this review. Other fillers are covered specifically in other reviews of this series.

Iron Oxide

The year 1960 brought a further notable decrease in the Canadian output of natural iron-oxide pigments. Shipments amounted to 909 short tons valued at $76,780. Production, at its lowest since 1894, was 26 per cent less than in 1959 and 93 per cent less than in 1950, the record year. These reductions reflect a decrease in the demand for gas produced from fuels. This gas is purified with iron oxide in eastern Canada. The dependence of the Canadian iron-oxide industry on this nonpigment market is shown by the table on page 366. Canada's production compares closely with the amount of iron oxide consumed by the coke and gas industries. The consumption of pigment grades by the domestic paint industry has been relatively stable: it follows the trend of industrial activity.

Exports of natural and synthetic iron oxides have decreased 35 per cent during the last decade. For 1960, they amounted to 2,523 tons valued at $404,619. The ochres, siennas, and umbers imported are relatively minor in quantity and have also diminished since 1950.

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*Mineral Processing Division, Mines Branch.

Iron Oxides - Production, Trade and Consumption

	1960		1959	
	Short Tons	$	Short Tons	$
Production (shipments)				
Natural (crude and calcined)..	909	76,780	1,235	108,286
Exports				
Natural and synthetic iron oxides				
United States...............	1,740	263,397	2,395	364,201
Australia..................	260	52,027	-	-
France.....................	137	24,682	129	21,032
Netherlands................	131	18,137	62	8,909
West Germany	125	22,176	-	-
Cuba.......................	31	5,320	13	2,131
Other countries	99	18,880	25	4,427
Total......................	2,523	404,619	2,624	400,700
Imports				
Ochres, siennas, umbers				
United States...............	572	60,473	784	75,561
United Kingdom	30	2,342	29	2,047
Sweden.....................	13	664	8	409
Spain	-	-	12	964
Total......................	615	63,479	833	78,981
	1959		1958	
Consumption				
Coke and gas industries......	100	1,211	237	2,446
Paint industry (calcined and synthetic iron oxide)........	1,889	442,477	1,826	471,356
Ochres, siennas, umbers	138	40,281	158	46,511

Source: Dominion Bureau of Statistics.

Occurrences and Production

Iron oxide of pigment grade is found in Champlain county, Quebec, Colchester county, Nova Scotia, and near New Westminster, British Columbia. It has been reported in other localities in British Columbia and in Saskatchewan, Manitoba, and Haliburton county, Ontario.

Iron Oxides - Production, Trade and Consumption, 1950-60
(short tons)

	Production	Imports		Exports	Consumption		
	Natural	Ochres Siennas Umbers	Oxides Fillers Colors etc.	Natural and Synthetic	Coke and Gas Industries	Paint Industry	
						Natural and Synthetic	Ochres Siennas Umbers
1950	13,696	1,544	4,096	3,934	11,624	2,453	268
1951	13,342	1,470	4,552	3,646	10,310	2,946	249
1952	11,487	998	4,215	3,060	8,302	2,441	227
1953	10,308	1,171	5,258	3,048	7,989	2,456	243
1954	5,798	1,052	4,443	3,111	9,167	2,190	212
1955	7,702	986	5,707	3,623	6,835	2,298	221
1956	8,803	1,162	6,237	3,203	8,745	2,166	220
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			

Source: Dominion Bureau of Statistics.

Domestic pigment-grade iron oxide is known to occur only in bog deposits formed by the precipitation of iron oxide leached from ferruginous rocks and unconsolidated sediments.

The largest known domestic concentrations of natural iron oxide of pigment grade are in Champlain county, Quebec. Several deposits of this kind near Three Rivers, Quebec, are being exploited by The Sherwin-Williams Co. of Canada, Limited, the only domestic producer of natural pigment-grade iron oxide. Bog iron oxide is trucked to the company's plant at Red Mill, Quebec, where it is dried, calcined, pulverized, and air-classified for use as pigments and abrasives.

Uses

Natural and synthetic iron-oxide pigments are extensively used in paints, rubber, linoleum, concrete, mortar, plaster, wood and paper stains, oilcloth, and other materials. They are desired because of the permanence of their color and their ability to inhibit the oxidization of metal surfaces. Iron oxide for this use should correspond to one of the recognized colors and have tinting strengths that can be conditioned to compare with those of standards. The particle size should be under 325-mesh, and the oil absorption should be in the range of that required for the type of pigment. The degree of opacity and 'hiding power' is important, whereas the chemical composition, within limits, is not.

Iron oxide is also used to color other materials such as fertilizer.

Certain grades of natural iron oxide are produced for use as jeweller's rouge for metal- and glass-polishing. Most of the output for this use is exported.

Until recently, most of the bog iron oxide produced in Canada was consumed during the removal of impurities from manufactured gas. When used for this purpose, the commodity does not have to be of pigment-grade quality.

Prices

As quoted by E & M J Metal and Mineral Markets of December 29, 1960, the price of ochre per ton, bagged, f.o.b. mills in Georgia, was $26.50 to $32.

Whiting Substitute

Although the term 'whiting' is commonly applied in industry to a variety of types, true whiting is pulverized and closely sized white chalk, a form of calcium carbonate. Precipitated whiting, or precipitated chalk, is a finely sized white calcium carbonate produced by the precipitation of solutions containing lime. Whiting substitute is white calcium carbonate resulting from the grinding of certain kinds of white marble, marl,or limestone.

Only whiting substitute is produced in Canada. It comes chiefly from two of the main marble quarries in Missisquoi county, southern Quebec. For 1960, the output amounted 10,319 tons valued at $124,902

Whiting exports are minor and are not reported separately. Imports consist chiefly of true whiting and precipitated whiting. In 1960, they totalled 8,835 tons valued at $250,507 and were from the United States, the United Kingdom, and France.

Intermittent increases have gradually raised whiting consumption.

Uses

Whiting is widely used for a number of purposes and, at least in part, for its whiteness. In many instances, however, its opacity is low in comparison with that of such synthetic pigments as titanium dioxide, zinc oxide, lithopone, and white lead. It is also commonly used as a filler.

Whiting is employed as a filler in oil-base paints and as a filler and pigment in cold-water paints. In these applications, color, fineness, chemical composition, bulk density, and, for oil-base paints, oil absorption are important.

Whiting - Production, Imports and Consumption

	1960		1959	
	Short Tons	$	Short Tons	$
Production				
Stone processed for whiting	10,319	124,902	11,633	140,873
Imports[1]				
Whiting, gilders' whiting, and paris white				
United States	4,210	189,221	4,524	197,338
United Kingdom	2,629	44,940	3,134	53,840
France	1,996	16,346	2,664	22,520
Total	8,835	250,507	10,322	273,698
Consumption[2]				
Ground chalk, whiting, and whiting substitute				
Explosives	156		211	
Pharmaceuticals	1,672		1,808	
Paints			15,694	
Soaps and toilet preparations	116		210	
Ceramics	922		3,169	
Linoleum, oilcloth, and asbestos products	15,442[3]		19,240[3]	
Rubber goods	8,398[3]		8,196[3]	
Tanneries	305		314	
Gypsum products	5,253[3]		7,017[3]	
Adhesives	267		210	
Pulp and paper	1,939		907	
Miscellaneous chemicals	182		340	
Starch and glucose	69		28	
Miscellaneous	1,434		7,589[3]	
Total	52,226[3]		64,933[3]	

Source: Dominion Bureau of Statistics.

(1) Import statistics for whiting substitute are not available.
(2) These quantities are calculated from information provided by the Dominion Bureau of Statistics.
(3) Includes some ground, off-white limestone.

Whiting - Production, Imports and Consumption, 1950-60
(short tons)

	Production(1)	Imports(2)	Consumption(3)
1950	17,603	21,336	26,110
1951	18,380	20,565	25,866
1952	17,527	11,986	25,554
1953	16,913	12,247	27,668
1954	15,460	10,824	28,370
1955	16,007	11,905	33,171
1956	17,448	11,356	34,241
1957	21,527	9,844	31,374
1958	11,900	11,121	37,268
1959	11,633	10,322	64,933(4)
1960	10,319	8,835	52,226(4)

Source: Dominion Bureau of Statistics.
(1) Whiting substitute only.
(2) Whiting only.
(3) Whiting and whiting substitute. Includes some ground, off-white limestone.
(4) This quantity is calculated from information provided by the Dominion Bureau of Statistics.

In the manufacture of floor tile, rubber products, and oilcloth, whiting serves in large quantities as a filler. It is also employed as a white filler in putty, asbestos products, plastics, pharmaceuticals, explosives, soaps and toilet preparations, adhesives, paper, starch, and various other products. It is used in the production of ceramics and to dust gypsum products. Of importance in these filler uses are chemical composition, color, fineness, bulk density, and sometimes oil absorption.

Other Pigments

In most markets, synthetic iron oxides have largely replaced natural ochres. Canada is a leading producer of synthetic iron-oxide pigments. The whole output comes from the plant of Northern Pigment Company, Limited,at New Toronto, Ontario.

Canada is becoming an important supplier of titanium-dioxide pigments. Canadian Titanium Pigments Limited produces the commodity at Varennes, Quebec, from titanium-dioxide slag supplied by Quebec Iron and Titanium Corporation (QIT). British Titan Products (Canada) Limited began construction of a pigment plant at Ville-de-Tracy, Quebec, during the latter half of 1960. In mid-1962 the plant will begin to process titania slag from QIT. In October, Continental Titanium Corp. started the construction of a titanium-dioxide-pigment plant at Baie St. Paul, Quebec. Technical-grade pigment is to be produced at a rate of 10 tons a day from ilmenite concentrates by a continuous pressure-leaching process. The combined annual rated capacity of Canadian titanium-dioxide-pigment plants in production or under construction is estimated to total 42,000 short tons.

MOLYBDENUM

V.B. Schneider*

Shipments of molybdenum contained in molybdic oxide (MoO_3) and molybdenite (MoS_2) concentrates amounted to 767,621 pounds valued at $1,015,380 The value was $74,784 greater than in 1959.

Molybdenite Corporation of Canada Limited was the principal Canadian producer of molybdenite and the only Canadian producer of molybdic oxide. Keremeos Mines Ltd. reported the shipment of some 5 tons of molybdenite concentrate to Sweden.

Free World production and consumption of molybdenum in 1960 reached estimated all-time highs of 75 million and 73 million pounds, respectively. Nearly a third of the molybdenum produced was a by-product of copper-mining. The leading producer is American Metal Climax,Inc., which has its molybdenite mine at Climax, Colorado. In 1960, production at Climax reached the new record of 49,631,000 pounds of molybdenum. The second-ranking producer was Kennecott Copper Corporation, which produced 27,426,000 pounds of by-product molybdenite in 1960 from its copper-mining operations in the United States and Chile.

Indications are that more than 500,000 pounds of contained molybdenum were exported from the Soviet bloc to Free World countries. Molybdic oxide imported by Canada from the Union of Soviet Socialist Republics in December 1960 amounted to 440,459 pounds.

Production

Canada

Molybdenite Corporation's property is at the junction of La Motte, Lacorne, Vassan, and Malartic townships, 23 miles north of Val d'Or, Quebec. Bismuth is produced as a by-product. On October 1 ore reserves amounted to 243,931 tons that assayed 0.36 per cent MoS_2 and were blocked out or broken in stopes, plus 800,000 tons indicated. During the year, development work on the 875- and 1,000-foot levels, which began late in 1959, was completed; the concentrator, operating on a six-day week, treated an average of 695.5 tons of ore a day; and the company began to sell lubricant-grade molybdenum disulphide.

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*Mineral Resources Division.

Molybdenum - Production, Trade and Consumption

	1960		1959	
	Pounds	$	Pounds	$
Production (shipments) [1]				
Mo content................	767,621	1,015,380	748,566	940,596
Imports				
Molybdic oxide[2]				
U.S.S.R.	440,459	404,544	-	-
United States	215,603	191,425	305,762	241,510
Total	656,062	595,969	305,762	241,510
Calcium molybdate (grouped with vanadium oxide and tungsten oxide for manufacture of steel)				
United States	236,936	332,248	75,987	82,653
Ferromolybdenum				
United States[3]...........	230,600	256,265	164,366	184,926
Exports[2]				
Molybdic oxide and molybdenum concentrates				
Austria			1,684,900	1,519,591
United Kingdom...........			897,700	535,780
Japan			786,200	757,346
Netherlands			235,900	237,983
West Germany............			91,900	81,331
Sweden			43,000	34,504
Australia			8,700	5,750
Total			3,748,300	3,172,285
Consumption (Mo content)				
By type				
Molybdic oxide	612,000		483,191	
Ferromolybdenum	358,000		72,201	
Calcium molybdate	16,000		30,000	
Sodium molybdate	37,947		172,130	
Molybdenum metal	3,584		151,485	
Molybdenum wire	3,763		8,135	
Other forms[4]	10,783		11,363	
Total	1,042,077		928,505[5]	

Molybdenum - Production, Trade and Consumption (cont'd)

	1960		1959	
	Pounds	$	Pounds	$
Consumption (cont'd)				
By end-use				
Iron and steel ferrous and nonferrous alloys	1,004,000		884,848	
Lubricants and pigments	21,377		34,286	
Electrical and electronic products	3,788		8,161	
Unspecified	12,912		1,210	
Total	1,042,077		928,505	

Source: Dominion Bureau of Statistics.
(1) Producers' shipments of molybdic oxide and molybdenum concentrates (Mo content).
(2) Gross weight. Export statistics are not available separately for the years after 1959.
(3) United States exports of ferromolybdenum (gross weight) to Canada as reported in United States Exports of Domestic and Foreign Produce. Imports of ferromolybdenum are not available separately in official Canadian trade statistics.
(4) Molybdic acid, molybdenum disulphide, ammonium molybdate, and barium molybdate.
(5) Consumption increase for 1959 is due largely to greater survey coverage.

At Lacorne, Molybdenite Corporation operates a roasting plant to convert molybdenite to technical-grade molybdic oxide, the material from which all types of molybdenum salts and compounds are produced. By far the greater part of molybdic oxide is used as a steel-alloying agent either included in the furnace charge or added to the molten metal. The company also operates a plant at Lacorne for the production of lubricant-grade molybdenum disulphide.

Preissac Molybdenite Mines Limited, in which Molybdenite Corporation of Canada Limited, holds a substantial interest, owns 3,550 acres in Preissac township, Quebec. In 1960 electric power was brought to the property, a headframe for a new three-compartment shaft was erected, and shaft-sinking operations were begun. The company expects that a 1,200-ton mill and a roasting plant will be in operation by 1963. Indicated ore reserves total 1,250,000 tons averaging 0.53 per cent MoS_2.

Molybdenum - Production, Trade and Consumption, 1950-60
(pounds)

	Production	Exports	Imports			Consumption
			Calcium Molybdate	Molybdic Oxide	Ferro-molybdenum	
	(1)	(2)	(5)	(6)	(7)	(8)
1950	62,130	(3)	141,544	444,185	250,550	486,140
1951	228,958	(3)	62,364	566,334	315,394	662,000
1952	303,578	(3)	169,392	520,104	439,476	709,271
1953	194,344	(3)	197,758	358,124	201,626	548,455
1954	451,450	(3)	121,339	423,344	79,856	374,118
1955	833,506	1,478,900	129,130	658,060	174,504	634,061
1956	842,263	1,318,200	322,295	955,308	495,748	855,468
1957	783,739	6,009,800(4)	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	(3)	236,936	656,062	230,600	1,042,077

Source: Dominion Bureau of Statistics.

(1) Producers' shipments of molybdenum concentrates (Mo content) 1950 to 1956 inclusive; 1957 to 1960, molybdic oxide and molybdenum concentrates (Mo content).

(2) 1955 and 1956, exports of molybdenum concentrates (gross weight); 1957 to 1959 inclusive, exports to molybdic oxide and molybdenum concentrates (gross weight).

(3) Not available.

(4) Includes 4,892,600 pounds of molybdic oxide exported to the United States. This was derived from molybdenum concentrates imported from the United States for roasting in Canada.

(5) Including vanadium oxide and tungsten oxide.

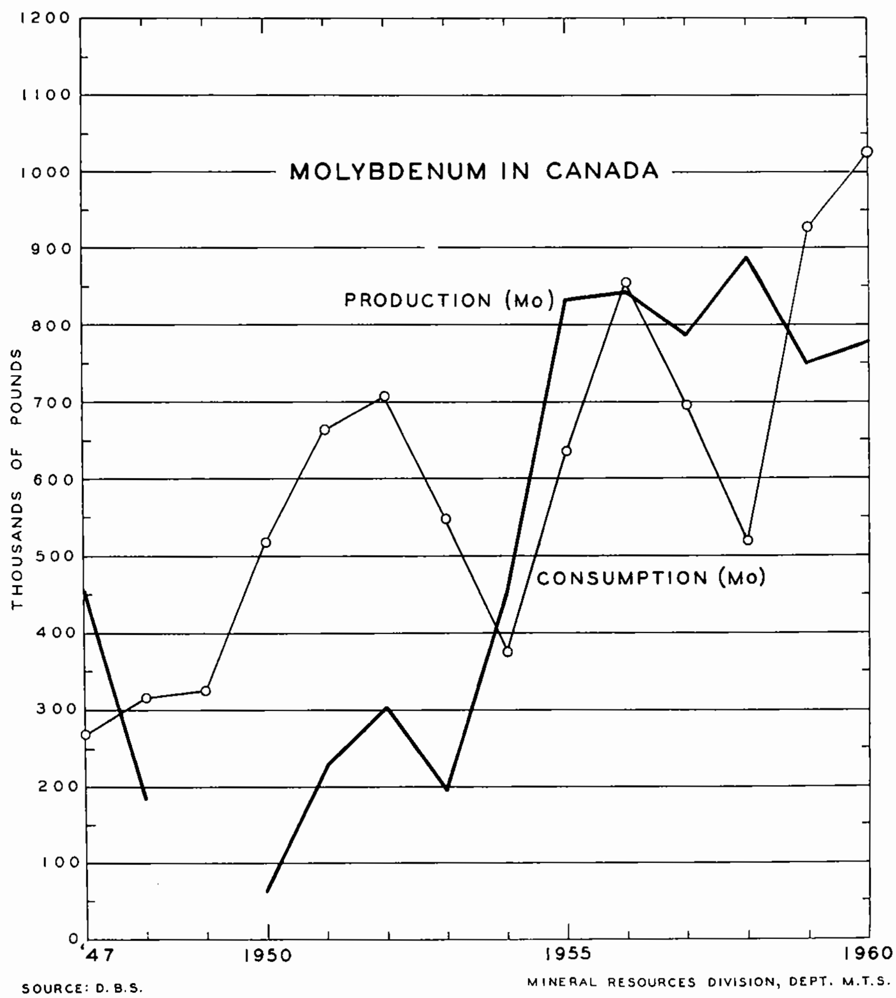
(6) Gross weight.

(7) United States exports to Canada reported in United States Exports of Domestic and Foreign Produce. Gross weight.

(8) Molybdenum addition agents (Mo content) reported by consumers.

Anglo-American Molybdenite Mining Corporation continued development and exploration work on its property about 5 miles north of Cadillac, in Preissac township. The company reports an indicated and inferred ore reserve of 560,000 tons grading 0.40 per cent MoS_2 and 0.75 pounds of bismuth a ton.

In British Columbia, Keremeos Mines Ltd. recovered by-product molybdenite from its copper mine 2 miles north of Olalla. The property was formerly known as 'the Golconda mine.' Huestis Molybdenum Corporation Ltd., continued exploration work on its property near Pitman, about 18 miles north-



east of Terrace. The property consists of a total of 93 claims, 87 of which are referred to as the 'Bell-Pitman claims' and the other six as the 'Grotto claims.' American Metal Climax Inc. and Kennecott Copper Corporation tested molybdenum prospects in the area around Lime Creek and Alice Arm. American Metal Climax dropped its option on its Mount Boss property, 50 miles east of Williams Lake.

United States

In 1960, the production, consumption, and exports of molybdenum were higher than in any previous year.* Shipments of concentrate amounted to 70 million pounds of contained molybdenum. Exports of concentrate and roasted oxide amounted to 30.2 million pounds of contained molybdenum, or

*U.S. Bureau of Mines, Minerals Yearbook, 1960, Molybdenum (preprint).

11.3 million pounds more than in 1959. The increase reflected a rise in exports that related to nearly every consuming country normally receiving molybdenum from the United States. The stock of molybdenum concentrates decreased again in 1960, but the stocks of molybdenum products (ferromolybdenum, molybdic oxide, and molybdenum salts and metal) increased at producers' and consumers' plants.

The United States Bureau of Mines reports* that molybdenum concentrates were produced in six states - Colorado, Utah, Arizona, Nevada, California, and New Mexico.

In November, Molybdenum Corporation of America announced that exploration work carried out with the financial assistance of the Defense Minerals Exploration Administration (DMEA), of the United States Department of the Interior, indicated a large molybdenum deposit on its property at Questa, New Mexico. The new deposit is near the company's former Questa mines, which produced some 20 million pounds of molybdenum disulphide from 1923 to 1956 inclusive. The new deposit is low-grade, averaging about 0.25 per cent molybdenite, but recent exploration has revealed zones averaging as high as 0.5 per cent molybdenite. The company has stated that further exploration of the high-grade zones will be necessary before mining operations can be initiated.

The large deposit at Climax, Colorado, which was first explored in 1917 and is at the site of the world's largest producer, is the only United States mine operated chiefly for molybdenum. Among the leading producers of by-product molybdenum, in addition to Kennecott Copper Corporation, were Bagdad Copper Corporation, Phelps Dodge Corporation, San Manuel Copper Corporation, Union Carbide Nuclear Company, American Smelting and Refining Company,and Duval Sulphur and Potash Company.

Molybdenum Corporation of America is second to American Metal Climax as a producer of molybdenum oxide and ferromolybdenum. Since 1937 Molybdenum Corporation has purchased a very large part of its molybdenum-concentrate requirements from Kennecott.

Chile

Chile is second among Free World countries in the production of molybdenum, all of which is obtained as a by-product from the country's large porphyry-copper operations. Since 1939, molybdenite concentrate has been recovered by Braden Copper Company from the copper ores of its El Teniente mine. In 1958, The Anaconda Company installed a molybdenite-recovery unit on its Chuquicamata copper property. The copper ore of Anaconda's El Salvador mine also contains considerable molybdenum.

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*U.S. Bureau of Mines, Minerals Yearbook, 1960, Molybdenum (preprint).

Other Countries

Japan, Norway, and Yugoslavia are minor producers. China, North Korea, and the Union of Soviet Socialist Republics also produce molybdenum, but data on their output are not available. The United States Bureau of Mines has estimated that Russian production totalled 9.9 and 11.0 million pounds in 1959 and 1960, respectively. This would rank Russia second to the United States, with an annual output a little less than three times that of Chile. Late in 1959, an Italian organization (Mazzacurati and Giacomelli, of Via Parma 22, Rome) announced the discovery of a large molybdenite deposit near Ala dei Sardi and Budduso, in northeastern Sardinia. The tonnage, which graded from 0.4 to 0.6 per cent MoS_2, was reported to be large.

World Production of Molybdenum, in Ores and Concentrates

(short tons)

	1960	1959
United States	34,119	25,478
Russia	5,500	4,950
Chile	2,220	1,893
China	1,650	1,650
Japan	421	397
Canada	384	374
Norway	249	249
Other countries	157	109
Total	44,700	35,100

Sources: U.S. Bureau of Mines, Minerals Yearbook, 1960 Molybdenum (preprint).

Consumption and Uses

About 70 per cent of the molybdenum consumed is in the form of molybdic oxide, which is followed by ferromolybdenum and molybdenum-metal powder. Molybdenum is used in lesser amounts in calcium, sodium, and ammonium molybdate, in molybdenum disulphide, and in molybdenite concentrate added directly to steel.

Small additions of molybdenum promote uniform hardness and strength throughout heavy sections. This ability to improve combinations of strength and toughness is the most notable effect of molybdenum as a steel additive.

United States Consumption of Molybdenum, by Use
('000 pounds of contained molybdenum)

	1960	1959	1958
Steel			
High-speed	1,756	2,488	1,072
Other alloys	19,480	19,091	13,776
Miscellaneous(1)	613	764	1,864
Gray and malleable castings	2,757	3,182	1,738
Rolls (steelmills)	1,152	1,028	601
Welding rods	259	233	249
High-temperature alloys	1,346	1,333	1,215
Molybdenum metal (wire, rod, and sheet)	2,336	2,206	1,867
Chemicals			
Catalysts	372	236	391
Pigments and other color compounds	856	901	760
Miscellaneous(2)	910	888	698
Total	31,837	32,350	24,231

Sources: U.S. Bureau of Mines, Minerals Yearbook 1959, and 1960 Molybdenum (preprint).

(1) Includes castings as well as hot-work and tool steels.

(2) Includes special alloys, lubricants, pesticides, refractories, magnets, and corrosion- and heat-resistant castings.

Metallic molybdenum is a refractory metal produced in the form of bars, sheet, plate, tube, and wire. It is superior in high-temperature applications and is used extensively in the electronics industry and for missile parts that have a short working life; but the solid-fuel rocket engines now being designed beyond the melting point of molybdenum will reduce the role of this metal in certain missile parts.

The use of molybdenum chemicals has been increasing in recent years. As a catalyst, molybdenum is applied in processes designed to raise the octane rating of gasoline, in the hydrogenation of coal and shale oils to produce liquid fuels, and in desulphurization. About 55 per cent of the molybdenum consumed by the pigment industry is employed in the production of molybdenum orange. The use of molybdenum as a trace element in agriculture, though still small, is becoming increasingly important. On some acid soils several ounces of molybdenum compound can do the work of several tons of limestone. In hill country too rough to lime or fertilize by conventional means, pastures are improved by the aerial seeding of clover and top-dressing with molybdenum and other fertilizers.

Molybdenum is of great strategic value to the United States, not only for its own particular alloying properties but because it can be used as a partial substitute for tungsten, nickel, chromium, and vanadium in low-alloy and certain high-speed steels.

Among the more important Canadian consumers of molybdenum primary products are: in Ontario - Atlas Steels Limited, Welland; The Algoma Steel Corporation, Limited, Sault Ste. Marie; Dominion Foundries and Steel, Limited, Hamilton; Welland Electric Steel Foundry, Limited, Welland; Canadian General Electric Company Limited, Toronto; The Steel Company of Canada, Limited, Hamilton; and Dominion Colour Corporation Limited, New Toronto; in Quebec - L'Air Liquide, Montreal; Canadian Steel Foundries Limited, Montreal; and Dominion Brake Shoe Company, Limited, Joliette; in Nova Scotia - Dominion Steel and Coal Corporation, Limited, Sydney.

Prices

E & M J Metal and Mineral Markets of December 29, 1960, quotes molybdenum prices in the United States as follows:

Molybdenum powder	Per lb, carbon-reduced, f.o.b. shipping point	\$3.35
Molybdenum ore	Per lb contained Mo, 95% MoS_2, f.o.b. shipping point Climax (effective Nov. 1, 1958), cost of container extra	\$1.25
Molybdic trioxide	Per lb Mo, f.o.b. shipping point	
	Bags	\$1.46
	Cans	\$1.47
Ferromolybdenum	Per lb contained Mo, lots 5,000 lb or more, packed, f.o.b. shipping point	
	58-64% Mo, powdered	\$1.82
	Other sizes	\$1.76
Calcium molybdate	Per lb Mo, lumps, packed	\$1.50

Tariffs

Canada

	British Preferential	Most Favored Nation	General
Calcium molybdate and molybdic oxide	free	free	5%
Molybdenum strip	"	"	30%
Molybdenum wire, rod, and tubing and molybdenum imported by manufacturers of radio tubes and parts	"	"	30%

Canada (cont'd)

	British Preferential	Most Favored Nation	General
Ferromolybdenum	free	5%	5%
Molybdenum ores and concentrates	"	free	free

United States

Molybdenum ores and concentrates per lb contained Mo	30¢
Calcium molybdate, ferromolybdenum, metallic molybdenum, molybdenum powder, and all other alloys and compounds of molybdenum, per lb contained Mo	25¢ plus 7 1/2% ad valorem
Molybdenum bars, ingots, sheets, shot, wire, and other forms not specifically provided for, and scrap containing more than 50% molybdenum carbide, or combinations thereof	
Bars, ingots, scrap, shot	21%
Other forms	25 1/2%

NATURAL GAS

D.W. Rutledge*

The National Energy Board's authorization in 1960 of large-scale exports of natural gas to the United States brought a renewal of activity in the Canadian natural-gas industry. Permission was granted to five pipeline companies to export a maximum of 1,071 million cubic feet a day. This resulted, during the latter half of the year, in the initiation of new gas-pipeline construction programs and an increase in the development of field facilities. The largest construction project begun was that of the Alberta-California pipeline, scheduled for completion in 1962. This line will carry more than 400 million cubic feet a day. In August, Trans-Canada Pipe Lines Limited began to export gas through Emerson, Manitoba, to the United States.

In 1960, Alberta produced nearly 73.4 per cent of Canada's net output of natural gas. British Columbia accounted for 16.4 per cent, Saskatchewan for 6.9 per cent, and Ontario for 3.3 per cent. The small remainder was from New Brunswick and the Northwest Territories. Manitoba, although it produced crude oil, produced no commercial quantities of natural gas.

In 1960 the net output of natural gas, exclusive of flared gas and waste, was over 25 per cent greater than in 1959. Net production increased 29 per cent in Alberta, 24 per cent In British Columbia, one per cent in Ontario, and 9 per cent in Saskatchewan. Production decreased 16 and 41 per cent respectively in New Brunswick and the Northwest Territories. The following table shows production by province.

Exploration and Development

British Columbia

Exploration was concentrated in the northeastern part of the province, where 22 natural-gas discoveries were made. Among the more notable discovery wells was one that found gas 120 miles northwest of Fort St. John, in the Mississippian of the Pocketknife anticline. An important find was made in the Devonian Slave Point formation at a point 35 miles northwest of Kotcho Lake and 35 miles south of previous discoveries at Petitot River. Canada's deepest well was drilled at Fording Mountain in southeastern British Columbia. It went to a depth of 16,540 feet, but was a dry hole. Development drilling extended the Kotcho Lake field several miles, and important development wells were drilled in the Triassic gas fields of the Jedney-Bubbles-La Prise Creek

*Mineral Resources Division.

Production of Natural Gas

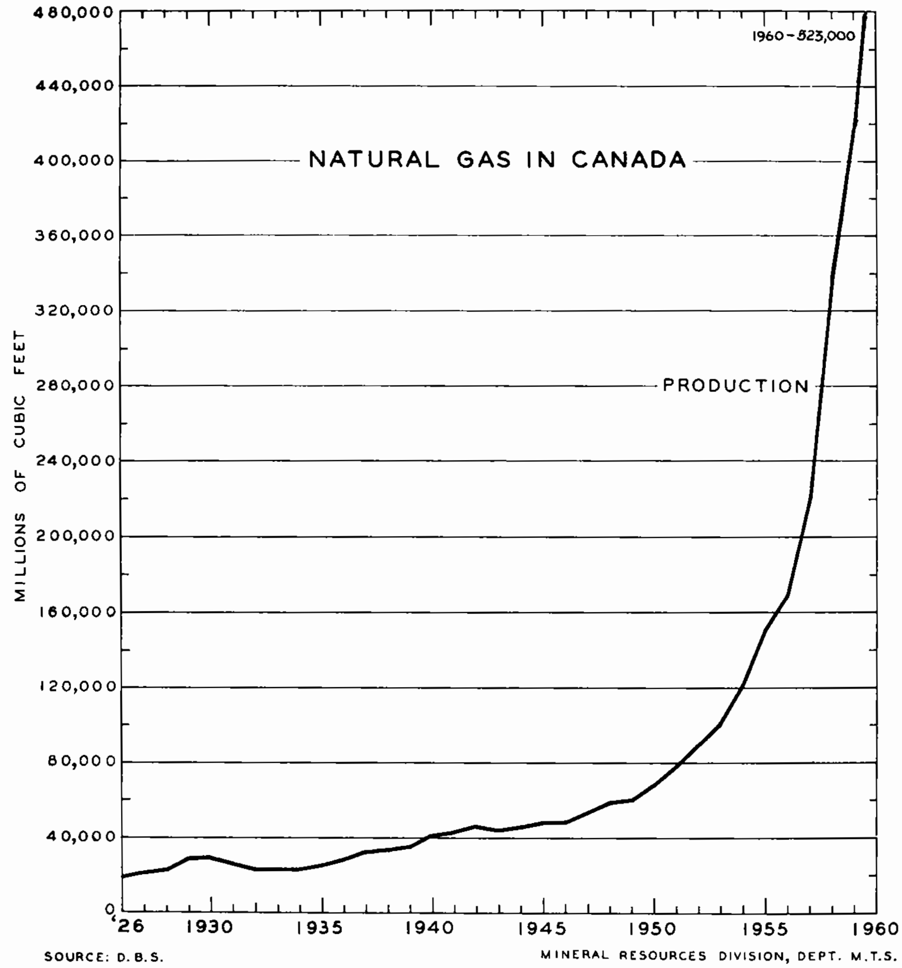
	1960		1959	
	Mcf*	$	Mcf*	$
Gross new production **				
New Brunswick........	98,701		117,502	
Ontario	16,987,056		16,839,236	
Saskatchewan	52,811,896		54,073,202	
Alberta...............	428,076,175		336,839,124	
British Columbia	86,376,327		69,956,418	
Northwest Territories..	39,785		67,189	
Total, Canada	584,389,940		477,892,671	
Waste				
Saskatchewan	16,240,263		20,460,236	
Alberta	44,393,189		39,270,198	
British Columbia	784,161		827,710	
Total, Canada	61,417,613		60,558,144	
Net new production				
New Brunswick	98,701	151,603	117,502	188,394
Ontario...............	16,987,056	6,573,990	16,839,236	6,516,784
Saskatchewan	36,571,633	3,722,992	33,612,966	3,327,684
Alberta	383,682,986	34,148,675	297,568,926	24,995,790
British Columbia	85,592,166	7,587,403	69,128,708	4,558,023
Northwest Territories..	39,785	12,219	67,189	22,718
Total, Canada	522,972,327	52,196,882	417,334,527	39,609,393

Source: Dominion Bureau of Statistics.
*Mcf = 1,000 cubic feet.
**Excludes withdrawals from storage.

area. At the end of the year, the province had 230 gas wells capable of being operated, but many were isolated in regions where there were no pipelines. Outside the 27 designated gas fields, only five wells were in operation of a total of 73 capable of being operated.

Alberta

The most important gas discoveries were in the western part of the province. In the Peace River district, two important exploratory wells in the Devonian D-3 extended the Worsley field eastward and westward a total of



14 miles. A major dry-gas find was made in the Panther River area of the southern Foothills, 40 miles west of the Harmattan-Elkton field. At Moose Mountain, 20 miles northwest of Turner Valley, gas was discovered in the Turner Valley formation. Dry gas was found in the Upper Mississippian of the Nordegg region, in two wells 60 miles southwest of the Pembina field. The Mississippian gas-producing horizon in the Crossfield area was extended eastward from the region where notably successful oil wells were drilled during the year in the Upper Cretaceous Cardium horizon. In 1960, Alberta gained 120 gas wells classed as capable of production, to make a year-end total of 950.

Saskatchewan and Manitoba

One natural-gas discovery was made near the North Hoosier field of west-central Saskatchewan, but there were no major discoveries in the province.

Natural-gas Fields Producing 10,000,000 Mcf* or More

(quantities in Mcf*)

	1960	1959
Alberta		
Pincher Creek	46,039,637	36,806,053
Pembina	34,521,769	34,948,221
Cessford	31,209,841	28,300,309
Jumping Pound	25,704,254	25,580,262
Turner Valley	22,510,342	25,975,430
Medicine Hat	18,211,114	12,978,531
Provost	16,993,343	15,421,064
Carstairs	15,603,408	-
Alexander	14,155,709	11,998,424
Nevis	13,588,697	1,076,755
Viking-Kinsella	13,463,300	11,221,766
Hussar	12,609,590	1,757,953
Leduc-Woodbend	12,393,867	13,422,872
Pouce Coupe	10,783,741	9,971,383
Okotoks	10,201,135	4,769,607
British Columbia		
Fort St. John	14,302,426	16,600,215
Buick Creek West	14,173,416	13,863,729
Fort St. John Southeast	12,459,104	11,020,214
Jedney	11,386,147	707,612
Saskatchewan		
Coleville-Smiley	15,615,677	16,593,758
Steelman	15,534,036	17,085,903

Source: Provincial-government reports.
*Mcf = 1,000 cubic feet.
-Nil.

Ten gas development wells brought to the capable-of-production stage raised the total to 203. In Manitoba, no gas was found and commercial production remained nonexistent.

Northwest Territories and Yukon Territory

The first important gas discovery in the Northwest Territories was made in the Celibeta Lake region. The gas, like that found in British Columbia's Petitot River region, 30 miles to the southeast, was in the Slave Point formation. Three other wells drilled within 3 to 6 miles of the Celibeta Lake discovery found the reservoir water-laden. Western Minerals Chance No. 1, the well that found oil and gas in Yukon Territory in 1959, finished drilling in 1960.

(text continued on page 386)

Value of Gas Production

	1957		1958		1959		1960	
	Total Value ($)	Value per Mcf(1) (¢)	Total Value ($)	Value per Mcf(1) (¢)	Total Value ($)	Value per Mcf(1) (¢)	Total Value ($)	Value per Mcf (1) (¢)
Alberta(2)	13,735,562	7.5	20,080,166	8.4	24,995,790	8.4	34,148,675	8.9
British Columbia	366,867	4.4	3,915,239	6.15	4,558,023	6.6	7,587,403	8.9
Saskatchewan	1,368,647	9.8	1,881,980	10.0	3,327,684	9.9	3,722,992	10.1
Northwest Territories	6,446	33.5	8,197	34.0	22,718	33.8	12,219	30.7
Ontario	5,328,338	37.0	5,974,755	37.0	6,516,784	38.7	6,573,990	38.7
New Brunswick	156,641	88.8	197,199	159.0	188,394	160.3	151,603	154.0
Total, Canada	20,962,501	9.5	32,057,536	9.5	39,609,393	9.5	52,196,882	9.9

Source: Calculations based on Dominion Bureau of Statistics figures.

(1) Mcf = 1,000 cubic feet.

(2) These figures include the value of gas withdrawn from storage in 1957 and 1958.

Wells* Completed, 1959-60

	Gas Wells		Oil Wells		Dry and Abandoned Holes		Total	
	1960	1959	1960	1959	1960	1959	1960	1959
Alberta	276	242	985	877	443	456	1,704	1,575
Saskatchewan	10	9	444	519	161	294	615	822
Manitoba	-	-	52	29	14	16	66	45
British Columbia	37	44	47	20	65	46	149	110
Northwest Territories and Yukon Territory	2	-	-	-	31	8	33	8
Total, western Canada	325	295	1,528	1,445	714	820	2,567	2,560
Ontario	92	100	49	19	125	162	266	281
Quebec	-	-	-	-	5	6	5	6
Maritimes	-	-	-	-	3	8	3	8
Total, eastern Canada	92	100	49	19	133	176	274	295
Total, Canada	417	395	1,577	1,464	847	996	2,841	2,855

Source: Provincial-government reports and Department of Northern Affairs and National Resources.
*Service wells excluded.

Footage* Drilled in Canada, by Provinces, 1959-60

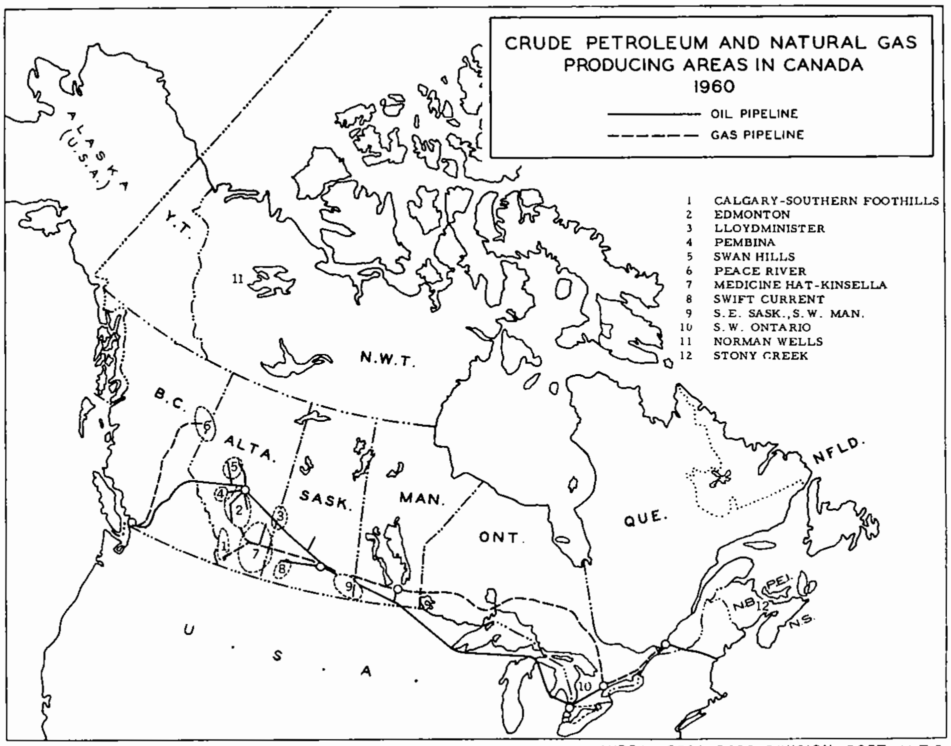
	Exploratory	Development	All Wells
		1960	
Alberta	2,938,449	7,210,648	10,149,097
Saskatchewan	549,765	1,781,701	2,331,466
British Columbia	472,478	294,120	766,598
Manitoba	36,875	110,073	146,948
Northwest Territories	102,756	-	102,756
Total, western Canada	4,100,323	9,396,542	13,496,865
Ontario	184,080	217,761	401,841
Quebec	4,288	-	4,288
Maritimes	22,863	-	22,863
Total, eastern Canada	211,231	217,761	428,992
Total, Canada	4,311,554	9,614,303	13,925,857
		1959	
Alberta	2,697,473	6,112,071	8,809,544
Saskatchewan	1,029,568	2,200,393	3,229,961
British Columbia	391,653	223,208	614,861
Manitoba	42,044	58,600	100,644
Northwest Territories	25,322	-	25,322
Total, western Canada	4,186,060	8,594,272	12,780,332
Ontario	193,735	209,132	402,867
Quebec	12,066	-	12,066
Maritimes	34,381	-	34,381
Total, eastern Canada	240,182	209,132	449,314
Total, Canada	4,426,242	8,803,404	13,229,646

Sources: Provincial-government departments and agencies; for Manitoba, Canadian Petroleum Association; for Quebec and the Maritimes, Canadian Oil & Gas Industries, April 1961.

*Service wells included.

Reserves

A compilation by the Canadian Petroleum Association for 1960 shows Canada's proven recoverable reserves of natural gas as being 15 per cent greater than in 1959. After subtracting 1960 production and adding net change in storage (C.P.A. data) the increase consisted of 4,312,815 million cubic feet



MINERAL RESOURCES DIVISION, DEPT. M.T.S.

in extensions and revisions in previously known fields and pools and 290,058 million cubic feet in new discoveries. About 69 per cent of the 1960 year-end total of recoverable natural-gas reserves was not associated with oil reservoirs; the remainder was associated with, or dissolved in, oil accumulations. Twenty-five new natural-gas fields and four new gas pools in oil fields were discovered during the year. The following table shows the Canadian Petroleum Association's compilation of recoverable natural-gas reserves, by province, for 1959 and 1960.

Estimated Year-end Recoverable Reserves of Natural Gas
('000,000 cubic feet)

	1960	1959
Alberta	26,014,370	23,300,669
British Columbia	3,097,930	1,825,238
Saskatchewan	1,305,759	1,235,592
Eastern Canada	217,068	209,815
Northwest Territories	37,366	32,063
Manitoba	1,559	1,959
Total	30,674,052	26,605,336

Source: Canadian Petroleum Association.

Transportation

Trans-Canada Pipe Lines Limited and Westcoast Transmission Company Limited provide the principal trunk lines of Canada's natural-gas-pipeline system. The 2,340-mile Trans-Canada pipeline receives gas from The Alberta Gas Trunk Line Company at the Alberta-Saskatchewan border and delivers it in Saskatchewan, Manitoba, Ontario, and Quebec and to a United States pipeline company at the International Boundary near Emerson, Manitoba. The Westcoast system moves gas from the Peace River district of British Columbia and Alberta to Vancouver and the nearby United States border.

By the end of 1959, natural-gas pipelines in Canada totalled 30,491 miles, and an additional 2,320 miles were added in 1960. Trans-Canada added 51 miles of 30-inch pipe extending from the Winnipeg area to Emerson, where in August it began deliveries to the Midwestern Gas Transmission Company. The Alberta Gas Trunk Line Company completed 209 miles of line during the year to connect with the Westerose South, Homeglen-Rimbey, Prevo, Gilby, and Wimborne fields and with additional parts of fields already served. In October, work was started on the clearing of the right-of-way for the pipeline of The Alberta Gas Trunk Line Company's Foothills Division, which will deliver gas to the British Columbia border at the Crowsnest Pass for eventual delivery to California and interim points. As in 1959, Saskatchewan Power Corporation was one of the most active builders, adding 310 miles of gas-transmission line and 113 miles of gas-distribution main.

Gas-pipeline Mileage in Canada

	1955	1956	1957	1958	1959**	1960
Gathering*						
New Brunswick	21	10	11	11	6	6
Ontario	2,166	851	941	940	955	910
Saskatchewan	474	99	92	311	280	285
Alberta	1,915	948	972	1,634	1,860	2,075
British Columbia	6	6	120	213	335	410
Total	4,582	1,914	2,136	3,109	3,436	3,686
Transmission						
New Brunswick	-	11	11	11	15	15
Quebec	-	-	26	26	25	25
Ontario	-	1,284	2,520	3,466	3,530	3,565
Manitoba	-	-	354	375	390	445
Saskatchewan	-	635	1,093	1,395	1,780	2,100
Alberta	-	1,797	2,127	2,581	3,095	3,460
British Columbia	-	37	1,101	1,101	1,105	1,105
Total		3,758	7,232	8,955	9,940	10,715

(table continued)

Gas-pipeline Mileage in Canada (cont'd)

	1955	1956	1957	1958	1959**	1960
Distribution						
New Brunswick	65	65	65	65	30	30
Quebec	-	-	963	971	1,025	1,115
Ontario	3,778	4,667	5,770	8,095	9,145	9,530
Manitoba	-	146	433	510	690	835
Saskatchewan	162	339	879	947	1,060	1,205
Alberta	1,672	1,879	2,075	2,202	2,455	2,560
British Columbia	6	925	1,902	2,380	2,710	3,135
Total	5,683	8,021	12,087	15,170	17,115	18,410

Source: Dominion Bureau of Statistics.
*Includes transmission lines for 1955.
**Some New Brunswick and Ontario lines were discontinued and reclassified.

Processing of Natural Gas

The rapid expansion of markets for natural gas during 1960 necessitated a concurrent increase in processing facilities. Components such as propane, butane, natural gasoline, and sulphur must be removed from much of western Canada's natural gas to make the gas salable. They are removed at the producing fields. Sixteen new natural-gas-processing plants commenced operations during the year, of which 14 were in Alberta and 2 were in Saskatchewan. This increased the number of natural-gas-processing plants in western Canada from 43 to 59. Most of the new plants are in a broad region between Calgary and Edmonton and in the Cessford-Princess area. The following table lists all the plants in operation at the end of the year.

Natural-gas-processing Plants in Canada
('000,000 cubic feet/day)

Fields Served	Raw-Gas Capacity	Residue Gas Produced
Alberta		
Acheson	5	4
Alexander	55	52
Bonnie Glen, Glen Park, Wizard Lake	30	24
Carbon	67	65
Carstairs	75	66
Cessford	125	120

Natural-gas-processing Plants in Canada (cont'd)
('000,000 cubic feet/day)

Fields Served	Raw-Gas Capacity	Residue Gas Produced
Alberta (cont'd)		
Cessford	12	12
Cessford	8	8
Cessford	22	20
Countess	18	17
Enchant	5	5
Gilby	18	17
Gilby	15	14
Harmattan-Elkton	15	12
Hussar, Chancellor	37	37
Innisfail	15	10
Jumping Pound	110	90
Leduc-Woodbend	35	31
Makepeace	20	20
Morinville, Atim	25	24
Nevis	50	43
Nevis, Stettler, Fenn-Big Valley	35	24
Okotoks	30	13
Oyen	3	3
Pembina (group of 9 plants)	91	77
Pembina	8	6
Pincher Creek	204	145
Prevo	4	4
Princess	4	4
Princess	22	21
Princess	13	12
Princess	3	3
Provost	90	85
Provost	17	12
Redwater	11	8
Samson	3	3
Sedalia	5	5
Three Hills	5	5
Turner Valley	100	87
Turner Valley	10	9
Wayne-Rosedale	6	5
Windfall	30	*
Wood River	5	5

Natural-gas-processing Plants in Canada (cont'd)
('000,000 cubic feet/day)

Fields Served	Raw-Gas Capacity	Residue Gas Produced
Saskatchewan		
Alida, Nottingham, Carnduff	9	6
Coleville	60	56
Smiley	4	3
Steelman	33	26
Success	25	24
British Columbia		
All fields, Fort St. John area	350	300

Source: Companies.

By-products from Natural Gas, Alberta and British Columbia, 1950-1960

	Propane (barrels)	Butane (barrels)	Natural Gasoline (barrels)	Condensate (barrels)	Sulphur (short tons)
1950	141,070	33,906	446,384	-	-
1951	248,554	84,527	515,027	-	-
1952	337,678	140,228	579,873	-	8,931
1953	433,083	198,401	602,771	-	18,298
1954	529,117	245,189	682,378	18,083	22,320
1955	796,482	492,051	868,416	160,100	29,093
1956	925,716	591,638	913,572	164,573	33,464
1957	1,111,355	747,709	968,162	153,278	100,706
1958	1,123,797	748,972	978,085	116,568	184,930
1959	1,690,114	1,424,452	1,396,979	862,434	292,337
1960	2,064,623	1,536,621	1,444,687	1,015,962	453,142

Source: Provincial-government reports.

Markets and Trade

An increase in exports and domestic sales resulted in an increase in natural-gas production in 1960. Domestic sales were nearly 15 per cent higher than in the previous year, and exports were up 32 per cent. The increase in exports reversed the downtrend of 1959. Imports of gas from the United States continued to diminish as Ontario's consumption of western Canada's natural gas continued to grow. Domestic sales of natural gas for residential, industrial, and commercial uses all showed important gains.

Natural Gas - Supply and Demand

('000,000 cubic feet)

Supply*	1960	1959
1. Gross new production(1)	574,063	468,475
2. Field waste and flared gas	-60,598	-59,753
3. Net new production(2)	513,465	408,722
4. Removed from storage	27,443	25,879
5. Placed in storage	-37,117	-26,540
6. Net withdrawals from storage(3)	-9,674	-661
7. Net supply of domestic gas(4)	503,791	408,061
8. Imports	5,551	11,708
9. Total supply	509,342	419,770
Demand		
10. Exports	112,484	83,184
11. Residential sales	110,133	97,937
12. Industrial sales	164,234	141,695
13. Commercial sales	51,122	43,485
14. Miscellaneous sales	121	113
15. Total domestic sales(5)	325,610	283,230
16. Consumption and losses in production(6)	67,670	50,244
17. Pipeline consumption, losses and metering differences(7)	5,972	3,660
18. Line Pack changes(7)	-1	390
19. Residual error	-2,393	-938
20. Total demand	509,342	419,770
21. Total domestic consumption(8)	396,858	336,586
22. Domestic consumption per day	1,084	922

Source: D.B.S., "Gas Utilities (Distribution Systems)".
Provincial government reports.
National Energy Board reports on exports and imports.

*Pressure data are standardized to 14.73 psia at 60° F.

(1) Excludes gas reproduced from storage.
(2) Sum of 1 and 2.
(3) Sum of 4 and 5.
(4) Sum of 3 and 6.
(5) Sum of 11, 12, 13 and 14.
(6) Consumption and Losses: Alberta total includes lease fuel, fuel returned to lease, plant fuel and waste, process shrinkage, and gathering-line losses and metering differences; Saskatchewan total includes field fuel, gas injection and lift and miscellaneous; British Columbia total includes lease use, plant waste and fuel, process shrinkage and gathering-line losses and metering differences.
(7) These apply to transport lines only as reported in "Gas Pipeline Transport".
(8) Total demand 20· minus exports 10.

In 1960, natural-gas sales in Canada amounted to 324,791 million cubic feet; in 1959 they totalled 283,230 million. The availability of the commodity in Alberta was reflected in that province's sales, which were the largest in Canada. Among the provinces, Ontario, however, is gradually overtaking Alberta as the main user of natural gas.

Sales of Natural Gas, 1960

	Mcf*	$	$/Mcf*	Number of Customers Dec. 31, 1960
New Brunswick	80,604	217,130	2.69	3,024
Quebec	11,035,936	13,217,240	1.20	231,665
Ontario	104,187,211	96,007,156	0.92	489,300
Manitoba	11,534,795	7,394,759	0.64	34,944
Saskatchewan	30,433,159	13,413,446	0.44	64,610
Alberta	141,731,535	40,741,186	0.29	203,402
British Columbia	25,788,045	23,427,797	0.91	122,156
Total, Canada	324,791,285	194,422,714	0.60	1,149,101
Previous totals				
1959	283,230,089	159,781,809	0.56	1,062,976
1958	206,553,170	115,242,246	0.56	1,035,591
1957	168,783,456	83,163,566	0.49	645,646

Source: Dominion Bureau of Statistics.
*Mcf = 1,000 cubic feet.

Sales of Natural Gas, on Percentage Basis

	1960	1959
Alberta	43.64	48.51
Ontario	32.08	29.36
Saskatchewan	9.37	10.15
British Columbia	7.94	7.11
Manitoba	3.56	3.03
Quebec	3.40	1.81
New Brunswick	0.02	0.03
Total	100.00	100.00

Source: Dominion Bureau of Statistics.

National Energy Board

The National Energy Board, established by the Government of Canada in 1959, has the responsibility, under the National Energy Board Act, of advising the Government on matters relating to energy or sources of energy, from exploration to sale to the consumer. Also, the Board has the authority to issue certificates of public convenience and necessity to pipeline companies. These certificates are required by all companies that propose to operate pipelines across provincial or international borders.

In 1960, the National Energy Board granted natural-gas-export permits to a number of Canadian pipeline companies. The quantities that may be exported under these permits, together with the portions of these quantities that the Federal Power Commission of the United States will admit into that country, are shown in the following table.

Natural Gas - Exports Allowable under 1960 Canadian Permits and Amounts Importable into United States

('000,000 cubic feet/day)

Company	Exports Allowed by National Energy Board		Imports Allowed by Federal Power Commission
	Maximum	Average	Average
Trans-Canada Pipe Lines Limited			
For export at Emerson, Manitoba	204	202.7	200
For export at Niagara Falls, Ontario	204*	204*	-
Alberta and Southern Gas Co. Ltd.	458.75	420	418
Canadian-Montana Pipe Line Company	36	30	30
Westcoast Transmission Company Limited	152	139.7	136.7
Niagara Gas Transmission Limited	16.71	10.3	-
Total	1,071.46	1,006.7	784.7

Sources: National Energy Board; Federal Power Commission.
*Interruptible gas.

NEPHELINE SYENITE

J.E. Reeves*

The nepheline-syenite industry in Canada has produced at a steadily increasing rate during most of its history and at a steeply increasing rate during the last decade. In 1960, shipments totalled nearly one quarter of a million tons - 5 per cent more than in 1959 - valued at $3 million.

This industry,which depends on export markets, kept its rates of increase for production and export almost parallel in 1960, exporting the equivalent of 80 per cent of its production total. About 95 per cent of the year's exports went to the United States, where the leading consumer is the glass industry.

Producers

All production originates at the large Blue Mountain deposit in Methuen township, a few miles northeast of Peterborough, Ontario. American Nepheline Limited operated its quarry and 600-ton mill at Nephton, in the southwestern part of the deposit. Early in 1961 this company was reorganized and renamed Industrial Minerals of Canada Limited. International Minerals & Chemical Corporation (Canada) Limited quarried nepheline syenite and processed it in a 350-ton plant at the northeastern end of Blue Mountain.

Other Canadian Occurrences

Nepheline-bearing rocks are common in many Canadian Localities.

In Ontario, many deposits smaller and chemically more variable than the Blue Mountain deposit are found in the Bancroft and Gooderham areas of the southeast; and from several of these, small intermittent shipments were made prior to 1942. Nepheline syenite also occurs in Bigwood township, northeast of Georgian Bay, as well as along the north shore of Lake Superior in the vicinity of Port Coldwell, but these two areas show little promise of yielding a marketable ceramic raw material.

In Quebec, an occurrence has been reported in the Labelle-L'Annonciation area, but little is known about it. Southeastern British Columbia has several deposits, the most notable of which is, however, in the Ice River area south of Field - mostly in national parkland.

In addition, in many places in Quebec and Ontario, there are deposits of complex alkaline rocks in parts of which nepheline is relatively common. These appear to be of no commercial interest as sources of nepheline.

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*Mineral Resources Division.

Production, Exports and Consumption

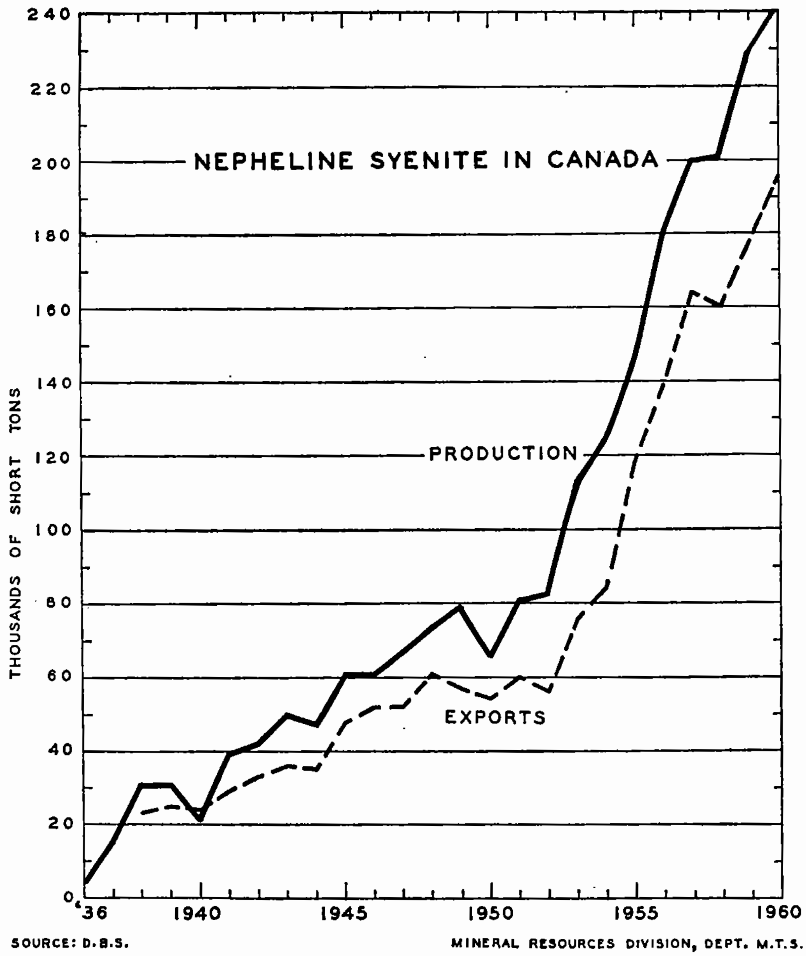
	1960		1959	
	Short Tons	$	Short Tons	$
Production (shipments)	240,636	2,891,095	228,722	2,930,932
Exports				
United States	183,864	2,231,761	170,094	2,213,938
United Kingdom	6,808	98,132	4,788	74,844
Puerto Rico	900	12,225	900	13,500
West Germany	368	6,820	388	6,941
Belgium and Luxembourg	353	6,326	240	4,635
Other countries	1,005	18,090	1,710	31,483
Total	193,298	2,373,354	178,120	2,345,341
Consumption*				
Glass	27,366		21,949	
Glass fibre	4,529		5,431	
Mineral wool	1,534		4,708	
Ceramic products	2,372		2,370	
Miscellaneous	248		103	
Total	36,049		34,561	

Source: Dominion Bureau of Statistics.
*Available data.

Foreign Occurrences

Deposits of nepheline syenite occur in the United States, particularly in New Jersey and Arkansas. It has not been possible, however, to reduce the iron content of these rocks sufficiently for the production of a ceramic raw material. Nepheline syenite from near Little Rock, Arkansas, is used in the manufacture of roofing granules.

Russia has been the only other producer of a ceramic raw material important for its nepheline content. A very large deposit of an unusual apatite-nepheline rock, situated near Kirovsk, in the Kola Peninsula, is being mined on a large scale for apatite, with nepheline as a by-product. Although it has a relatively high iron content (as much as 4 per cent Fe_2O_3), this nepheline concentrate has about 29 per cent alumina (Al_2O_3), 11 per cent soda (Na_2O), and 9 per cent potash (K_2O) and has been well received by manufacturers of dark-green glass. It has also become an important source of aluminum. Other nepheline deposits, with potential as aluminum ores, are reported to exist in the Krasnoyarsk and Kemerovo areas to the west of Lake Baikal.



There are nepheline-syenite deposits in several other countries, including Norway, India, and Peru. During 1960, the deposit on the island of Stjerny, off the northern coast of Norway, near Alta, was under development; and a dry-processing plant, capable of producing 20,000 tons of glass-grade and 15,000 tons of finer grades annually, was constructed. Minor shipments were made before the end of the year.

Technology

Nepheline-syenite is a quartz-free crystalline rock consisting principally of nepheline (an aluminum silicate with sodium and a minor proportion of potassium), soda feldspar, and potash feldspar. It has an industrial application because of a relatively high content of alumina and total alkali (sodium plus potassium) and because of its firing properties. To be of commercial interest, it must be amenable to treatment for the removal of iron-bearing impurities such as magnetite, biotite, and hornblende. In Canada, high-intensity magnetic separation is used to reduce the iron-oxide (Fe_2O_3) content from between 1.5 and 2 per cent in the mill feed to less than 0.1 per cent in the finished product. Dry milling methods are used throughout the processing.

Uses and Specifications

Nepheline syenite finds its major uses in the ceramics industry, the largest proportion being consumed in the manufacture of glass products. In glass batches it supplies a higher proportion of alumina than does the same amount of feldspar and provides a comparatively high alkali content. It is important also for its relatively low melting temperature. A particle size that is essentially minus 30 mesh and plus 200 mesh, U.S. standard, is specified. For most glassware, the maximum iron content, expressed as Fe_2O_3, should be 0.1 per cent.

In the whiteware industry (which produces sanitaryware, floor and wall tile, electrical porcelain, semivitreous ware, low-temperature vitreous ware, dental porcelain, and similar commodities), nepheline syenite is used in both the body and the glaze. It is more fusible and is a more active flux than potash feldspar, and this permits either a lower firing temperature or the use of a smaller amount of this vitrifying agent. The use of a lower firing temperature can result in savings in refractory and fuel costs. Size specifications call for all material to be minus 200 mesh and a certain proportion (from 95 to 100 per cent according to the end product) to be minus 325 mesh. For some uses an excess amount of fines is not desirable, and thus control of particle-size distribution is important. An Fe_2O_3 content of less than 0.1 per cent is necessary.

In porcelain enamels for sheet steel and cast iron, nepheline syenite gives good results as a frit ingredient, chiefly because of its low fusion temperature. For cover coats, specifications are similar to those for whitewares.

Fine-ground material is used as an extender pigment in paints.

Cheaper, lower-grade by-products, which differ only in having a higher iron content, are used in colored glass, ground-coat enamels, structural-clay products and glass fibre, as a body and glaze additive in the manufacturing of sewer pipe, and in other manufactured products in which the higher iron content is of no importance. Some crude is sold for use in the manufacture of mineral wool for insulation purposes.

NICKEL

C.C. Allen*

Nickel production in Canada rose to a new peak in 1960. Amounting to 214,506 short tons, or 15 per cent more than in 1959, it reached maximum capacity and was one aspect of the mineral industry that showed widespread expansion and development.

World demand for nickel during 1960 was extremely heavy, although a slight decline, which made it possible for producing companies to restock badly depleted inventories, occurred toward the end of the year. In Europe the demand for nickel was very high throughout the year, particularly in the steel industry. In the United States, demand was high immediately after the end of the steel strike but tapered off during the summer because of a decrease in American steel production.

The General Services Administration of the United States government released 19 million pounds of cathode nickel from stockpile in January to alleviate any shortage. The remaining contracts between The International Nickel Company of Canada, Limited, and the United States Defense Materials Procurement Agency (DPA) were cancelled, and International Nickel assumed the 1960 deliveries of Falconbridge Nickel Mines, Limited. In October the DPA inventory was estimated to contain 130 million pounds of nickel.

With the decline in stockpile commitments, more nickel will be available to the open market, and consumption and production figures will be in closer balance. Production from International Nickel's property at Thompson, Manitoba, which begins in 1961 at an annual rate of 37,500 tons of nickel, will make up much of the loss caused to the Free World market by recent events in Cuba.

Domestic Mine Production and Development

Ontario

In the Sudbury area, International Nickel continued to operate its Creighton, Frood-Stobie, Garson, Levack, and Murray mines. Development work at the Crean Hill mine continued and was started at the Clarabelle open pit and the Copper Cliff north property. Production from the Clarabelle pit, southwest of the Murray mine, is scheduled for late 1961 and will eventually replace ore from the Frood open pit. A 3,000-foot shaft will be sunk on the Copper Cliff north property for exploration of the Copper Cliff offset. Stations

(text continued on page)

*Mineral Resources Division.

Nickel - Production, Trade and Consumption

	1960		1959	
	Short Tons	$	Short Tons	$
Production				
All forms[1]				
Ontario	201,650	277,924,234	173,964	240,053,265
Manitoba	9,059	12,400,485	10,139	13,523,225
British Columbia	1,890	2,645,915	531	743,072
Northwest Territories	1,907	2,669,645	1,921	2,689,239
Total	214,506	295,640,279	186,555	257,008,801
Exports				
In matte				
United Kingdom	39,822	53,759,359	27,394	36,986,865
Norway[2]	33,242	44,877,578	29,408	39,787,120
United States	846	1,141,830	7,831	10,614,076
Other countries	-	-	1,024	1,383,141
Total	73,910	99,778,767	65,657	88,771,202
In oxide sinter				
United States	5,645	6,801,596	2,389	2,852,886
United Kingdom	2,034	1,763,649	515	365,546
France	1,826	2,470,056	5	6,934
Sweden	1,179	1,594,767	459	610,888
Italy	1,066	1,441,361	270	359,328
Australia	607	728,229	198	238,094
Belgium and Luxembourg	529	711,820	221	293,943
Other countries	371	490,847	100	130,594
Total	13,257	16,002,325	4,157	4,858,213
Refined metal				
United States	63,413	80,652,622	78,460	100,552,253
United Kingdom	9,770	12,373,032	6,947	8,866,599
Belgium and Luxembourg	7,651	10,848,262	4,098	5,820,321
West Germany	6,645	9,220,237	2,732	3,926,726
Russia	3,748	5,323,092	850	1,206,945
Sweden	3,419	4,822,627	2,721	3,848,277
France	2,989	4,252,406	521	738,900
Czechoslovakia	2,813	3,851,886	2,274	3,178,785
Italy	2,576	3,587,781	936	1,276,932
Other countries	5,326	7,617,550	2,572	3,811,611
Total	108,350	142,549,495	102,111	133,227,349
Imports				
Semifabricated[3]				
United States	1,689	3,837,125	1,822	3,450,779
Norway	62	87,094	-	-
United Kingdom	8	15,053	30	73,608
Other countries	3	12,131	5	16,779
Total	1,762	3,951,403	1,857	3,541,166

Nickel - Production, Trade and Consumption (cont'd)

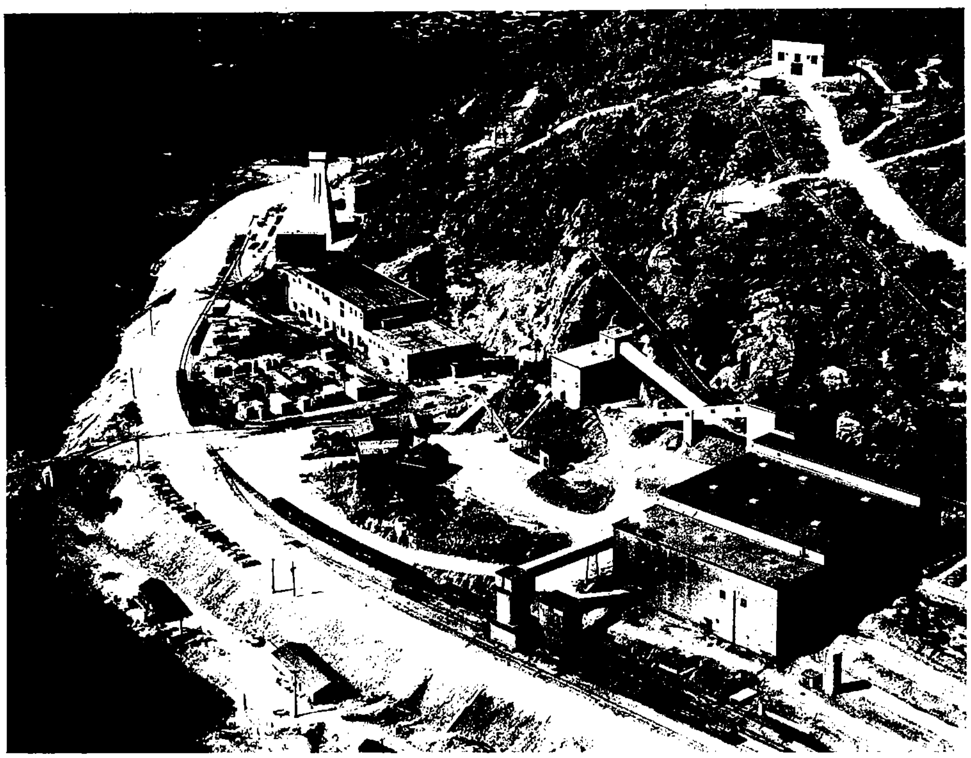
	1960		1959	
	Short Tons	$	Short Tons	$
Imports (cont'd)				
Manufactures				
United States............		1,244,898		1,606,992
United Kingdom		181,986		196,473
West Germany		203,555		172,791
Other countries		125,706		169,592
Total...................		1,756,145		2,145,848
Total imports...........		5,707,548		5,687,014
Consumption(4)				
Refined metal	4,077		3,801	

Source: Dominion Bureau of Statistics.
(1) Includes nickel matte exported, refined metal produced in Canada, and nickel in oxides and salts sold or produced.
(2) For refining and re-export.
(3) Nickel in bars, rods, strips, sheets, and wire; nickel and nickel-silver in ingots; nickel-chromium in bars.
(4) As reported by consumers.

Nickel - Production, Trade and Consumption, 1950-60
(short tons)

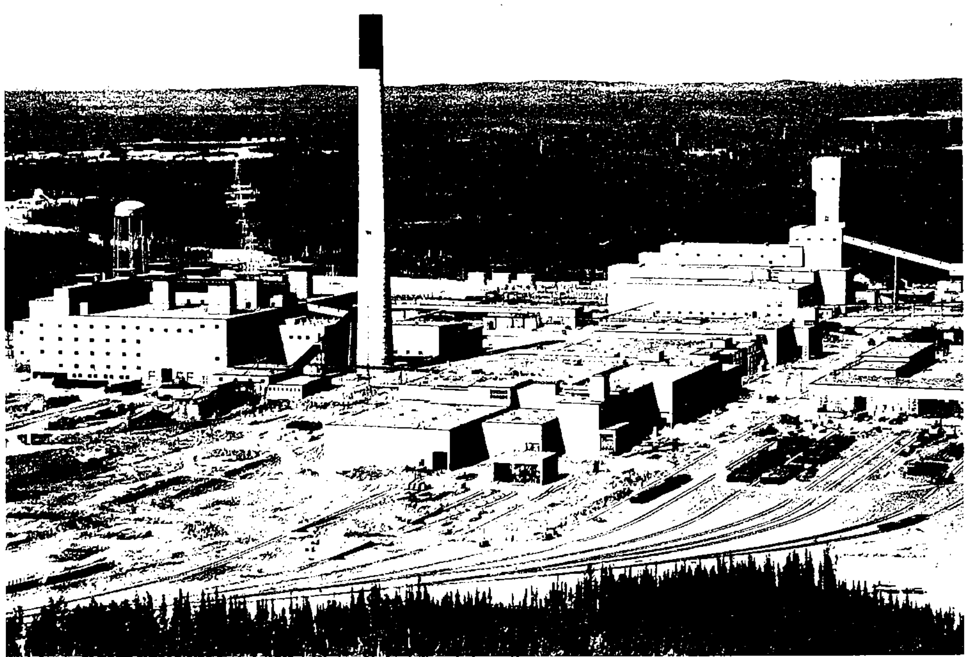
	Production(a)	Exports				Imports(b)	Consumption(c)
	All Forms	In Matte	In Oxide Sinter	Refined Metal	Total		
1950	123,659	53,090	1,668	66,894	121,652	1,337	2,226
1951	137,903	57,882	944	72,357	131,183	1,306	2,744
1952	140,559	63,753	1,211	77,058	142,022	1,650	2,223
1953	143,693	63,909	1,299	79,909	145,117	3,083	2,275
1954	161,279	65,823	1,486	91,410	158,719	1,584	2,595
1955	174,928	65,954	1,453	106,473	173,880	2,103	5,020
1956	178,515	70,715	1,767	104,356	176,838	2,554	5,545
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	3,801
1960	214,506	73,910	13,257	108,350	195,517	1,762	4,077

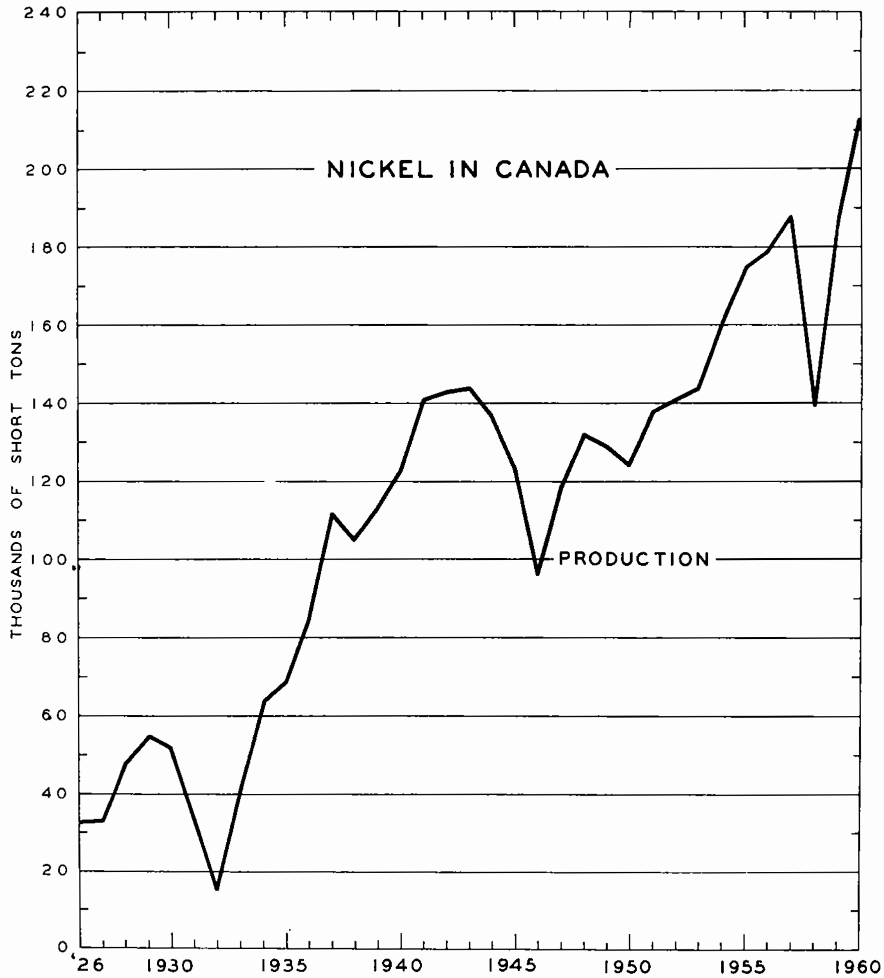
Source: Dominion Bureau of Statistics.
(a) Refined metal, plus the content of oxide and matte exported.
(b) Nickel in semifabricated forms, including nickel in bars, rods, strips, sheets, and wire; nickel and nickel-silver in ingots; nickel-chromium in bars.
(c) For 1959 and 1960 consumption of refined metal as reported by consumers; for all other years, producers' domestic shipments of refined metal.



The Fecunis Lake mine of Falconbridge Nickel Mines, Limited, on the north side of the Sudbury basin. The mill is at the lower right foreground.

Surface building of the Thompson mine in north-central Manitoba in mid-1960. *Courtesy of The International Nickel Company of Canada, Limited.*



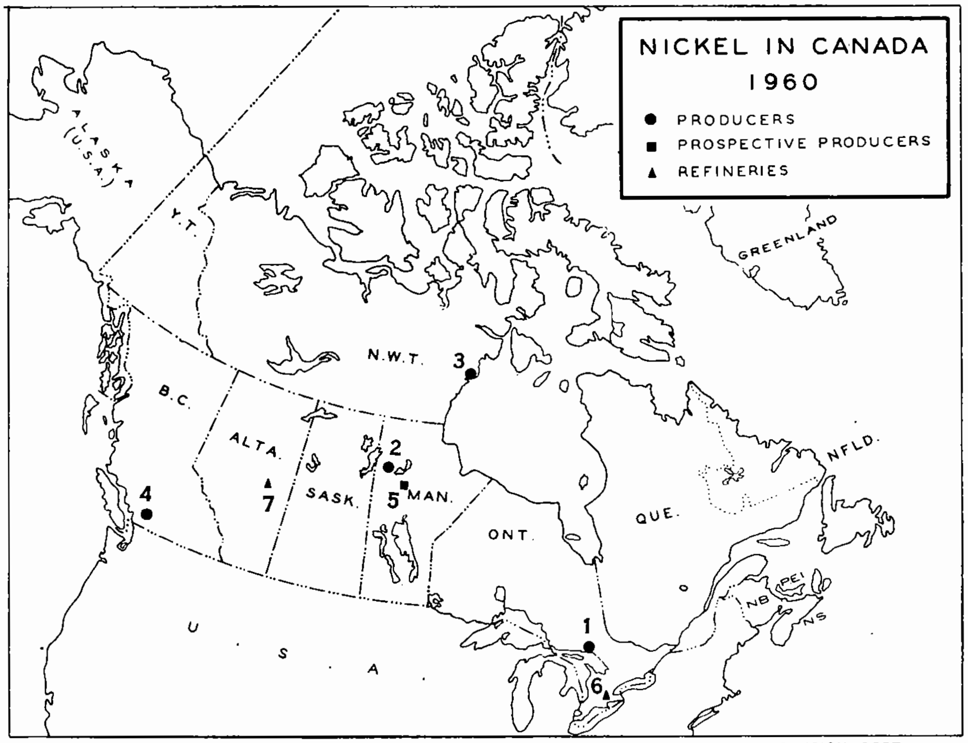


SOURCE: D.B.S. MINERAL RESOURCES DIVISION, DEPT. M.T.S.

will be cut at the 1,000-, 2,000-, and 3,000-foot levels, and from these stations diamond-drill drifts will be driven. International Nickel's production capacity in the Sudbury area remains at 310 million pounds of nickel a year.

Ore mined during the year totalled 16,768,000 tons. At the end of the year ore reserves amounted to 290,273,000 tons containing 8,715,300 tons of nickel and copper. For the first time these reserves included 25 million tons containing 742,500 tons of nickel and copper from the Thompson deposit in northern Manitoba. During the year the company delivered 351,880,000 pounds of nickel, of which 51,410,000 pounds were acquired from the United States government or its suppliers.

International Nickel has a $5 million fluid-roast plant under construction at Copper Cliff. It recently announced a further $50 million program



MINERAL RESOURCES DIVISION, DEPT. M.T.S.

Producers

1. Sudbury area
   International Nickel Company of Canada, Limited, The (5 mines, 2 smelters)
   Falconbridge Nickel Mines, Limited (6 mines, 1 smelter)
   Norduna Mines Limited
2. Sherritt Gordon Mines Limited, Lynn Lake, Manitoba
3. North Rankin Nickel Mines Limited
4. Giant Nickel Mines Limited, near Hope, British Columbia

Prospective Producers

5. International Nickel Company of Canada, Limited, The - Thompson project

Refineries

6. International Nickel Company of Canada, Limited, The, Port Colborne, Ontario
7. Sherritt Gordon Mines Limited, Fort Saskatchewan, Alberta

that will triple the capacity of its iron-recovery plant. Of this amount, $10 million is scheduled to be spent in 1961. The feed for the iron-recovery plant is pyrrhotite tailings, from which the nickel is first removed by atmospheric ammonia leaching.

Falconbridge Nickel Mines, Limited continued to operate its six mines in the Sudbury basin - the Falconbridge, East, McKim, and the Hardy, Longvack, and Fecunis. It also treated custom ore from Norduna Mines Limited. Falconbridge has begun a $25 million undertaking in which $5 million will go for a 100,000-ton-a-year iron-recovery plant, between $10 million and $15 million for a shaft and development program at the large Strathcona deposit, and between $7.5 million and $10 million for plant expansion and the refinement of plant operations. The last-mentioned are, however, basically efficiency measures rather than real plant expansion. During 1960 Falconbridge began to use natural gas in steam operations and sintering, with an initial consumption of 1 million cubic feet a day.

Production from the Boundary and Onaping mines, on the west side of the Sudbury basin, will start early in 1961. The nickel-production capacity of Falconbridge is about 65 million pounds of refined nickel a year. Ore reserves at the end of the year, including developed and indicated ore, totalled 46,089,100 tons averaging 1.46 per cent nickel and 0.81 per cent copper.

Manitoba

Sherritt Gordon Mines, Limited milled 1,151,419 tons, or 3,164 tons a day. Ore reserves at December 31, 1960, were 14,300,000 tons averaging 0.92 per cent nickel and 0.53 per cent copper. Development work on the 2,000-foot level from the Farley shaft is continuing. Production at the Fort Saskatchewan, Alberta, refinery was 23,258,338 pounds of nickel from Lynn Lake and purchased concentrates, and 7,710,893 pounds of nickel refined on a toll basis. When the year ended, the powder-rolling plant producing metal strip, rod, and wire was virtually completed, and in January it began commercial operation. During 1960, Sherritt Gordon stopped delivering nickel to the United States stockpile, and the balance from the contract was sold to industry.

International Nickel's Thompson project in northern Manitoba was officially opened on March 25, 1961, but produced its first electrolytic nickel in February. Full-scale production will be reached before mid-year. Other phases of the project are now in operation, and artificial nickel-sulphide anodes are being held in readiness for the completion of the electrolytic refinery. Although the rate planned for the production of electrolytic nickel at Thompson is 75 million pounds a year, the output will ultimately exceed this; and within the next few years nickel production may be expanded beyond that of the present facilities. The ore reserves proven to date are included in International Nickel's general reserve. The company is also exploring nickel deposits in northern Manitoba that lie some distance southwest of Thompson and are "greater than those in the immediate Thompson area."

Northwest Territories

North Rankin Nickel Mines Limited continued to ship concentrates to the Fort Saskatchewan, Alberta, refinery of Sherritt Gordon. At October 1, proven ore reserves stood at 177,120 tons averaging 3.47 per cent nickel and 0.99 per cent copper.

British Columbia

Giant Nickel Mines Limited continued to ship nickel-copper concentrates to Japan.

Exploration in Canada

Ontario

At its Gordon Lake property 55 miles northwest of Kenora, Nickel Mining & Smelting Corporation is exploring new ground from the winze that extends from the 1,200- to the 1,650-foot level. Three levels were cut at 1,350, 1,500 and 1,650 feet. Drilling from the 1,350-foot level in the 'A' zone outlined an ore length of 363 feet averaging 1.80 per cent nickel and 0.63 per cent copper over a 41-foot width. Two long drives are being extended to explore the 'B' and 'G' zones.

Fatima Mining Company Limited suspended underground development at its nickel property 20 miles southwest of Timmins. Surface exploration is continuing.

Ryanor Mining Company Limited began diamond-drilling its claims on the north side of the Sudbury basin.

Conwest Exploration Company Limited started drilling on the property of McVittie-Graham Mining Company Limited, east of the Crean Hill mine, Sudbury district. Only the initial results were encouraging, and drilling was stopped.

Manitoba

Consolidated Marbenor Mines Limited and National Malartic Gold Mines Limited actively explored a jointly owned nickel property some 40 miles southwest of Thompson, in the Wabowden area. Initial diamond-drill results outlined 2.0 to 2.5 million tons of material averaging 0.90 per cent nickel over a 1,300-foot length to the 800-foot horizon.

Quebec

Shaft-sinking was started on the property of Marbridge Mines Limited, in La Motte township. Production at a minimum rate of 300 tons daily has been scheduled for January 1963. The owners are Falconbridge and Marchant Mining Company Ltd.

World Development and Production

Cuba

The United States government announced in September the closing of its Nicaro plant because of confiscatory taxes and harassment. The plant was subsequently nationalized by the Cuban government. This, with the earlier closing of the Moa Bay property of Freeport Nickel Company, resulted in a loss to the Free World market of an annual production capacity of 52,000 short tons of nickel. The Nicaro operation is in partial production under Cuban management.

Dominican Republic

The pilot plant of Minera y Beneficiadora Falconbridge Dominicana C por A will be completed and in operation in 1961.

Finland

The smelter at Harjavalta was under construction late in 1960. Nickel concentrates will be shipped from a nickel mine at Kotalahti and from other mines. Concentrates will be flash-smelted and processed into electrolytic nickel.

Greece

International Nickel began to evaluate the nickel-silicate deposits at Lárimna.

Japan

Japanese nickel interests are considering a plan to develop Indonesian nickel-laterite deposits in the Celebes.

New Caledonia

Société Anonyme Le Nickel has a production capacity of about 55 million pounds of contained nickel a year. Le Nickel produces ferronickel and matte in New Caledonia. The matte is refined to metallic nickel at Le Havre, France. In New Caledonia, four new electric furnaces producing ferronickel were in operation in January 1961 and the installation was begun of a fifth furnace to operate on surplus power. The water-jacket ovens producing matte are being modernized in another cost-reduction program. Temporary subsidies granted to the company by the French government ceased on June 30, 1960. Production during 1960 was 9,631 metric tons of refined nickel and matte and 11,408 tons of ferronickel.

United States

The nickel-production capacity of Hanna Nickel Smelting Company, Riddle, Oregon, remains at an annual 23.5 million pounds of contained nickel marketed as ferronickel.

Venezuela

The Venezuelan government cancelled International Nickel's lateritic-nickel-ore concessions, but the cancellation is being appealed.

World Production of Nickel, 1960
(short tons)

Canada	214,506
Russia	64,000(e)
New Caledonia	42,300
Cuba	14,147
United States	12,530
Union of South Africa	3,200
Other countries	2,517
Total	353,200

Source: American Bureau of Metal Statistics, 1960.
(e) Estimated.

Free World* Nickel-production Capacity, 1961
(short tons)

International Nickel (including Thompson)	192,500
Falconbridge	32,500
Sherritt Gordon	13,750
New Caledonia (French and Japanese)	42,500
Hanna Nickel Smelting	11,750
Total	293,000

Source: Company reports.
*Cuba excluded.

Consumption and Uses

Free World nickel consumption, by products, as outlined by International Nickel, is as follows:

	1958	1959	1960
Stainless steels................	27%	29%	32%
High-nickel alloys	16%	16%	15%
Electroplating	13%	15%	16%
Nickel-alloy steels.............	16%	15%	13%
Foundry products	12%	12%	12%
Copper-nickel alloys	6%	4%	4%
All other products	10%	9%	8%

Consumption gained in stainless steels and nickel plating. Stainless steels accounted for much of the nickel consumed in Europe and were in great demand in North America for household products. Stainless steel was of major use in the food industry, hospital supplies, and corrosion-resistant equipment for the chemical industry, and it is now being more widely employed in curtain walls and interior trims. Nickel-plating by the duplex method has created another large field of nickel consumption. The automobile industry, which is one of the more important users of nickel in the United States, provided the outlet for an estimated 20.6 per cent of the nickel consumed in that country in 1959.

For use in the new field of cryogenics, International Nickel has developed a 9-per-cent-nickel steel that remains tough in temperatures as low as -320°F. Research is under way into the coating of carbon steel to produce corrosion-resistant materials for the automobile industry. After-burners used under the California antismog laws to rid the air of automobile fumes may soon contain nickel steels or nickel alloys.

Prices

The Canadian price of electrolytic nickel, f.o.b. Port Colborne, Ontario, was 70 cents a pound throughout 1960. On January 1, 1961, International Nickel increased it to 72 3/4 cents a pound.

The United States price, including the 1 1/4-cent United States import duty, remained at 74 cents (U.S.) f.o.b. Port Colborne.

Tariffs

Canada

	British Preferential	Most Favored Nation	General
Nickel, and alloys consisting 60% or more of 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 90% or more of nickel, when imported by manufacturers of nickel electrode wire for spark plugs for use exclusively in the manufacture of such wire for spark plugs in their own factories	"	"	10%
Metal, alloy strip or tubing, not being steel strip or tubing, consisting not less than 30% by weight of nickel and 12% by weight of chromium, for use in Canadian manufactures	"	"	20%
Anodes of nickel	5%	7 1/2%	10%
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 the manufacture of such storage batteries	10%	10%	20%

United States

Nickel ore, nickel matte, and nickel oxide	free
Nickel, and alloys in which nickel is the component material of chief value:	
In cathodes, cubes, grains, ingots, pigs, shot, or similar forms	1 1/4¢ lb

United States (continued)

In anodes, bars, castings, electrodes, plates, rods, sheets, strands, strips, or wire	12 1/2%
In tubes or tubing	6 1/4%
Any of the foregoing, if cold-drawn, cold-rolled, or cold-worked, shall be subject to an additional duty as follows:	
Tubes and tubing	2 1/2%
Other forms	5%

NIOBIUM AND TANTALUM

V. B. Schneider*

The previous review on niobium and tantalum was issued by this Division in 1958 and covered developments to the end of 1957.

Columbium ore has not been commercially produced in Canada since 1955. In 1954, Boreal Rare Metals Limited began to manufacture the pentoxides of columbium (Cb_2O_5) and tantalum (Ta_2O_5) at its plant at Cap de la Madeleine, Quebec. During 1954 and 1955, small quantities of the pentoxides were produced from concentrates from a lithium-tantalum-columbium property 70 miles east of Yellowknife, Northwest Territories. Mining operations were suspended early in 1955 when the mill burned down.

In 1958, The Consolidated Mining and Smelting Company of Canada Limited acquired the controlling interest in Nova Beaucage Mines Limited, which has a columbium property near North Bay, Ontario. Research on the concentration of the company's pyrochlore,+ conducted in 1958 and 1959 by the company at Kimberley, British Columbia, and at its North Bay plant, and by the Government of Canada at the Mines Branch, in Ottawa, was partially successful on a laboratory scale.

Columbium Mining Products Ltd., Quebec Columbium Limited, and St. Lawrence Columbium and Metals Corporation, all with properties near Oka, Quebec, about 35 miles northwest of Montreal, have conducted exploration work, beneficiation tests, and market surveys to ready their properties for eventual production.

In 1960, Columbium Mining Products Ltd. announced the signing of a purchase contract and sales-agency agreement with W. R. Grace and Company, of New York, and Metallgesellschaft A.G., of West Germany. The company also announced plans to build a 250-ton-a-day pilot plant on its property with an initial capacity of 750,000 pounds of columbium pentoxide a year.

St. Lawrence Columbium and Metals Corporation was formed in 1960 through the merger of holding properties of St. Lawrence River Mines Ltd., in the Oka area of Quebec, and Lake Superior Iron Ltd. The merger was made to obtain the funds required to bring the main Oka property into production. The principal assets of Lake Superior Iron were a balance of cash payments from The Anaconda Company (Canada) Ltd. and 60,000 shares of Anaconda Iron Ore (Ontario) Limited.

+Pyrochlore is essentially $(Na,Ca)_2Cb_2O_6F+ThO_2$ and oxides of rare-earth elements.

*Mineral Resources Division.

Niobium (Columbium) and Tantalum--Trade and Consumption

	1960		1959		1958	
	Pounds	$	Pounds	$	Pounds	$
Imports						
Special tabulation(1)						
Ferrocolumbium	(2)	(2)	(2)	12,178	--	12,600
Ferrocolumbium-tantalum	(2)	(2)	(2)	(2)	--	21,900
From United States(3)						
Columbium metal and alloys, semifabricated	11	1,448	230	5,390	(2)	(2)
Tantalum metal and alloys, crude form and scrap	7,216	62,772	(2)	(2)	(2)	(2)
Tantalum semifabrications	320	15,060	95	7,595	42	2,274
Exports (4)						
Columbium ore and concentrates	--	--	14,000	291	--	--
Columbium metal	--	--	--	--	23	592
	Short Tons		Short Tons			
Consumption						
Ferrocolumbium and ferrotantalum-columbium consumed by steel industry	8	(2)	5	(2)	(2)	(2)
On hand at end of year	2	(2)	3	(2)	(2)	(2)

Source: Dominion Bureau of Statistics except where otherwise indicated.

(1) Shipments of $1,000 or more as shown in Trade of Canada.

(2) Not available.

(3) U.S. Department of Commerce, United States Exports of Domestic and Foreign Merchandise, Report No. FT410, Part II, 1960.

(4) U.S. Department of Commerce, United States Imports of Merchandise for Consumption, Report No. FT110, 1960.

A 500-ton pyrochlore concentrator, on which construction was begun in November, is expected to be completed and in operation by August 1961. Overburden was removed from part of the proposed open-pit site and by December an area about 300 feet square had been cleared to bedrock. About one quarter of the overburden removed consists of an altered material containing a high percentage of ore assaying 0.60 per cent Cb_2O_5. This material was stockpiled and will be used as mill feed.

St. Lawrence Columbium appointed South American Minerals and Merchandise Corp. (SAMINCORP), of New York, as agent for the sale of its columbium concentrates. SAMINCORP has agreed to sell a minimum of 500,000 pounds of columbium concentrate (minimum 50 per cent Cb_2O_5) during the 15-

month period beginning October 1, 1961. A typical analysis of the pilot-mill production of December 1960 is as follows:

Cb_2O_5	53.0 %+
P	0.2 % to 0.3%
TiO_2	4.0 % " 5.0%
SiO_2	0.3 % " 3.0%
TaO_2	0.09% " 0.5%
S	0.1 % " 0.3%
WO_3	Not detected
SnO_2	"

The Mines Branch in Ottawa has conducted investigations related to the addition of columbium in steelmaking and to the improvement of concentration techniques.

Also in 1960, Metallurgical Products Company Limited, of Montreal, produced ferrocolumbium from imported pyrochlore concentrate, using the aluminothermic reduction process. The company expects to use domestic pyrochlore concentrates from Oka when they are available. Dominion Gulf Company continued research on the extraction of columbium from its deposit in Chewett township, 17 miles northeast of Chapleau, Ontario.

Canadian Occurrences

Northwest Territories

In addition to the property of Boreal Rare Metals Limited, there are many columbium-tantalum occurrences in the Yellowknife area, north of Great Slave Lake. The presence of columbite-tantalite has been noted in many pegmatite dikes in association with beryl, spodumene, and amblygonite.

British Columbia

The placer deposits on Bugaboo, Vowell, and Forster creeks about 45 miles southeast of Golden consist of columbium-bearing gravel. In 1956, Quebec Metallurgical Industries Ltd., at Billings Bridge, Ontario, processed gravity concentrates to produce high-purity columbium oxide, columbium alloys, and columbium sponge. The project was discontinued, however, as uneconomical.

Ontario

The columbium-uranium deposits of Nova Beaucage Mines Limited are 6 miles west of North Bay in an area covering the Manitou Islands of Lake Nipissing. Estimates of tonnage and grade vary considerably, but it is estimated that the reserves in the zone east of Newman Island, on which most of the exploration work has been conducted, amount to 2.7 million tons averaging 0.69 per cent Cb_2O_5 and 0.042 per cent uranium oxide (U_3O_8).

Dominion Gulf Company has outlined two areas of columbium mineralization in Chewett township. One area contains an estimated 20 million tons of material averaging 0.5 per cent Cb_2O_5.

Multi-Minerals Limited has outlined two pyrochlore-bearing deposits on its Nemegos property, about 14 miles southeast of Chapleau.

Quebec

Quebec Columbium Limited, jointly owned by Molybdenum Corporation of America and Kennecott Copper Corporation; Columbium Mining Products Ltd., jointly owned by Headway Red Lake Gold Mines Limited and Coulee Lead and Zinc Mines Limited; and St. Lawrence Columbium and Metals Corporation control large pyrochlore deposits near the town of Oka, 20 miles west of Montreal.

The mineral deposits associated with and contained in what is referred to as the Oka complex are about 2 miles east of Oka, at La Trappe. Few outcrops are to be seen, as the overburden varies from 6 to 100 feet in thickness and in places may be as much as 200 feet thick.

The grade and tonnage of the mineralized material in the Oka area is not known. One estimate of reserves suggests that 18,000 million tons grading 0.25 per cent Cb_2O_5 may be present, but 0.25 per cent Cb_2O_5 cannot be considered economic at the present time.

St. Lawrence Columbium and Metals Corporation has calculated that there are 62.7 million tons of indicated and proven pyrochlore ore containing 500 million pounds of Cb_2O_5 on the explored part of its property. This calculation concerns only ore containing, as a computed average, a minimum of 8 pounds of Cb_2O_5 per ton (the ore averages 0.40 per cent Cb_2O_5).

Columbium Mining Products Ltd. believes it has reserves amounting to 100 million tons assaying 0.3 per cent Cb_2O_5. Quebec Columbium Limited, the largest property holder in the area, is noncommittal.

World Mine Production

Free world production of columbium and tantalum concentrates amounted to 6,350,000 pounds in 1960 compared to 6,170,000 pounds in 1959. Nigeria leads in the production of columbium concentrate (columbite); the Republic of the Congo is the principal source of tantalum concentrate (tantalite). Other known occurrences of tantalite of commercial quality and quantity are limited, and fear of a reduction in the supply from the Congo caused the price of 60-per-cent-Ta_2O_5 concentrate to increase from a mid-year low of $4.80 to $7.50 per pound of contained oxide. Sources of columbium ore are much more numerous.

A pyrochlore deposit at Araxá, Brazil, is believed to contain some 7,500 short tons of columbium in ore assaying more than 3.0 per cent Cb_2O_5. It is controlled jointly by Molybdenum Corporation of America and Wah Chang Corporation. Early difficulties in concentrating the ore are reported to have been overcome, and production may start in 1961.

The Sove niobium mine, in the Fen area, near Ulefoss, which is 72 miles southwest of Oslo, Norway, produces about 40 tons a month of 50-per-cent-Cb_2O_5 concentrate. This concentrate, with a columbium-tantalum ratio of 100:1, is shipped to the European market.

Consumption and Uses

In the United States, capacitors for electronic and communications equipment provided the largest single use for pure tantalum metal in 1960. Most of the output of pure columbium metal was purchased by the United States government in the form of bars and mill products for use in connection with the application of atomic energy.

In Canada, the need is for ferrocolumbium and ferrotantalum-columbium. In 1959, about 5 tons of columbium addition agents were consumed by the Canadian iron-and-steel industry. Indications are that an increase in consumption is imminent, with wider application in carbon steels in which columbium provides higher degrees of strength. This could be important in the fabrication of skelp and plate for use in oil- and gas-transmission piping.

Union Carbide Canada Limited, Metals and Carbon Division, and Metallurg (Canada) Ltd. are the principal Canadian suppliers of ferrocolumbium.

The more important Canadian consumers of columbium and tantalum are: Ontario-Atlas Steels Limited, Welland; The William Kennedy and Sons Limited, Owen Sound; Dominion Foundries and Steel, Limited, Hamilton; and Canadian Westinghouse Company, Limited, Hamilton; Quebec-Shawinigan Chemicals Limited, Shawinigan.

Prices

According to E & M J Metal and Mineral Markets, late-in-the-year columbium and tantalum prices were as follows:

Columbium metal	Per lb 99 1/2%	
	Roundels	\$36.00
	Rough ingots	\$50.00
Tantalum metal	Per lb f.o.b. shipping point	
	Powder	\$30.00 to \$58.60
	Sheet	\$50.35 " \$59.18
	Rod	\$73.04 " \$80.23
Ferrocolumbium (E & M J, Dec. 8, 1960)	Per lb contained C (50-60% Cb, max. 0.40% C, max. 8% Si), ton lots, lump (2"), packed, delivered continental U.S.A.	\$ 3.45

Tariffs

	British Preferential	Most Favored Nation	General
Canada			
Columbium and tantalum ores and concentrates	free	free	free
Ferrocolumbium, ferrotantalum, ferrotantalum-columbium	"	5%	5%
Columbium metal or tantalum metal in pure form, in lumps, powder, blocks, ingots	"	15%	25%
Columbium metal or tantalum metal if in alloy form, in rods, sheet, or any semiprocess form	15%	20%	25%

United States	
Columbium and tantalum ores and concentrates	free
Columbium and tantalum metal	12 1/2%
Ductile columbium or niobium metal, ductile nonferrous alloys of columbium or niobium metal or tantalum metal, and ductile tantalum metal	40%
Ferrocolumbium, ferrotantalum, ferrotantalum-columbium	12 1/2%

PETROLEUM

D.W. Rutledge*

Production of crude petroleum reached an all-time high in 1960, being recorded as 191,892,470 barrels. This is 3.8 per cent over the highest previous output, that of 1959. In Alberta, the rate of increase slowed notably, dropping to 2.2 million barrels for the year from the 1959 increase of 16.7 million barrels. Saskatchewan's production increase of 4.5 million barrels represented a further improvement over the 2.8 million-barrel increase of 1959. In 1960, Manitoba's decline amounted to 0.3 million barrels; its 1959 decline was nearly 0.8 million. Ontario's production slightly exceeded the previous all-time record established in 1959. Output in the Northwest Territories increased appreciably. In British Columbia it increased slightly, and in New Brunswick it continued to decline.

Alberta accounted for 69.3 per cent of Canada's production (70.3 in 1959); Saskatchewan for 27.1 per cent (25.7 in 1959); Manitoba for 2.5 per cent (2.7 in 1959); and Ontario, British Columbia, the Northwest Territories, and New Brunswick for the remaining 1.1 per cent (1.3 in 1959).

The number of producing oil wells in western Canada at the end of 1960 totalled 13,156 with 8,633 in Alberta, 3,685 in Saskatchewan, 755 in Manitoba, 52 in British Columbia, and 31 in the Northwest Territories. There were 15,370 wells capable of production; thus 2,214 wells were inoperative. Many of the producing wells were operating far below capacity, and the whole of Canada's crude-oil industry was producing at less than half its capability.

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*Mineral Resources Division.

Production of Crude Oil, by Province and Field

	1960		1959	
	Barrels	$	Barrels	$
Alberta				
Pembina	39,310,358		37,056,141	
Leduc-Woodbend	13,357,643		14,598,083	
Redwater	12,560,447		15,112,108	
Joffre	6,184,434		6,326,789	
Fenn-Big Valley	5,466,087		6,199,976	
Bonnie Glen	5,064,747		5,951,008	
Swan Hills	4,891,302		1,794,829	
Joarcam	3,394,695		3,410,524	
Sturgeon Lake South	2,827,221		3,199,001	
Wizard Lake	2,301,274		2,719,898	
Innisfail	2,256,634		2,259,940	
Kaybob	1,976,214		1,207,622	
Acheson	1,752,445		2,056,804	
Stettler	1,613,289		1,818,549	
Golden Spike	1,516,973		1,758,758	
Harmattan East	1,477,052		1,088,098	
Gilby	1,453,785		1,204,763	
Harmattan-Elkton	1,414,660		1,845,919	
Erskine	1,262,579		1,260,449	
Turner Valley	1,207,584		1,352,518	
West Drumheller	1,179,110		1,354,822	
Sundre	1,167,919		1,129,624	
Pincher Creek	1,019,282		797,459	
Other fields and pools	18,209,483		14,463,630	
Total	132,865,217[1]	308,277,187[1]	129,967,312	306,917,803
Saskatchewan				
Weyburn	10,687,067		5,763,487	
Steelman	8,460,855		11,247,528	
Dollard	4,034,094		4,095,848	
Midale	3,726,019		2,312,572	
Nottingham	2,558,666		2,460,672	
Coleville-Smiley	2,269,178		2,529,797	
Fosterton	1,951,053		2,040,618	
Carnduff	1,911,670		2,505,353	
Instow	1,786,523		1,618,490	
Alida	1,584,204		1,380,502	
Success	1,400,979		1,434,348	
Queensdale	1,382,927		1,070,029	
Hastings	1,204,697		791,217	
Alameda	1,147,802		1,142,320	
Parkman	1,085,381		354,276	
Other fields and pools	6,817,313		6,695,441	
Total	51,908,428	103,957,009	47,442,498	97,731,546

Production of Crude Oil, by Province and Field (cont'd)

	1960		1959	
	Barrels	$	Barrels	$
Manitoba				
Virden-Roselea	1,314,713		1,318,713	
North Virden-Scallion	1,768,452		1,930,505	
Other fields and pools	1,680,880		1,806,857	
Total	4,764,045	10,690,384	5,056,075	11,619,872
Ontario	1,005,030	3,150,065	1,001,580	3,194,000
British Columbia	867,057	1,626,590	866,234	1,583,129
Northwest Territories	468,545	641,219	430,319	1,025,914
New Brunswick	14,148	19,807	14,479	20,271
Total, Canada	191,892,470[1]	428,362,261[1]	184,778,497	422,092,535

Source: Dominion Bureau of Statistics.
(1) Includes Alberta field condensate amounting to 2,358,249 barrels valued at $5,435,764.

Reserves

Reserves of crude oil in Canada at the end of 1960 were listed by the Canadian Petroleum Association as 3,678,542,000 barrels, or 181,418,000 barrels more than the 1959 year-end total. If the 1960 production (CPA figure) is included, the over-all increase is 372,522,000 barrels. Of this quantity, 350,478,000 barrels were added through the 1960 extension of established fields and the year's revision of known reserves; the addition of 22,044,000 barrels resulted from discoveries in new fields and from new oil pools.

Crude-oil Reserves

Province	At End of 1960 ('000 barrels)	% of Total	1960 Additions ('000 barrels)
Alberta	3,051,192	83.0	284,201
Saskatchewan	502,078	13.6	58,398
Northwest Territories	51,498	1.4	-
British Columbia	44,956	1.2	26,424
Manitoba	20,750	0.6	2,446
Eastern Canada	8,068	0.2	1,053
Total, Canada	3,678,542	100.0	372,522

Source: Canadian Petroleum Association.

Crude Oil - Production, Trade and Consumption, 1948-60
(barrels)

	Production	Imports	Exports	Consumption(1)		
				Domestic(2)	Imported (3)	Total
1948	12,286,660	75,535,943	-	11,941,677	75,463,113	87,404,790
1949	21,305,348	73,934,543	-	20,032,098	76,186,071	96,218,169
1950	29,043,788	78,648,571	-	26,666,376	82,476,476	109,142,852
1951	47,615,534	83,283,171	341,780	47,185,925	83,139,573	130,325,498
1952	61,237,322	81,199,086	1,424,456	58,894,631	82,467,322	141,361,953
1953	80,898,897	79,477,343	2,507,314	69,345,587	81,406,110	150,751,697
1954	96,080,345	78,771,914	2,344,948	92,679,819	76,773,031	169,452,850
1955	129,440,247	86,678,057	14,833,971	105,050,563	86,751,128	191,801,691
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	191,892,470*	125,559,631	42,234,937	149,259,745	126,824,208	276,083,953

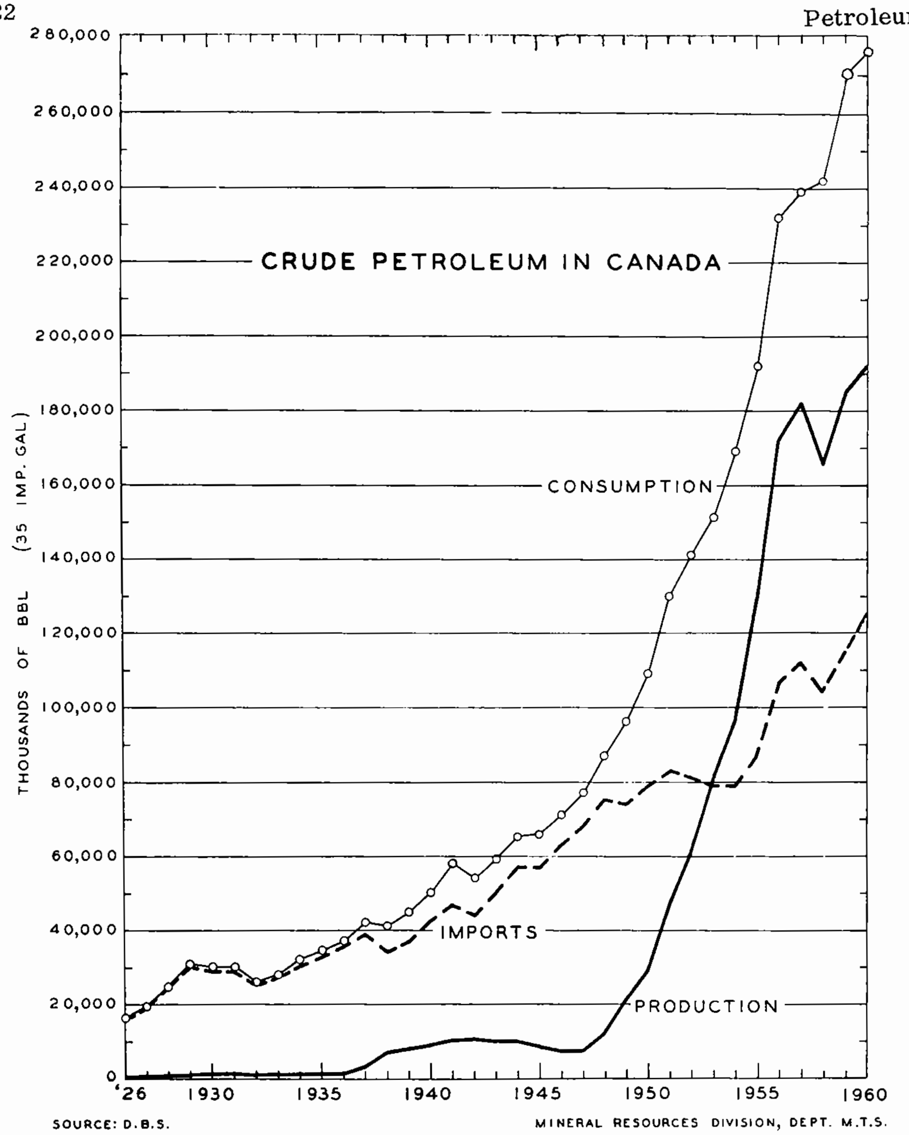
Source: Dominion Bureau of Statistics.

(1) For 1948-50 inclusive - as reported in Petroleum Products Industry (DBS); for 1951- inclusive - receipts at refineries as reported in Refined Petroleum Products (DBS).

(2) 'Domestic' includes crude naphtha and absorption gasoline to 1950 only.

(3) 'Imported' includes reduced crude for all years.

* Includes 2,358,249 barrels of Alberta field condensate.



The picture of the liquid-hydrocarbon reserves is not complete unless, in addition to the crude-oil total, it includes the liquids often obtained in the production of natural gas. The large increase expected in natural-gas output will bring these liquids into competition for an increasingly important share of the crude-oil market. Natural-gas liquids generally include propane, butane, and pentanes plus, and a mixture of these is called 'condensate.' Alberta has 90.1 per cent of Canada's reserves of natural-gas liquids, British Columbia 6.1 per cent, and Saskatchewan 3.8 per cent. These liquids make up 42 per cent of British Columbia's liquid-hydrocarbon reserves. In 1960, the liquid-hydrocarbon reserves of the whole of Canada increased by 5.5 per cent.

Liquid-hydrocarbon Reserves at End of 1960
('000 barrels)

	Natural-gas Liquids (N.G.L.)	Crude Oil plus N.G.L.
Alberta	485,066	3,536,258
Saskatchewan	20,473	522,551
British Columbia	32,982	77,938
Other areas	-	80,316
Total, Canada	538,521	4,217,063

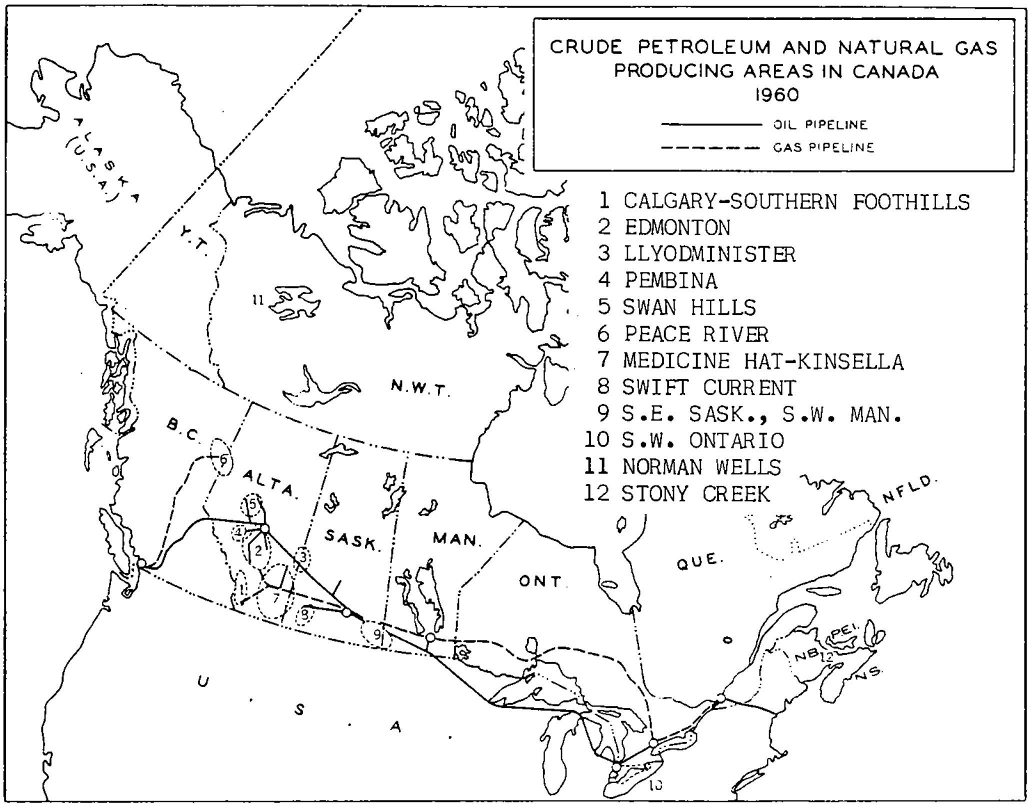
Source: Canadian Petroleum Association.

Exploration and Development

At the end of 1960, petroleum and natural-gas land holdings in western Canada totalled more than 256 million acres, slightly less than at the end of 1959. Of these, 73 million acres were in Alberta, 21.3 million in Saskatchewan, 38.5 million in British Columbia, and 3.2 million in Manitoba. Of the 120 million acres in Yukon Territory and the Northwest Territories, 47 million were in the Arctic Islands. The decrease in land holdings in all provinces was largely compensated by the gain in land holdings in the Arctic Islands, which came under the control of new permit regulations.

The downtrend in geophysical activity that began in 1953 in western Canada continued through 1960. The most common type of survey, the seismic, declined 16 per cent in crew-months. The trend of movement in geophysical surveys was northwestward: Saskatchewan had a 49-per-cent decline in the number of seismic-survey crew-months, while Yukon Territory and the Northwest Territories had an increase of 88 per cent in the number of crew-months worked on the mainland. Seismic crew-months in British Columbia remained about the same, but a 19-per-cent decline occurred in Alberta. Geophysical activity in Manitoba was negligible.

A compilation by the Canadian Petroleum Association shows the number of successful exploratory oil wells drilled in western Canada to have decreased in 1960 by 27 per cent - to 102 from the 1959 total of 140. In addition, there were 147 successful exploratory gas wells. The number of unsuccessful exploratory wells, including those drilled in the search for natural gas, was 568. These figures indicate that in 1960 exploratory drilling was 31 per cent successful. In 1959 the success ratio was 30 per cent. An increase from 4,920 feet in 1959 to 5,357 feet in 1960 in the average depth of exploratory wells in western Canada reflected a proportional increase in deep-strata drilling in the northwestern regions. In eastern Canada, more than 13 per cent of exploratory holes were successful, but these were predominantly gas wells. The trend there was toward deeper wells also, the average depth of exploratory holes being 2,014 feet.



MINERAL RESOURCES DIVISION, DEPT. M.T.S.

Wells* Drilled to Completion - Western Canada

	Oil Wells		Gas Wells		Dry and Abandoned Holes		Total	
	1960	1959	1960	1959	1960	1959	1960	1959
Alberta	985	877	276	242	443	456	1,704	1,575
Saskatchewan	444	519	10	9	161	294	615	822
Manitoba	52	29	-	-	14	16	66	45
British Columbia	47	20	37	44	65	46	149	110
Northwest Territories	-	-	2	-	31	8	33	8
Total	1,528	1,445	325	295	714	820	2,567	2,560

Source: Provincial government reports and Department of Northern Affairs and National Resources.

*Service wells are excluded.

Oil Wells in Western Canada at End of 1960

	Producing Wells			Wells Capable of Production		
	1960	1959	1958	1960	1959	1958
Alberta	8,633	8,281	7,811	9,878	9,217	8,536
Saskatchewan	3,685	3,445	2,961	4,435	4,090	3,655
Manitoba	755	730	736	893	876	877
British Columbia	52	37	29	104	59	39
Northwest Territories	31	29	22	60	62	38
Total	13,156	12,522	11,559	15,370	14,304	13,145

Source: Provincial government reports and Department of Northern Affairs and National Resources.

Development, by Areas

Alberta

In 1960, as in 1959, the most significant exploratory and development drilling for oil was 125 miles northwest of Edmonton, in the Swan Hills area. The Judy Creek West field, discovered in September 1959, was enlarged in 1960 by the addition of six new oil wells. Important extensions were made to the main fields of the area - Swan Hills, Judy Creek, Virginia Hills, and Carson Creek North. A high success ratio was maintained in drilling operations. In the Swan Hills field, the number of oil wells capable of production at the end of the year was 244; for the previous year-end it was 92. In the adjacent Judy Creek field the wells capable of production increased from 12 to 72. The five main oil fields of the area, all producing from the Devonian Beaverhill Lake formation, now have proven recoverable reserves nearly as large as those of the Pembina, Canada's largest oil field. The Pembina field, in a far more advanced state of development, had 2,790 oil wells capable of production and was thus by far the biggest field in terms of the number of wells. Of this total, 210 were added in 1960, when the provincial total of new oil wells capable of production was 661. The Swan Hills field ranked second in new producers, with 152 additions. The Pembina and Swan Hills fields alone brought in 55 per cent of the new oil wells capable of production.

Also highlighted by development and exploration was the Crossfield area, 30 miles north of Calgary, along the section known as 'Cardium Alley.' Rapid extension of the producing zone of the Upper Cretaceous Cardium formation was brought about by the net addition of 75 oil wells. Because of this, the Crossfield field ranked third for 1960 from the standpoint of increase in the number of oil wells capable of production. The deep Simonette field, whose producing horizon is between 11,000 and 12,000 feet, was extended northeastward by Shell Simonette 4-16-63-25, which found the thickest Devonian D-3 pay zone yet, one totalling 311 feet.

Exploratory drilling resulted in no new major oil fields, but several discoveries are noteworthy. At the end of the year, a significant Foothills discovery of light-gravity oil was made in the Mississippian limestone in the Waterton field, southwest of Pincher Creek. The well, Shell 12 Waterton 7-5, found oil at an initial flow of 2,100 barrels a day, thereby causing concern lest production from the gas-cap should result in a loss of gas-drive pressure on the oil column. In central Alberta, the Great Plains B.A. Lousana 16-19 well found oil in the Devonian Nisku (D-2), 7 miles west of the Fenn-Big Valley field. Another well, 6 miles northeast of the first, also discovered oil in the Nisku horizon.

The footage of initial well completions, including that of oil, gas, and abandoned wells, totalled 10,149,097 feet, or 15 per cent more than in the previous year. The obtainment of this footage despite an increase of only 8 per cent in the number of wells drilled indicates the trend toward deeper drilling. In the distribution of oil wells drilled in the western provinces, Alberta gained a larger share, up by 3.5 per cent to 64.5 per cent of the total, largely at the expense of Saskatchewan, which saw a sharp drop in drilling activity.

Saskatchewan

There were 444 oil-well completions in Saskatchewan in 1960, compared with 519 completions in 1959. The footage drilled, excluding that of service wells, totalled 2,331,466 feet, or 28 per cent less. Exploratory footage constituted only 24 per cent of the total, while in 1959 it made up 32 per cent. There was a 47-per-cent decline in the exploratory footage drilled. No major fields were discovered. The Kissinger Carievale 9-19 discovery in the extreme southeastern corner of the province resulted in a small oil field producing from a Mississippian formation. The Colorado Whitebear 2-16 and subsequent wells, just northwest of the Parkman field, made a notable extension to that producing area.

Showing a decline for the third successive year, development-drilling footage in Saskatchewan was 19 per cent less than in 1959. In the southeastern part of the province, the most important development drilling was in the Weyburn, Midale, and Parkman fields, the first two of which had been virtually merged by step-out drilling. When the year ended, the Weyburn and Midale fields had 134 more oil wells capable of production than at the end of 1959. In the Parkman field the net increase was 41 wells. In western Saskatchewan, the main development took place in the Dodsland field, which was expanded by 36 oil wells. Other fields with notable net increases in the number of wells capable of production were: Steelman, 27; Carnduff, 24; Hastings, 24; and Coleville-Smiley, 22.

Manitoba

Exploratory drilling continued to decline, the number of wells drilled during 1960 totalling 13, or 24 per cent fewer than in the preceding year. No new fields were discovered. The most important discovery was the Paradise E. Scallion 3-7 well, 1 mile north of the limits of the Virden-Roselea field.

With the drilling of 53 wells, development drilling in the province was nearly double its 1959 total. Development, centred mainly in the Virden-Roselea area, was related to the discovery referred to in the preceding paragraph. The total footage, both development and exploratory, rose from 104,819 feet in 1959 to 144,095 feet in 1960. The average well depth was 2,183 feet.

British Columbia

Exploration remained concentrated in the northeast. The rate of natural-gas discovery continued high, oil discoveries being of comparatively minor importance. Triassic oil was found 4 miles southeast of the Milligan Creek field by well Union H.B. Wildmint D-46-A and just east of the same field by Union H.B. Woodrush D-74-H. Nine successful exploratory oil wells were drilled, six more than in 1959.

Most of the development drilling was done in the Boundary Lake and Peejay fields. The Boundary Lake field, with 62 wells capable of production at the end of the year, gained 34 wells during 1960. The province had 104 oil wells capable of being operated. Development-drilling footage amounted to 294,120 feet, and exploratory footage was 472,478 feet.

Yukon and Northwest Territories

No important oil discoveries were made in 1960, although there was one significant natural-gas discovery. The success ratio was thus very low, 33 wells having been completed. One of these had found gas and some oil in 1959.

Eastern Canada

The smallness of the oil fields and reserves of eastern Canada makes this region relatively unimportant in terms of the volume of petroleum produced, which amounts only to about half of 1 per cent of the whole Canadian output. Commercial quantities were discovered and produced in eastern Canada, however, long before discovery and production in western Canada, production statistics having been recorded in southwestern Ontario as early as 1862. Oil discoveries are still being made in a comparatively small productive area, and Ontario's 1960 output set an all-time record.

Exploratory drilling in Ontario brought two oil and 11 gas discoveries, one of the oil discoveries being Devonian and the other Silurian. Of 94 exploratory wells, 81 were dry. Nine wells were drilled on offshore tests in Lake Erie. The rates of flow in the two oil discoveries were very small by comparison with those of many wells in western Canada. Development drilling resulted in the completion of 172 wells. Oil was found in 47, and 44 were dry. One development well in the gas-producing Gobles field, in Blenheim township, Oxford county, discovered a significant oil zone in Upper Cambrian sandstone.

In Quebec, where five wells were drilled, a negligible quantity of oil was recovered from a well drilled on the Gaspé Peninsula. In New Brunswick, two wells whose combined depths amounted to more than 13,000 feet failed to find oil or suitable reservoir beds. A well put down nearly 10,000 feet on Nova Scotia's Cape Breton Island disclosed no signs of oil. Because of the lack of success in petroleum-drilling operations, exploratory drilling in the Maritimes has been suspended.

Pipelines

The principal components of Canada's oil-pipeline network are the systems of Interprovincial Pipe Line Company, which delivers crude oil to eastern Canada, and those of Trans Mountain Oil Pipe Line Company, which serves the west coast. These two operate 2,674 miles of oil pipeline, or about 32 per cent of the total mileage in Canada. Thirty-six other pipeline companies gather and distribute crude oil to the Interprovincial and Trans Mountain pipelines and refineries in the western provinces. The following table gives year-to-year figures on the oil-pipeline mileage in Canada. In addition, extensions of Canadian pipelines into the United States totalled 1,360 miles at the end of 1960. These extensions were used exclusively to carry Canadian crude oil.

Crude-Oil and Products Pipeline Mileage in Canada

Year-end	Miles	Year-end	Miles
1950	1,423	1955	5,079
1951	1,577	1956	6,051
1952	2,500	1957	6,873
1953	3,794	1958	7,148
1954	4,656	1959	7,945
		1960	8,435

Source: Dominion Bureau of Statistics.

From the end of 1951 to the end of 1957, oil-pipeline additions averaged nearly 900 miles a year. Later pipeline growth has been slower because the major systems' essential parts, which lie in the southern sections of the provinces, have been completed. The pipeline added in 1960, apart from extensive additions in the Pembina field and the fields of southeastern Saskatchewan, was chiefly in the more recently developed northern fields, such as those of northeastern British Columbia and the Swan Hills and Simonette areas of Alberta. About 65 per cent of the 460 miles of new oil pipeline was built in Alberta, and most of the rest was shared nearly equally between Saskatchewan and British Columbia.

Interprovincial Pipe Line Company

Canada's longest oil pipeline, the Interprovincial, extends from the Redwater field, 29 miles northeast of Edmonton, to Port Credit, near Toronto. It includes the line of Lakehead Pipe Line Company,Inc., Interprovincial's wholly owned subsidiary in the United States, through which the crude oil passes from Manitoba's southern border to Sarnia, Ontario. The system serves refineries located at the following places: Saskatoon, Moose Jaw, and Regina, in Saskatchewan; Winnipeg and Brandon, in Manitoba; Sarnia, Port Credit, Clarkson, and Bronte, in Ontario; Wrenshall and St. Paul, in Minnesota; Superior, Wisconsin; Bay City, West Branch, and Trenton, in Michigan. Late in the year an important new market area came to be served in Toledo, Ohio, through deliveries to the Buckeye Pipe Line Company at Sarnia. Another significant development that took place late in 1960, was Interprovincial's successful pipeline delivery to Michigan and Ontario of a mixture of Alberta natural-gas liquids and crude oil.

Deliveries totalling 127.9 million barrels made 1960 the company's best throughput year. The line normally carries about 4 million barrels of pipeline fill. It reaches its maximum capacity, 434,000 barrels a day, in the vicinity of Gretna, Manitoba. Interprovincial's deliveries are shown in the following table.

Deliveries of Crude Oil
(millions of barrels)

Destination	1960	1959
Western Canada	34.2	32.7
United States	23.0	20.3
Superior (for tankers)	0.9	-
Ontario	69.8	69.9
Total	127.9	122.9

Source: Interprovincial Pipe Line Company, annual report, 1960.

Trans Mountain Oil Pipe Line Company

The 718-mile Trans Mountain pipeline carries crude oil from Edmonton to Vancouver. An extension in the United States moves oil into the State of Washington, to refineries at Ferndale and Anacortes. In addition to receiving crude oil from feeder lines in the Edmonton area, the pipeline takes on condensate near Edson, Alberta. The condensate is delivered from the Windfall area by the pipeline of Hudson's Bay Oil and Gas Company Limited.

In 1960, deliveries increased 15 per cent, most of the increase going to refineries in the State of Washington. In 1959, Washington refineries took 37 per cent of Trans Mountain's deliveries; in 1960, they took 44 per cent. The following table shows Trans Mountain's deliveries.

Deliveries of Crude Oil
(millions of barrels)

Destination	1960	1959
British Columbia	23.3	22.6
State of Washington	18.1	13.3
Tankers	-	-
Total	41.4	35.9

Source: Trans Mountain Oil Pipe Line Company, annual report, 1960.

Other Oil Pipelines

In Alberta, Federated Pipelines Ltd. added 79 miles of 16-inch main-line loop to its line from Swan Hills to Edmonton and extended its gathering system to the Judy Creek West, Carson Creek North, and Deer Mountain fields. Pembina Pipe Line Ltd. added 65 miles to its gathering lines, mainly in the Pembina field. Peace River Oil Pipe Line Co. Ltd. built 44 miles of 8-inch line to join the Simonette field with the main Peace River pipeline. In south-eastern Saskatchewan, Producers Pipelines Ltd. added 77 miles of gathering line to its system. The first oil pipeline in northeastern British Columbia was installed in 1960 by Trans-Prairie Pipelines, Ltd. Part of the 79 miles completed serves the Boundary Lake field, delivering crude to a small refinery at Fort St. John.

Petroleum-refining

At the end of 1960 there were 44 operating refineries in Canada - four more than in the previous year. Two of the new plants, designed to treat natural-gas condensate as well as crude oil, are in western Canada. The other two are in eastern Canada. At Taylor, British Columbia, Pacific Petroleums Ltd. added a 2,000-barrel-a-day crude-distillation unit to the facilities that had already been installed to treat condensate from the adjoining natural-gas-scrubbing plant. Catalytic cracking and catalytic reforming units were also added. Near Innisfail, Alberta, Canadian Oil Companies, Limited, completed a 4,500-barrel-a-day refinery designed to treat a feed of crude oil and natural-gas condensate. The plants in eastern Canada were much larger, and both were designed to treat foreign crudes. In May, the 47,500-barrel-a-day refinery of Irving Refining Limited, at Saint John, New Brunswick, and the 26,000-barrel-a-day plant of BP Refinery Canada Limited, at Montreal, were put on stream.

Crude-oil-refining Capacity, by Regions

	1945		1955		1960	
	Bbl/Day	%	Bbl/Day	%	Bbl/Day	%
Maritimes	34,250	14.8	18,300	3.0	96,800	10.2
Quebec	59,000	25.5	210,000	34.0	297,000	31.3
Ontario	75,450	32.6	148,800	24.0	260,820	27.4
Prairies and Northwest Territories	41,515	18.0	174,850	28.3	196,940	20.7
British Columbia	21,000	9.1	66,500	10.7	98,700	10.4
Total, Canada	231,215	100.0	618,450	100.0	950,260	100.0

Source: Company correspondence.

Canadian Crude Oil as Percentage of Refinery Receipts, by Regions

	1940	1945	1950	1955	1958	1959	1960
Maritimes	0	0	0	0	0	0	0
Quebec	0	0	0	0	0	0	0
Ontario	1.2	0.5	1	78.8	93.7	96.8	95.2
Prairies and Northwest Territories	92.3	58.2	99	100	100	100	100
British Columbia	0	0	0	100	100	100	100
Total, Canada	16.4	11.7	24.4	54.7	55.6	56.6	54.1

Source: Calculations based on figures published by the Dominion Bureau of Statistics.

Marketing and Trade

At Canadian refineries, the receipts of crude oil from domestic fields decreased by 2.25 million barrels, or 1.5 per cent, while the receipts of imported crude increased by 10.48 million barrels, or 9.0 per cent. The increase in the imports of crude petroleum was partly offset by a decrease in the volume of refined-petroleum products imported, which were recorded as having dropped by 3.64 million barrels, or 9.1 per cent, to 35.18 million barrels. The increase in the imports of crude and the decrease in those of refined products were due largely to the operation of the two new refineries in eastern Canada.

The amount of crude oil received at refineries in Quebec and the Maritimes in 1960, all of which was imported, increased by 8.1 per cent. The only other province to record a large increase in crude-oil-refinery receipts was Manitoba, which gained by 3.20 million barrels, or nearly 40 per cent. Alberta recorded a decrease of 5.19 million barrels, equivalent to 18 per cent of the receipts of 1959. Saskatchewan's refinery receipts declined 3.6 per cent; Ontario's increased 1.3 per cent; British Columbia's increased 3.3 per cent. Ontario imported only 3.65 million barrels of foreign crude, but received 25 million barrels of refined petroleum products from Quebec refineries, all extracted from foreign crude.

The countries of origin of imported crude oil are shown in the table below. Venezuela held its position as the chief supplier of imported crude, providing 1.24 million barrels less than in 1959. The Middle East countries of Saudi Arabia, Kuwait, and Iran supplied most of the increase of imports, providing 12.21 million barrels more than they, together with Iraq, provided in 1959. The relatively small imports of crude oil from Trinidad and the United States decreased in 1960.

Crude Oil Received at Canadian Refineries, 1960
(barrels)

Country of Origin	Location of Refineries				Total, Canada
	Maritimes and Quebec	Ontario	Prairies and Northwest Territories	British Columbia	
Canada	-	72,100,463	53,101,900	24,057,382	149,259,745
United States	-	172,657	-	-	172,657
Middle East	50,424,877	-	-	-	50,424,877
Trinidad	1,730,970	1,170,371	-	-	2,901,341
Venezuela	71,017,228	2,308,105	-	-	73,325,333
Total imported	123,173,075	3,651,133	-	-	126,824,208
Total received	123,173,075	75,751,596	53,101,900	24,057,382	276,083,953

Source: Dominion Bureau of Statistics, "Ref. Pet. Products, 1960".

Imports of the main petroleum products for 1959 and 1960 are listed in the following table. Among the more notable changes were the sharp decreases in the imports of motor and aviation gasoline, the changes in the former being due mainly to an increase in refining capacity on the east coast and those in the latter partly to an increase in the use of long-range jet and turbo-prop aircraft.

Imports of Refined Petroleum Products
(millions of barrels)

	1960	1959
Heavy fuel oil	13.44	12.43
Light fuel oil	6.98	8.91
Stove oil	3.67	5.47
Motor gasoline	0.89	2.72
Aviation gasoline	1.74	2.83
Diesel fuel	2.69	1.63
Lubricating oil	1.17	1.17
Petroleum coke	1.94	1.51

Source: Dominion Bureau of Statistics.

All the crude oil exported went to the north-central and northwestern United States. For Canadian crude-oil producers, a substantial increase in the exports of crude more than compensated for the loss of some of the domestic market. Exports increased from 33.4 million barrels in 1959 to 42.2 million in 1960. The United States Great Lakes region received 56 per cent of these exports, and the Puget Sound area took the remainder.

There is no tariff on crude oil entering Canada. There is a United States import tax of 5 1/4 cents a barrel on Canadian crude oil testing under 25° A.P.I. gravity and 10 1/2 cents a barrel on oil testing at or above that gravity.

Regional Consumption of Petroleum Products - Net Sales, 1960
(barrels)

	Motor Gasoline	Kerosene, Stove Oil, Tractor Fuel	Diesel Oil	Light Fuel Oils 2 and 3	Heavy Fuel Oils 4, 5, and 6
Newfoundland	1,029,537	798,428	956,139	872,353	2,139,501
Maritimes	6,648,581	2,156,953	2,091,116	4,729,007	6,814,917
Quebec	20,929,038	5,954,663	5,675,945	15,926,223	19,022,200
Ontario	37,661,334	4,529,770	5,356,683	29,699,544	12,310,485
Manitoba	5,409,528	174,029	1,609,152	2,942,518	1,500,111
Saskatchewan	8,106,432	384,812	2,342,256	2,483,733	1,383,101
Alberta and Northwest Territories	11,116,959	276,580	3,878,543	1,340,937	832,661
British Columbia and Yukon Territory	9,468,445	2,070,472	3,792,945	3,985,978	6,004,498
Total, Canada	100,369,854	16,345,707	25,702,779	61,980,293	50,007,474

Source: Dominion Bureau of Statistics, Refined Petroleum Products, 1960.

Supply and Demand - All Oils

(barrels)

	1960	1959
Supply		
Production		
Crude oil (Incl. field condensate)	191,892,470	184,778,497
Natural gasoline and liquid petroleum gases	6,747,379	5,669,178
Total, Canada	198,639,849	190,447,675
Total, Canada, barrels per day	542,732	521,774
Imports		
Crude oil (including natural gasoline)	126,824,208	116,342,270
Refined-petroleum products	36,036,591	38,821,689
Total	162,860,799	155,163,959
Change in stock		
Crude oil	-1,022,119	+1,090,064
Refined-petroleum products	-2,814,661	-7,810,204
Total, net	-3,836,780	-6,720,140
Oils not accounted for	+1,878,589	+ 480,496
Total supply	359,542,457	338,891,494
Demand		
Exports		
Crude oil	42,234,937	33,362,234
Products	3,190,441	1,694,462
Total	45,425,378	35,056,696
Domestic sales		
Motor gasoline	100,271,514	95,883,318
Middle distillates	108,844,277	104,161,017
Heavy fuel oil	49,328,005	49,808,249
Other products	32,541,984	32,223,652
Total	290,985,780	282,076,236
Uses and losses		
Refinery	22,016,983	20,922,493
Field and pipeline	1,114,316	355,573
Total	23,131,299	21,278,066
Total demand	359,542,457	338,410,998

Source: Dominion Bureau of Statistics and provincial-government reports.

PHOSPHATE

J.E. Reeves*

Canadian production of phosphatic raw material seems improbable at present, although the record quantity of phosphate rock imported by Canada in 1960 is encouraging for the future utilization of apatite from two domestic areas. Multi-Minerals Limited considered the linking of its apatite reserves in the Nemegos area of Ontario with the excess capacity of the sulphuric-acid plant of Noranda Mines, Limited, at Cutler, Ontario; and St. Lawrence Columbium and Metals Corporation studied the possibility of producing apatite as a by-product of its new niobium (columbium) operation in the Oka area of Quebec.

Imports of phosphate rock for the fertilizer and chemical industries were considerably higher than in 1959. All of this commodity, which ranges in price from about $6 to $7 a ton, originates in the United States. Consumers in eastern Canada use Florida rock and those in western Canada rock from Montana and Idaho. Through a subsidiary, The Consolidated Mining and Smelting Company of Canada Limited operates its own mines near Garrison, Montana, and ships large quantities of phosphate rock to its fertilizer plants at Trail and Kimberley, in British Columbia.

Included in the statistics on imports of phosphate rock from the United States are sizable amounts(totalling possibly 30,000 tons) of high-priced defluorinated phosphate rock and dicalcium phosphate, which are derived from the treatment of phosphate rock and are for use as feed supplements. Their inclusion inflates the value of these imports from the United States and gives them an apparent average value of about $8.50 a ton.

The imports from Europe and Japan, averaging $50 and $65 a ton respectively, have also been especially prepared as low-fluorine feed supplements; imports from the Netherlands Antilles, at $45 a ton, are the only natural low-fluorine phosphate rock.

Electric Reduction Company of Canada, Ltd., produces elemental phosphorus from Florida phosphate rock at Varennes, Quebec, and processes the phosphorus at Buckingham, Quebec, to obtain phosphoric acid and phosphorous chemicals. A new plant, under construction in 1960 at Port Maitland, Ontario, will produce sodium tripolyphosphate. The company is actively entering the field of phosphatic fertilizers, and at this plant it will soon start to produce wet-process phosphoric acid for the manufacture of triple

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*Mineral Processing Division, Mines Branch.

Phosphate - Trade and Consumption

	1960		1959	
	Short Tons	$	Short Tons	$
Imports				
Phosphate rock*				
United States	935,745	7,999,906	790,878	7,125,909
Belgium and Luxembourg	3,326	168,282	5,446	298,152
Netherlands Antilles	1,825	81,975	-	-
Japan	1,102	69,966	739	44,307
Total	941,998	8,320,129	797,063	7,468,368
Phosphate fertilizers				
Triple superphosphate				
United States	83,142	3,925,911	63,828	2,861,567
Belgium	-	-	500	23,741
Total	83,142	3,925,911	64,328	2,885,308
Superphosphate not otherwise provided				
United States	117,382	2,145,433	142,143	2,605,896
Netherlands	2,307	32,924	-	-
Total	119,689	2,178,357	142,143	2,605,896
Phosphate fertilizer not otherwise provided				
Tunisia	4,375	32,356	-	-
United States	1,868	203,533	3,985	273,386
Total	6,243	235,889	3,985	273,386
Total, phosphate fertilizers	209,074	6,340,157	210,456	5,764,590
Phosphoric acid and phosphorous compounds	5,816	1,212,474	5,886	1,181,075
Exports				
Phosphate-nitrogen fertilizers				
United States		18,965,467		20,156,947
India		826,845		-
Colombia		644,660		1,561,537
Korea		296,545		510,864
Guatemala		81,212		135,391
Philippines		39,276		162,169
Other countries		48,850		367,203
Total		20,902,855		22,894,111

Phosphate - Trade and Consumption (cont'd)

	1960		1959	
	Short Tons	$	Short Tons	$
Consumption of phosphate rock (available data)				
Fertilizers*.............	729,106		656,044	
Industrial phosphates	130,000(e)		130,000(e)	
Total..................	859,106		786,044	

Source: Dominion Bureau of Statistics.

* Includes some defluorinated phosphate rock and dicalcium phosphate for use as stock-feed supplements. Includes, also, a small amount of phosphate rock used in pig-iron production.

(e) Estimated.

Phosphate Rock - Production, Imports and Consumption, 1950-60
(short tons)

	Production	Imports	Consumption
1950	129	491,026	488,237
1951	6	499,711	519,143
1952	-	470,913	511,757
1953	-	576,500	512,090
1954	-	644,860	628,061
1955	-	588,209	585,326
1956	-	627,648	552,646
1957	-	723,220	772,715
1958	-	744,164	728,906
1959	-	797,063	786,044
1960	-	941,998	859,106

Source: Dominion Bureau of Statistics.

superphosphate, using calcined phosphate rock from Florida and sulphuric acid from the nearby newly constructed zinc-roasting plant of Sherbrooke Metallurgical Company Limited. An agreement whereby International Minerals & Chemical Corporation will supply the phosphate rock and market the fertilizer products in the United States was announced during the year. Since mid-1959, Electric Reduction Company has been producing normal superphosphate at Port Maitland, in a plant formerly owned by Dominion Fertilizers Limited.

In 1960, the imports of triple superphosphate increased appreciably, but those of normal superphosphate declined. These commodities are consumed mainly in eastern Canada. Because of lower sales to the United States and to most overseas markets, the exports of ammonium phosphate fertilizers from western Canada were notably lower than in the previous year.

Occurrences and Production

Apatite occurs commonly in relatively small, irregular, coarse-grained deposits - frequently with phlogopite and calcite - in southwestern Quebec and, to a much lesser extent, in southeastern Ontario. From 1878 to 1892 apatite-mining flourished in Canada, most of the output coming from the Buckingham area of Quebec, from a few of the larger deposits in which apatite predominated. Production declined sharply with the development of the large sedimentary deposits in Florida. Minor production continued until a few years ago, but no market now exists for small shipments.

Apatite is relatively abundant in some of the alkaline rock complexes that occur in parts of Ontario and Quebec. Near Nemegos, about 150 miles northwest of Sudbury, in northern Ontario, extensive zones contain about 20 per cent apatite, large quantities of titaniferous magnetite, and minor amounts of the niobium mineral pyrochlore. The niobium deposits in the Oka area, near Montreal, contain between 5 and 10 per cent apatite, which is potentially recoverable as a by-product in future niobium-mineral production.

Apatite also occurs on the north shore of the Saguenay River near Arvida, Quebec,as an essential constituent in titaniferous-magnetite deposits associated with anorthosite.

Some sedimentary phosphate rock occurs between Banff, Alberta, and the Crowsnest-Fernie area of southeastern British Columbia. From 1927 to 1934, The Consolidated Mining and Smelting Company investigated deposits, especially near Crowsnest, as a source of raw material for fertilizer, but these proved to be of low grade and only about 4,000 tons were shipped.

World Production

Most of the world supply of phosphate comes from sedimentary marine deposits of phosphate rock, frequently referred to as phosphorites; a little more than 10 per cent is derived from deposits of apatite and a minor amount from guano deposits.

World production of phosphate has risen considerably over the last few years as appreciation of the agricultural use of phosphorous compounds has grown and their importance in industry has increased. The United States output, which consists entirely of sedimentary phosphate rock and originates principally in Florida, amounts to 40 per cent of the total. Other major producers of sedimentary phosphate rock are Morocco, Russia, Tunisia, and the southern Pacific island of Nauru. Russia, Chile, and India produce apatite. Peru and Chile are the main guano producers. The Netherlands Antilles markets a low-fluorine phosphate rock, which is important as a raw material for stock and poultry feeds.

World Production of Phosphate, 1960

('000 short tons)

United States	19,618
Southern Morocco	8,236
Russia	7,274
Tunisia	2,316
Nauru	1,543
Algeria	648
Other countries	5,277
Total	44,912

Source: U.S. Bureau of Mines, Minerals Yearbook 1960.

Technology

The sources of phosphorus, which is essential to plant and animal life, are phosphatic raw materials. Phosphorus is supplied to plants by the addition of certain fertilizers to the soil. Superphosphate, one of the commonest of such fertilizers, has an 18- to 22-per-cent content of available P_2O_5 (phosphorus pentoxide). It is manufactured by treating phosphate rock with sulphuric acid. Triple superphosphate, produced by acidulating phosphate rock with phorphoric acid, contains 45 to 48 per cent P_2O_5 and is more important where high transportation costs are concerned. These fertilizers can be used separately or they can be blended with compounds containing nitrogen and potash to produce mixed fertilizers. Ammonium phosphate is manufactured by adding ammonia to phosphoric acid, generally wet-process acid produced by acidulating phosphate rock with sulphuric acid in much the same way as in the manufacture of superphosphate. Ammonium phosphate provides nitrogen as well as phosphorus.

High-purity elemental phosphorus is manufactured by fusing a mixture of phosphate rock, silica, and coke in an electric furnace. From this, phosphoric acid and numerous phosphorous chemicals are produced.

Canadian apatite would be generally acceptable as a phosphatic raw material if the mineral supplied could be competitive with currently imported phosphate rock and if considerable reserves were available. It is not as amenable to acid treatment as the open-textured sedimentary rock but could be acidulated if ground very fine. In furnace treatment, highly concentrated apatite would permit a smaller feed with lower temperatures and less slag than are possible with sedimentary phosphate rock.

Uses and Specifications

A large proportion of the phosphate rock used in Canada goes into the manufacture of fertilizers (a minor amount is fine-ground and applied directly to the soil). Smaller amounts are used for making phosphorus and phosphorous chemicals and feed supplements for livestock and poultry.

Phosphorous chemicals are consumed by a wide variety of industries. The main application is in the manufacture of soaps and detergents. The food-processing industry uses considerable amounts as a leavening agent in baking powders, cake mixes, etc., and in food preservatives. They are also used in water-conditioning, metal treatment, plastic- and paper-manufacturing, the synthesis of organic phosphates, and the manufacture of chemical reagents and pharmaceutical preparations, as well as in paints, stock-feed supplements, munitions and fireworks, and many other products.

Chemical analyses of phosphate rock are reported in terms of the P_2O_5 content or the B. P. L. (bone phosphate of lime), which is the tricalcium phosphate, or $Ca_3(PO_4)_2$, content (1.0 B. P. L. = 0.458 P_2O_5).

For electric-furnace use, phosphate rock should contain a minimum of about 70 per cent B. P. L. and a maximum of 1 per cent Fe_2O_3, and should be as coarse as possible to facilitate the furnace treatment. For fertilizers, it should contain about 74 to 75 per cent B. P. L. Particle size does not matter because the rock must be ground fine before further treatment.

Prices and Tariffs

According to E & M J Metal and Mineral Markets of December 29, 1960, the United States prices of Florida land-pebble phosphate rock per long ton were as follows:

% B.P.L.	f.o.b. Mine or Mill	f.o.b. Vessel
77 to 76	$8.21	$10.00
75 " 74	$7.21	$ 9.00
72 " 70	$6.21	$ 8.00
70 " 68	$5.56	$ 7.50
68 " 66	$5.16	$ 6.85

Phosphate rock enters Canada duty-free.

PLATINUM METALS

C.C. Allen*

The platinum metals are platinum, palladium, rhodium, ruthenium, iridium, and osmium. Canada's output, a by-product of the treatment of nickel-copper ores, includes all except osmium.

At 483,604 ounces, the volume of Canada's platinum-metal production was higher in 1960 than at any time since the war years of 1942 and 1945; and because of this greater volume and higher, more stable prices, the output value, which in 1959 was $16,932,438, amounted for 1960 to $28,873,508.

Canada continues to be one of the three leading producers. The other two - the Union of South Africa and the Union of Soviet Socialist Republics - do not publish production statistics. The sales of Rustenburg Platinum Mines Limited, South Africa's top-ranking producer, were down for the first seven months of the year in the United States but improved elsewhere. The company, however, increased its output so that its metal inventories would be adequate to any demand. Platinum metals make up Rustenburg's primary production; nickel and copper are its by-products. In Russia, platinum metals are obtained from the placer deposits of the Urals and as by-products from the nickel-copper operations at Norilsk, Petsamo, and Monchegorsk.

Principal World Producers, 1960
(troy ounces)

Union of South Africa	435,000(e)
Canada	483,604#
Russia	275,000(e)
Colombia	28,855
United States	23,609

Source: U.S. Bureau of Mines, Mineral Industry Surveys Report No. 68, May 26, 1961 for all countries except Canada.
(e) Estimated.
Dominion Bureau of Statistics.

Domestic Mine Production

Platinum metals occur with most nickel-copper sulphide ores and are recovered as by-products in pyrometallurgical treatment. Although the values are low, the large ore tonnages treated yield appreciable quantities. Canada's entire production comes from the Sudbury district of Ontario. British Columbia occasionally reports the by-product production of a few ounces from placer-

*Mineral Resources Division.

Platinum Metals - Production and Trade

	1960		1959	
	Troy Ounces	$	Troy Ounces	$
Production				
Platinum, palladium, rhodium, ruthenium, iridium	483,604	28,873,508	328,095	16,932,438
Exports				
Domestic origin				
Platinum metals in concentrates				
United Kingdom	374,201	14,793,907	333,749	11,652,381
Norway	19,519	860,924	15,830	598,161
United States	6,000	98,512	6,000	72,224
Japan	3,490	312,865	2,319	174,455
Cuba	30	2,520	-	-
Total	403,240	16,068,728	357,898	12,497,221
Platinum, old and scrap				
United Kingdom	388	30,838	179	11,355
United States	313	5,000	816	45,595
Total	701	35,838	995	56,950
Foreign origin(1)				
Platinum metals refined and semiprocessed				
United States	199,563	8,404,563	238,235	8,676,998
Imports				
Platinum metals, semiprocessed and manufactured				
United States		264,222		228,753
United Kingdom(2)		12,686,823		6,237,527
West Germany		375		-
Total		12,951,420		6,466,280
Platinum-crucibles				
United States		1,979,363		1,828,108
United Kingdom		2,826		452
Total		1,982,189		1,828,560

Platinum Metals - Production and Trade (cont'd)

	1960		1959	
	Troy Ounces	$	Troy Ounces	$
Imports (cont'd)				
Catalysts for refining petroleum				
United States		1,871,582		2,234,702
United Kingdom		8,194		456,144
Total		1,879,776		2,690,846

Source: Dominion Bureau of Statistics.

(1) Exports from Canada to the United States of platinum metals in a refined and semiprocessed state. They are considered exports of foreign produce since they are re-exports of imports from the United Kingdom (see the following footnote).

(2) Derived from Canadian concentrates refined and processed in the United Kingdom.

gold operations. The chemical-leaching process used at the Fort Saskatchewan, Alberta, refinery of Sherritt Gordon Mines, Limited to treat ore from Lynn Lake, Manitoba, and North Rankin Nickel Mines Limited, in the Northwest Territories, does not result in the recovery of platinum metals.

Producers in the Sudbury district are The International Nickel Company of Canada, Limited, and Falconbridge Nickel Mines, Limited. Both companies, because of the extreme demand for nickel during 1960, operated at maximum capacity.

International Nickel's 1960 deliveries of platinum metals amounted to 359,300 ounces. The 16,768,000 tons of ore milled came from the company's five Sudbury-basin mines - the Creighton, Frood-Stobie, Murray, Garson, and Levack. Proven ore reserves in the Sudbury area amounted to 265,273,000 short tons containing 7,972,800 tons of nickel and copper. Underground development work continued at the Crean Hill mine and development work began at the Clarabelle open pit and the Copper Cliff north property. Production from the Clarabelle, expected in 1961, will replace ore from the Frood open pit. The Frood ore, which is higher in platinum metals than the average ore of the Sudbury district, accounted for the record production of 1945.

Falconbridge continued to operate its six Sudbury-area mines - the Falconbridge, East, McKim, and the Hardy, Longvack, and Fecunis. At December 31, 1960, developed and indicated ore reserves totalled 46,089,100 tons averaging 1.46 per cent nickel and 0.81 per cent copper. Ore delivered to

Platinum Metals - Production and Trade, 1950-60

	Production[1]			Exports			Imports[4]
	Platinum (troy oz)	Other Platinum Metals (troy oz)	Total (troy oz)	Domestic[2] ($)	Foreign[3] ($)	Total ($)	($)
1950	124,571	148,741	273,312	11,549,811	9,650,977	21,200,788	21,339,915
1951	153,483	164,905	318,388	15,411,319	14,928,891	30,340,210	17,077,931
1952	122,317	157,407	279,724	17,609,955	12,919,157	30,529,112	17,373,023
1953	137,545	166,018	303,563	15,357,335	10,921,621	26,278,956	16,517,392
1954	154,356	189,350	343,706	16,693,716	10,936,039	27,629,755	17,784,372
1955	170,494	214,252	384,746	14,605,539	11,697,861	26,303,400	15,723,099
1956	151,357	163,451	314,808	20,571,623	14,814,488	35,386,111	19,579,826
1957	199,565	216,582	416,147	17,638,093	10,081,412	27,719,505	15,430,931
1958	146,092	154,366	300,458	15,014,321	4,893,616	19,907,937	8,641,360
1959	150,382	177,713	328,095	12,497,221	8,676,998	21,174,219	6,466,280
1960	*	*	483,604	16,068,728	8,404,563	24,473,291	12,951,420

Source: Dominion Bureau of Statistics.

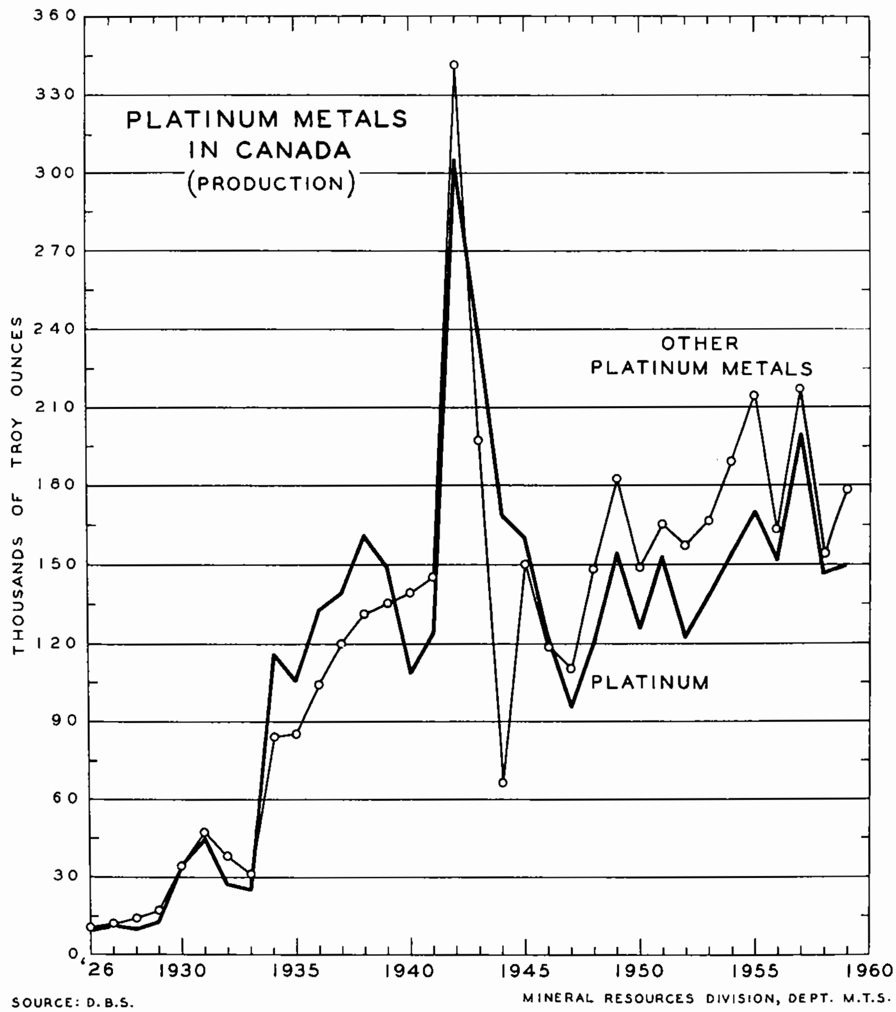
(1) Platinum metals, content of residues, concentrates, and matte shipped to the United Kingdom and Norway for treatment. From 1950 to 1952 inclusive small quantities of alluvial platinum are included.

(2) Value of platinum metals in concentrates exported for treatment.

(3) Exports of platinum metals, refined and semiprocessed. These are considered exports of foreign produce, since they are essentially re-exports of platinum metals from the United Kingdom.

(4) These are largely imports from the United Kingdom of refined and semiprocessed platinum metals derived from Canadian concentrates and residues shipped to the United Kingdom for treatment.

* Breakdown not available.



treatment plants from company mines during the year totalled 2,429,803 tons. Shaft-sinking at the large Strathcona deposit was scheduled to start in 1961, and production from the Boundary and Onaping mines was to begin early in the same year. Falconbridge made preparations for shaft-sinking at the property of Marbridge Mines Limited, in La Motte township, Quebec. Production there has been scheduled for January 1963 at a minimum rate of 300 tons of ore a day.

Production from International Nickel's large deposit at Thompson, in northern Manitoba, began in February 1961. Small quantities of platinum metals are present in the deposit in association with the nickel-copper ore, the palladium content approaching the Sudbury average, that of the other platinum metals being much lower. The residue of precious metals is to be further processed at the refinery at Copper Cliff, Ontario. Final treatment and recovery are to take place at Acton, England. Proven ore reserves at Thompson are given as 25 million tons with a nickel-copper content of 742,500 tons.

Encouraging results in nickel-copper are also being obtained by Nickel Mining & Smelting Corporation and National Malartic Gold Mines Limited. At the Nickel Mining & Smelting property at Gordon Lake, 55 miles northwest of Kenora, Ontario, new ground is being explored from the winze extending from the 1,200- to the 1,650-foot level. Consolidated Marbenor Mines Limited and National Malartic are exploring a jointly owned property some 40 miles southwest of Thompson near Wabowden, Manitoba. Information on the platinum-metals content has not been released.

Consumption and Uses

About 90 per cent of the 1 million ounces of platinum metals produced in the world every year is marketed in the United States, which uses it in industry and re-exports some in manufactured form. The platinum metals sold in the United States during the first nine months of 1960 amounted to 577,000 ounces; for the same period of 1959 sales totalled 558,000 ounces.

The 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 consumed. Iridium, osmium, ruthenium, and rhodium are used mainly as alloying elements to modify properties of platinum and palladium. Rhodium is also used extensively in rhodium plating.

Platinum is used in the chemical, electrical, and jewelry industries. It finds its greatest scope in the chemical industry, primarily as a catalyst that is particularly applicable in petroleum-refining. A stable 'DNS' platinum-plating solution recently developed provides a bath of consistent and reliable performance and readily leaves bright, lustrous deposits that require no polishing and may be as thick as 0.001 inch. An improvement in the handling of corrosive chemicals is the use of platinum-clad stainless steel to make crucibles and other types of laboratory equipment that are four times as strong as those of pure platinum and cost only about one sixth as much.

Palladium is used mainly in the electrical industry. It provides points and contacts that are highly reliable at low amperages and is finding increasing application in the plating of electric circuits. Palladium is also used in the chemical and jewelry fields.

Prices

In marketing and prices, the platinum metals were more orderly in 1960 than in 1958 and 1959. The price of an ounce of platinum rose from \$77-\$80 to \$81-\$85; that of palladium from \$22-\$24 to \$24-\$26. At the end of 1960 iridium had declined by an average of \$5 an ounce, ruthenium was unchanged, and rhodium was \$15 above the prices prevailing at the beginning of the year. The price changes indicate the variations in the demand for the respective platinum metals.

The prices of platinum metals per troy ounce in the United States, according to E & M J Metal and Mineral Markets of December 29, 1960, were as follows:

Iridium	$ 70	"	$ 75	Platinum	$ 81	to	$ 85
Rhodium	$137	"	$140	Palladium	$ 24	"	$ 26
Ruthenium	$ 55	"	$ 60	Osmium	$ 70	"	$ 90

Tariffs

Canada

	British Preferential	Most Favored Nation	General
Platinum wire and platinum bars, strips, sheets, and plates; platinum, palladium, iridium, osmium, ruthenium, and rhodium, in lumps, ingots, powder, sponge, or scrap	free	free	free
Platinum crucibles	"	"	"
Platinum retorts, pans, condensers, tubing and pipe, and preparations of platinum for use in manufacture of sulphuric acid	"	"	"
Platinum and black oxide of copper, for use in manufacture of chlorates and colors	"	10%	10%

United States

Ores of platinum metals	free
Platinum, unmanufactured or in bars, ingots, plates, or sheets not less than 1/8" thick, scrap, and sponge	"
Iridium-osmium, palladium-rhodium, and ruthenium, and native combinations thereof with one another or with platinum	"
Chemical compounds, mixtures, and salts of which gold, platinum, rhodium, or silver constitutes the element of chief value.	12 1/2%

POTASH

C.M. Bartley*

Work was in progress during 1960 in three shafts in the potash area of southern Saskatchewan. At the one already sunk to the potash horizon, alterations and repairs were being carried out; at another, sinking and shaft-wall construction through the Blairmore formation by a method unique in Canada were nearing completion; at another, preparations were being made for a resumption of shaft-sinking. In addition, exploration drilling continued. One hole was drilled west of Regina to test the potash horizon and investigate a method of producing potash by solution mining.

The most significant event of the year was the installation of cast-iron tubbing through the deeply frozen Blairmore formation at the Esterhazy property of International Minerals & Chemicals Corporation (Canada) Limited. At the end of the year, enough progress had been made to show that such tubbing was a satisfactory means of penetrating this difficult formation.

The term 'potash' is derived from pot ashes, which were originally obtained by evaporating, in iron pots, solutions leached from wood ashes. Although minerals are now used almost entirely as the source, the term 'pot ashes' has been retained in its modern form, which signifies potassium-bearing compounds. The trade gives the potassium content of the various compounds in terms of the oxide (K_2O) equivalent, although K_2O does not exist in nature and is not manufactured for use.

Minerals valued for their potassium content occur almost entirely as bedded evaporite deposits in sedimentary rocks or are recovered from the brines of lakes where the mineral content of inflowing water is being concentrated by evaporation.

The more common and useful potassium-bearing minerals, their chemical formulae, and their K_2O content expressed as a percentage, are as follows:

Mineral	Formula	K_20 Equivalent as Percentage
Sylvite	KCl	63.3
Carnallite	$KCl.MgCl_2.6H_2O$	17.0
Langbeinite	$K_2SO_4.2MgSO_4$	22.6
Kainite	$KCl.MgSO_4.3H_2O$	18.9
Nitre	KNO_3	46.5

*Mineral Processing Division, Mines Branch.

Potash - Production and Imports

	1960		1959	
	Short Tons	$	Short Tons	$
Production*				
K_2O content		178,700		1,408,462
Imports				
Potash fertilizers				
Muriate of potash				
United States......	89,342	1,906,550	54,790	1,289,437
West Germany.....	28,660	732,122	18,752	482,978
France	17,150	431,545	16,269	382,548
Spain	5,952	137,113	-	-
U.S.S.R.	5,581	174,597	5,488	127,091
Total............	146,685	3,381,927	95,299	2,282,054
Sulphate of potash				
United States......	12,924	444,951	14,542	496,779
France	5,559	184,220	6,105	180,598
West Germany.....	5,461	196,715	4,095	137,634
Total............	23,944	825,886	24,742	815,011
Sulphate of potash magnesia				
United States......	5,064	68,366	4,451	72,250
West Germany.....	500	11,512	-	-
Total............	5,564	79,878	4,451	72,250
Total, potash fertilizers.........	176,193	4,287,691	124,492	3,169,315
Potash chemicals and compounds				
Potash and pearl ash	472	79,878	456	76,626
Potash, bichromate, crude.............	129	45,465	132	43,340
Potash, caustic......	4,409	449,690	4,243	428,398
Potash, chlorate, ground...........	40	10,102	43	12,590

Potash - Production and Imports (cont'd)

	1960		1959	
	Short Tons	$	Short Tons	$
Potash chemicals and compounds (cont'd)				
Potash, red or yellow prussiate...	10	7,123	8	5,884
Potash, nitrate, or saltpetre..........	741	107,975	741	104,161
Cream of tartar in crystals..........	155	86,201	190	99,958
Potassium cyanide..	68	45,684	89	59,386
Potash chemicals not otherwise provided	6,244	1,137,701	4,827	1,000,913
Total, potash chemicals and compounds	12,268	1,969,819	10,729	1,831,256

Source: Dominion Bureau of Statistics.
*Producers' shipments.

The high potassium content of sylvite makes it the most valuable of these minerals; and because of the large quantities of it they contain, the Saskatchewan deposits are among the most attractive in the world. Saskatchewan also has large quantities of carnallite but only minor amounts of other potassium minerals. The term 'sylvinite,' commonly used by potash miners, is not a mineralogical name but designates mechanical mixtures of halite and sylvite (salt and potash) that are the main constituents of the potash ore.

No potash was produced in Canada in 1960. Potash Company of America, Ltd., started production late in 1958 at its mine near Saskatoon but in-mid 1959 was forced to suspend mining to repair water leaks in the shaft. The potash shipments made in 1959 were valued at $1,408,462, and the shipments made in 1960, presumably from stock, were worth $178,700. Potash production and shipments are expected to be resumed in the latter part of 1961 or early in 1962.

The Saskatchewan Deposits

Potash occurs in three or more fairly continuous and consistent layers in the upper 200 feet of the Prairie Evaporite formation of Devonian age that underlies southern Saskatchewan and adjacent parts of Manitoba and Alberta. The Prairie Evaporite is a basin structure consisting largely of salt, which trends northwest-southeast and is tilted gently to the southwest. Portions of the salt and potash deposited in the original basin have been removed by solution, but the dissolved sections are only a small part of the basin. The main barren area is in the southern part of the province, at depths of more than 5,000 feet.

The shallowest potash occurrences are found along a line that runs approximately through Binscarth, in Manitoba, and Yorkton, Saskatoon, and Unity, in Saskatchewan. At Saskatoon, potash is about 3,300 feet below the surface; at Binscarth, the depth is less, and at Unity and southward toward Regina, it is greater.

Potash Operations in Canada

Attempts to recover potash from the Saskatchewan deposits began in 1951 when Western Potash Corporation Limited (later renamed Continental Potash Corporation Limited) tested a brining method through drill holes at its property near Unity. Although some potash was obtained, the method was not considered economically successful, and in 1953 a shaft was started.

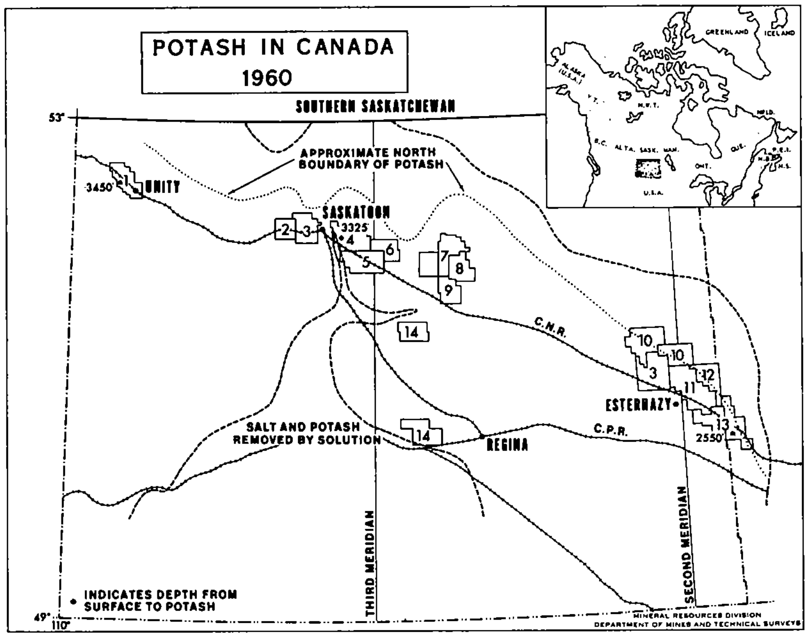
In 1960, Continental Potash Corporation Limited made changes in surface facilities, converted the top 200 feet of its shaft to a circular concrete-lined section, and deepened it from 1,675 to 1,711 feet. At the end of the year, staff and equipment were being assembled to continue sinking through the Blairmore formation by a pre-grouting method under the general direction of Soletanche and Rodio of Canada Limited, General Contractors, of Montreal.

In 1954, Potash Company of America, Ltd., started shaft-sinking at its Patience Lake property, about 15 miles east of Saskatoon. Sunk through pre-frozen ground to immobilize the wet Blairmore formation, the shaft was completed in June 1958. Underground development was begun and some potash obtained, but in mid-1959 leaks through the concrete shaft lining forced the company to stop underground work and turn its full attention to shaft-wall improvement and repair.

The Cementation Company (Canada) Limited was engaged to rehabilitate the shaft in stages from bottom to top by systematic thawing and the injection of grout. Steady progress was made throughout 1960, and it is expected that the shaft-repair program will be completed in the latter half of 1961, although the step-by-step nature of the work makes it impossible to predict the completion date with certainty.

The concentrator is designed to handle 4,000 tons of ore a day and produce 360,000 tons of K_2O annually.

International Minerals & Chemicals Corporation (Canada) Limited started shaft-sinking at its Esterhazy property in June 1957. An attempt to stabilize the Blairmore formation with a chemical grouting process was not completely successful and, after considerable difficulty and delay, was abandoned. Early in 1960 Associated Mining Construction Company, an amalgamation of four West German firms, was engaged to sink the shaft through the Blairmore. It froze the shaft area in this formation to -50° F by circulating lithium-chloride brine through a ring of freeze holes, excavated the sandy Blairmore material in short sections, and, working downward, installed a wall of cast-iron segments. The wall is made of successive rings 5 feet in height



1. Continental Potash Corporation Limited
2. National Potash Company
3. Duval Sulphur and Potash Company
4. Potash Company of America, Ltd.
5. United States Borax and Chemicals Corporation
6. Consolidated Morrison Explorations Limited
7. Alwinsal Potash of Canada Limited
8. Sturgeon Petroleums Ltd.
9. Medallion Petroleums Limited
10. Southwest Potash Corporation
11. International Minerals & Chemical Corporation (Canada) Limited
12. Canberra Oil Company Ltd.
13. Tombill Mines Limited
14. Standard Chemical Limited

and 18 feet in diameter. Each ring consists of 11 similar segments, and the segments and rings are bolted together with sheet-lead gaskets one eighth of an inch thick. This cast-iron tubbing, which extends well above and below the Blairmore, is sealed to the walls of the shaft excavation at top and bottom by blocking with special pitch-pine wedges, and the space between the tubbing and the wall is filled with concrete so that water cannot move down into it.

Below the Blairmore the formations consist mainly of limestones, and normal shaft-sinking and wall-construction practices can be employed. A multiple-decked sinking-stage will be used to speed completion of the shaft to the potash horizon, some 3,150 feet below the surface.

An initial output of 420,000 tons a year is expected at Esterhazy, and plans to double capacity are well advanced.

In addition to shaft work at the properties mentioned, considerable exploration work, such as core drilling and geological studies, was carried on in 1960. Alwinsal Potash of Canada Limited completed 10 exploration drill holes during the year on its holdings between Saskatoon and Quill Lakes.

Interest in the possibility of potash recovery by solution-mining methods has not been continuous. The attempts made by Western Potash Corporation Limited in 1951 and General Petroleums of Canada Limited in 1958 were test projects and no effort was made to operate commercially. In August 1960, however, a third project was started when Standard Chemical Limited, subsidiary of Columbia-Southern Chemical Corporation, drilled a hole about 5,100 feet to the potash horizon on its permit area northeast of Moose Jaw. The drilling of the hole to test the formation was the first step in the investigation of a potash solution-mining method. The project will continue in 1961 and, if successful, will result in the production of potash by solution mining.

Salt is recovered efficiently by solution, but the recovery of potash by this means is considerably more difficult. Both the advantages and the disadvantages of this method arise from the high solubility of these two substances. Salt often occurs in large deposits containing only minor amounts of other minerals. When it does, brining methods can be used effectively. Potash, however, is always found with salt, and it is difficult to dissolve and recover the potash without dissolving the salt at the same time. A successful method of recovering potash by brining would be valuable in Saskatchewan, particularly at depths of more than 5,000 feet; and the dip of the province's deposits may encourage the development of such a method. In the immediate future, large amounts of potash will be obtained from the shallower deposits by standard mining methods. Later, solution mining may eliminate deep expensive shafts and the recurring problems encountered in sinking them through the Blairmore formation.

At the end of December 1960, 14 companies had a total of more than 1,240,000 acres under potash disposition. These companies and their properties are shown on the accompanying map.

Production and Treatment

Most of the potash produced is derived from underground mines by methods and with equipment similar to those used in coal mines. Salt normally dilutes the mined potash ore, but above the potash layer it provides a highly satisfactory roof for mining operations, acting as a cushion and distributing pressure evenly. Being more plastic than rock, it is less likely to give way under pressure. Because of it, roof failures in potash mines are rare.

The solubility of both potash and the associated salt is the basis of many of the problems of potash mining. Shafts sunk to potash deposits must have water-tight walls to prevent surface or underground water from reaching the potash. Water leaks, if not controlled and eliminated at once, often result in the loss of both shaft and underground workings. Difficulties of this kind have been encountered in European potash mines, and various methods of solving them have been developed.

In Saskatchewan, shaft-sinking through water-bearing formations has been difficult and costly. Because the wet Blairmore formation is more than 200 feet thick and is about 1,200 feet underground, it contains large amounts of water under high pressure. For several reasons, the simpler methods of dealing with the water problem have not been effective. On the other hand, the shafts sunk into the formation, together with their cast-iron tubbing or special concrete construction, are expensive and difficult to construct, and only time and experience will make known their comparative costs and merits.

Underground mining at the Saskatchewan properties will be by mechanical mining machines and drilling and blasting. Transportation to the shafts will be by conveyor belts and shuttle cars. Ore will be loaded into skips from large underground storage bins, hoisted to the surface, and dumped into surface storage bins.

The treatment of potash ore to obtain a marketable product consists in purifying and concentrating the potash minerals by removing salt and other impurities such as muds. The ore is crushed, ground to the required fineness, and put into a saturated salt solution, and the potash minerals are recovered by wet-gravity, flotation, and precipitation methods. The basic principles of potash recovery are relatively simple but, depending on the nature of the ores and the purity and plant-efficiency requirements, the satisfactory application of the processes is often difficult.

The product is a concentrate of the potash and is usually from 96 to 98 per cent potassium chloride.

World Review

Because the potash produced in Saskatchewan will greatly exceed the national requirements, large amounts will be available for export. The full development of the Canadian potash industry will,in fact, depend largely on major exports. For this reason, the size and significance of the Canadian industry depends on other sources and markets and must be considered in relation to them.

The United States is the leading producer and consumer of potash. Trends that have prevailed since 1950 indicate that in 1970 consumption may amount to 3 million tons; and a decline in the reserves of better-grade material in the Carlsbad area of New Mexico makes it seem that considerable amounts of potash will have to be imported. A new source of potash has, however, been discovered in Utah, and the announcement made by Texas Gulf Sulphur Company in November 1960 that construction of a large-scale mining and processing operation would begin there immediately suggests that potash from this source may be available by 1963. The reserves are reported to be large, and the grade,

World Production of Potash (K_2O Equivalent), 1960
(short tons)

United States	2,638,574
West Germany	2,179,267
East Germany	1,764,000(e)
France	1,686,500(e)
Russia (U.S.S.R.)	1,212,500(e)
Spain	298,000(e)
Other countries	221,159
Total	10,000,000

Source: U.S. Minerals Yearbook, 1960.
(e) Estimated.

about 25 per cent K2O, is comparable to that of the Canadian deposits now under development. Production from this source would considerably reduce United States potash-import requirements.

Western Europe produces and consumes more potash materials than any other comparable area, and substantial additional tonnages are produced, consumed, and exported by East Germany and the Union of Soviet Socialistic Republics. In 1959, the Europe-U.S.S.R. region produced nearly 7 million short tons of an estimated world output of 9,400,000. In descending order of volume these producing countries were West Germany, East Germany, France, the U.S.S.R., and Spain, all of which export large amounts of potash materials. In 1959, the exports from East Germany, West Germany, France, and Spain totalled more than 2 million tons of K_2O and were shipped as far as Australia and Japan and to the east coast of North America. Although the resources of Europe and the U.S.S.R. are large, their average grade is lower than that of the North American deposits. Yet, because their industries are large, well-established, and efficiently operated, their mining costs lower, and their shipments made by water, they are able to compete with United States producers in the markets of eastern North America.

Potash is also produced in Italy and Israel, and minor production has been reported from Jordan, Chile, Japan, and Poland. Deposits of potash are known to exist in England, Denmark, Morocco, Ethiopia, Gabon (French Equatorial Africa), and China, but for various reasons they have yielded little or no production to date.

The present distribution of production and the location of the Canadian deposits indicate that the export outlets for Canadian potash are at present largely in the United States but that the greatest market growth of the future will be in Asia and Australasia or in South America rather than in Europe or Africa. Japan might be an early consumer and India and China later importers.

Uses and Specifications

About 95 per cent of the potash consumed is used in agriculture - usually in mixed fertilizers. Such fertilizers are combinations of nitrogen, phosphate, and potash with various fillers, and the percentages of the main ingredients, which are always listed alphabetically, are shown by three numbers - for example, 7-7-7. Most fertilizer potash is consumed as potassium chloride of various concentrations, but some crops and some soils require other forms such as potassium sulphate.

The need for chemical fertilizers is increasing as populations grow and living standards rise in the less developed countries. This is particularly true at present, when the economics of agriculture demand larger yields from smaller acreage.

Small amounts of potash are used in the manufacture of potash chemicals for industrial and consumer use. For chemical use, the concentrate supplied by mining companies is refined to high purity and made into potassium hydroxide, chlorate, carbonate, nitrate, and other compounds. These are used in the manufacture of soap, glass, textiles, matches, explosives, and a variety of consumer products and fine chemicals.

Potash for the manufacture of fertilizer is usually a 96- to 98-per-cent concentrate of potassium chloride. It is marketed in three grain sizes to meet customer requirements. For this material, physical specifications of size and uniformity are important. A concentrate of greater than 99-per-cent purity is produced for chemical purposes by removal of such impurities as iron and magnesium.

Prices

The Oil, Paint and Drug Reporter of December 26, 1960, quoted the following prices:

	(1)	(2)
Potassium muriate		
Standard		
Bulk, car lots, works, unit-ton	$ 0.35	$ 0.37
Bagged, 60% min. K_2O, same basis, per ton	$26.00	$27.20
Granular		
Bulk, car lots, works, unit-ton	$ 0.36	$ 0.38
Bagged, 60% min. K_2O, same basis, per ton	$26.60	$27.80
Potassium sulphate, min. 50% K_2O, agricultural, bulk, car lots, works, unit-ton, per lb	$ 0.67 1/2	$ 0.69 1/2

(1) The inside prices apply to material contracted for before July 1, 1960.
(2) The outside prices apply to material contracted for after July 1, 1960, but also for delivery during the current month.

Tariffs

Canada

German potash salts, muriate and sulphate of potash, saltpetre, and potash nitrate	free

United States

Crude potash salts, muriate of potash, and potassium sulphate	"

ROOFING GRANULES

F.E. Hanes*

The consumption of all types of roofing granules by manufacturers of asphalt roofing and siding products amounted in 1960 to 113,826 short tons valued at $2,962,363. The year's volume and value were thus down by 18 per cent and 29.2 per cent respectively.

The decreases resulted directly from the rate of residential construction, which month for month was less than in the preceding year. The decline began in 1959, when consumption in each of the last 10 months of the year was less than in each of the corresponding months of 1958.

In 1960, the decline in value from the all-time high of $4,509,638, established in 1958, reached its lowest point. Late in the year an upward trend became evident and, owing to National Housing Act amendments that have eased financial restrictions, it is expected to continue.

Housing starts in 1960 at 108,858 were 23 per cent lower than the record number of 141,345 in 1959.

The decline in the average price of granules, reported in last year's review as the beginning of a significant trend, continued in 1960. From the high of $31.82 a short ton, established in 1958 (on the basis of the total of granule consumption), the price average dropped in 1959 to $30.14 and in 1960 to $26.03. The lower unit price prevailing in 1960 is due partly to an increase in the use of Canadian-made granules, which are available at a lower cost than the tariff-bearing imported product. As a proportion of all the granules consumed in Canadian residential construction, Canadian-made granules rose from 28.3 per cent in 1958 to 37.1 per cent in 1959 and 44.8 per cent in 1960.

Imported, artificially colored granules, except blue and buff, were lower in value, by color group, than in 1959. The decreases varied from 16 cents to $2.66 a short ton. The most widely used imported granules were of the white and green groups, whose selling prices were respectively $2.66 and $1.85 a short ton below the 1959 level. The 1960 prices of blue and buff granules per short ton were respectively 56 cents and 74 cents higher.

The Canadian artificially colored granules available ranged in descending order of popularity from green through black, white, red, gray, and buff to blue. The gray sold at a slightly higher average price, but the prices of the granules of all other colors showed decreases ranging from $1.37 to $7.56 a short ton.

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*Mineral Processing Division, Mines Branch.

Roofing Granules - Consumption and Imports

	1960(1)		1959(2)	
	Short Tons	$	Short Tons	$
Consumption				
By kind				
Naturally colored......	36,217	672,199	29,457	613,226
Artificially colored....	77,609	2,290,164	109,301	3,569,389
Not classified.........	-	-	-	-
Total.................	113,826	2,962,363	138,758	4,182,615
By color				
Black and gray-black ..	32,722	707,249	41,451	903,277
Green...............	25,624	701,480	33,172	1,080,867
Red.................	9,569	237,146	14,410	413,908
Blue	5,214	201,787	7,916	306,300
White	17,344	593,081	23,793	923,227
Gray................	16,964	311,779	8,450	241,772
Buff	805	28,483	1,176	42,282
Brown and tan.........	3,922	115,115	6,577	202,287
Coral, cream, and yellow..............	1,121	42,296	1,813	68,695
Turquoise	462	21,105	(3)	(3)
Not classified.........	79	2,842	-	-
Total.................	113,826	2,962,363	138,758	4,182,615
Imports				
United States				
Naturally colored	24,851	507,331	26,789	570,044
Artificially colored....	38,103	1,253,044	60,459	2,052,018
Total.................	62,954	1,760,375	87,248	2,622,062

(1) Compiled from figures supplied to the Mines Branch by consumers.
(2) The consumption figures reported for 1959 represent returns from 16 of the 17 plants.
(3) Reported with green granules in 1959.

The granule-manufacturing operations of Building Products Limited have been taken over by Minnesota Minerals Limited, a subsidiary of Minnesota Mining and Manufacturing of Canada Limited. Minnesota Minerals now operates Building Products' crushing and granule-coloring plant at Havelock, Ontario, but Building Products still manufactures roofing and siding.

As a percentage of all the granules used in Canada, imports (all from the United States) have steadily decreased since 1955, when they made up 85 per cent of the value and 81.7 per cent of the volume of the year's consumption. Statistics for 1960 show imported granules accounting for 59.1 per cent of the value and 55.3 per cent of the volume.

In 1960, the consumption of black-slag granules was 21 per cent lower in volume and 19.5 per cent lower in value than in 1959, but the average price, $21.57 a short ton, was 39 cents higher. The production of black-slag granules amounted in 1960 to 20,935 short tons valued at $451,659 and in 1959 to 26,498 short tons worth $561,198. Prior to 1960-61, the black-slag granule was imported from the United States, but the slag from Canadian steam-generating plants is now being processed by a Canadian company.

Roofing-granule Plants in Canada

Canadian-made granules are manufactured in Ontario's Havelock-Madoc area and in the Montreal area. At Havelock, Minnesota Minerals Limited crushes a fine-grained, dark basalt (trap) rock for the production of artificially colored granules by the sodium-silicate process. It also produces a gray slate for naturally colored granules. A black-slag granule produced from the waste slag obtained from certain types of steam-generating plants will soon be marketed from a plant in the Montreal area.

Roofing and Siding Plants in Canada

Shingles and siding manufactured in 1960 by the application of roofing granules to an asphalt-impregnated felt base were processed in 17 plants operated by eight companies. The companies and their plants are as follows:

Company	Location
Barrett Company Limited, The	Montreal, Que. Vancouver, B.C. St. Boniface, Man.
Building Products Limited	Montreal, Que. Hamilton, Ont. Winnipeg, Man. Edmonton, Alta.
Canadian Gypsum Company Limited	Mount Dennis, Ont.
Canadian Johns-Manville Company, Limited	Asbestos, Que.
IKO Asphalt Roofing Products Limited	Calgary, Alta. Brampton, Ont.

(table continued on page 461)

Company	Location
Murray-Brantford Limited	
Brantford Roofing Company Limited	Brantford, Ont.
	Saint John, N.B.
	Lachine, Que.
Philip Carey Company Limited, The	Lennoxville, Que.
Sidney Roofing and Paper Company Limited	Burnaby, B.C.
	Lloydminster, Alta.

Some Properties of a Good Granule-base Rock

The stone must be hard enough to resist impact shattering and pulverizing during quarrying, transportation, and handling.

It must have suitable fracture characteristics to allow for size reduction while retaining particle shape. Slabby and elongate fragments are undesirable.

The base rock should be weather-resistant.

The rock should be even-textured and of fine grain.

Color constancy in the rock base is essential, particularly at temperatures that are well above the limit reached during the coloring.

A low-absorptive rock is preferred. Base rocks with high absorptivity are susceptible to structural failure and require greater quantities of covering solutions during color processing.

The lighter-colored base rocks, other qualities being favorable, give a higher degree of color constancy. Any plucking or wear that develops during the life of the product is less noticeable where light-colored base rocks have been used.

Good adhesion is essential, both for the bond between the granule and the color-covering medium and for the bond between colored (or naturally colored) granules and the asphalt-impregnated felt.

Opaque rock fragments are preferable to translucent types. The greater the opacity of the rock fragment and its color coating, the greater the protection given the asphalt. The asphalt, if overheated, will dry out and cause early cracking and disintegration.

The base rock should be free from oxidizable mineral components so that the possibility of staining will be minimized. Also, mineral grains (metallic) provide polished surfaces that lower bonding efficiency.

The source rock must be within economic hauling distance of the point of manufacture.

Canadian Prices of Artificially Colored Granules

The values of virtually all artificially colored granules consumed in 1960 were below their 1959 averages, but the general prices given in the 1959 review were based solely on color, both natural and artificial. More realisitic price averages can be obtained by classifying the granules into imported and Canadian-made.

In any given color group the prices vary considerably, and the averages shown in the accompanying table are calculated on the consumption of all the types of granules in each of the color groups indicated. What the consumer pays depends on the granule's mineralogical type, its color quality, and its durability, as well as on variable transportation costs. Tariff charges add to the cost of imported granules.

Average Prices of Artificially Colored Granules Consumed in Canada

(per short ton)

Granule Color	Imported		Domestic	
	1960	1959*	1960	1959
Red	$27.42	$29.31	$23.19	$27.92
Green	$30.88	$32.73	$28.53	$32.29
Black	$26.05	$27.34	$20.03	$22.70
Blue	$39.29	$38.73	$30.72	$38.02
White	$36.21	$38.87	$31.15	$38.71
Gray	$28.75	$30.80	$24.62	$24.44
Buff	$34.52	$33.78	$37.25	$38.62
Brown and tan	$29.35	$30.76	-	-
Coral, cream, and yellow	$37.73	$37.89	-	-

*The prices quoted in the 1959 review for imported artificially colored granules do not correspond with the average 1959 prices shown in this table. The prices in last year's review represented a medial value rather than the average now calculated on a value-volume basis. In neither instance are the values given wholly realistic, being used purely for purposes of comparison and as indicators of price trends.

SALT

R. K. Collings*

Salt is recovered from underground deposits in Canada by mining at three locations - Pugwash, Nova Scotia, and Goderich and Ojibway, Ontario - and by brining followed by evaporation at nine locations - Nappan, Nova Scotia; Goderich, Sarnia, Sandwich, Watford, and Amherstburg, Ontario; Neepawa, Manitoba; Unity, Saskatchewan; and Lindbergh, Alberta.

Salt brine for use in the manufacture of chemicals is produced from underground salt beds at Amherstburg, Sandwich, and Sarnia, Ontario, and at Duvernay, Alberta.

The salt production of 1960, at 3,314,920 short tons, was 0.8 per cent higher than that of the previous year. Its value, $19,355,658, was 7.3 per cent higher. Forty-seven per cent of the 1960 output was in the form of brine for direct use by the chemical industry. Mined rock salt represented 40 per cent of the total, and the remaining 13 per cent consisted of fine evaporated salt and salt recovered in chemical operations.

Imports dropped from 369,967 short tons in 1959 to 191,940 short tons in 1960. This decrease occurred largely because Sifto Salt Limited, having established its own rock-salt-mining operation at Goderich, Ontario, reduced its imports.

The value of salt exports, $3,461,366, was 25.4 per cent less than in 1959. Most of the salt exported was in the form of brine for use by chemical plants in the United States.

Producers**

Ontario

Ontario accounted for more than 90 per cent of Canada's salt production in 1960. The entire output was from salt beds 800 to 1,800 feet below the surface in the area between Amherstburg and Goderich, in the southwestern part of the province.

Fine salt, obtained by vacuum-pan evaporation of brine from local wells, is produced by The Canadian Salt Company Limited, at Sandwich, and by Sifto Salt Limited, a subsidiary of Dominion Tar & Chemical Company, Limited

(text continued on page 468)

**See map, Page 471

*Mineral Processing Division, Mines Branch.

Salt - Production and Trade

	1960		1959	
	Short Tons	$	Short Tons	$
Production (shipments)				
By type:				
Fine vacuum salt.........	433,538	9,195,429	459,857	8,918,231
Mined rock salt	1,322,856	8,235,380	1,221,999	7,512,695
Salt recovered in chemical operations	14,899	55,123	17,210	63,675
Salt content of brines used and shipped	1,543,627	1,869,726	1,590,910	1,539,921
Total	3,314,920	19,355,658	3,289,976	18,034,522
By province:				
Ontario	3,007,599	13,994,545	3,036,230	13,228,977
Nova Scotia..............	163,901	2,256,423	120,225	1,897,708
Alberta	72,431	1,206,433	61,198	1,092,331
Saskatchewan	49,064	1,337,096	48,776	1,189,675
Manitoba	21,925	561,161	23,547	625,831
Total	3,314,920	19,355,658	3,289,976	18,034,522
Imports (by type)				
Table:				
United States	705	52,898	175	62,743
United Kingdom	46	3,079	-	-
Total	751	55,977	175	62,743
For fisheries:				
Spain	35,312	137,494	26,607	117,504
Bahamas	24,827	100,261	32,029	120,824
Jamaica	4,297	15,561	5,032	17,572
United States	500	4,679	-	-
St. Pierre...............	142	2,553	40	764
United Kingdom	22	688	33	966
Portugal	-	-	48	449
Total	65,100	261,236	63,789	258,079
Other, in bulk:				
Mexico..................	74,837	89,571	82,240	97,227
United States	41,082	231,287	205,778	911,064
French Africa	-	-	3,360	9,265
Total	115,919	320,858	291,378	1,017,556

Salt - Production and Trade (continued)

	1960		1959	
	Short Tons	$	Short Tons	$
Other, in bags, barrels, and other covering:				
United States	9,833	196,560	13,198	211,818
United Kingdom	337	6,346	1,427	27,416
Total	10,170	202,906	14,625	239,234
Total imports	191,940	840,977	369,967	1,577,612
Exports				
United States.............		3,398,350	1,273,923	4,630,149
United Kingdom		55,815	-	-
Bermuda		6,933	131	6,440
Other countries		268	23	2,933
Total		3,461,366	1,274,077	4,639,522

Source: Dominion Bureau of Statistics.

Salt - Production and Trade, 1950-60
(short tons)

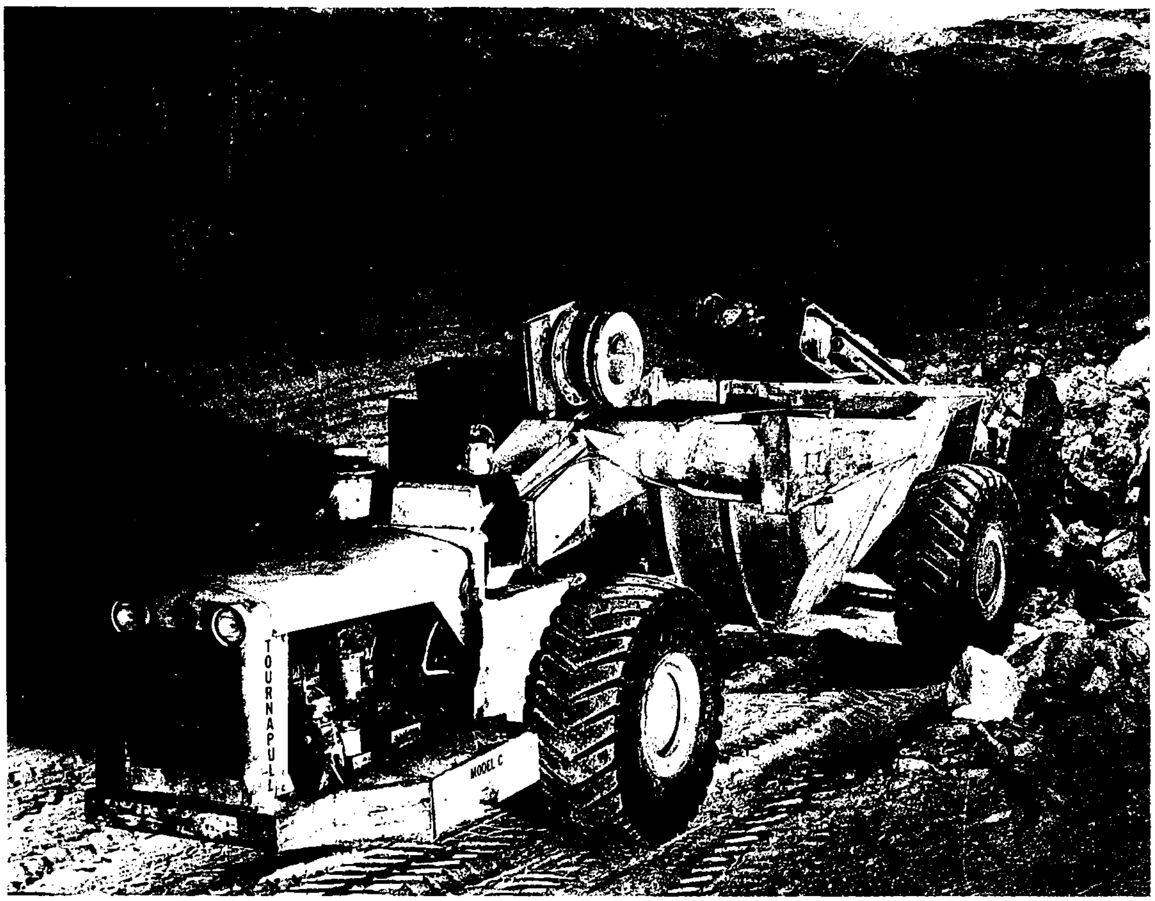
	Production(1)	Imports	Exports
1950	858,896	238,239	4,100
1951	964,525	258,822	4,561
1952	971,903	288,125	2,844
1953	954,928	307,333	2,354
1954	969,887	370,412	1,199
1955	1,244,761	365,255	146,472
1956	1,590,804	319,124	333,935
1957	1,771,559	367,483	457,888
1958	2,375,192	340,887	906,707(2)
1959	3,289,976	369,967	1,274,077
1960	3,314,920	191,940	(3)

Source: Dominion Bureau of Statistics.

(1) Producers' shipments.

(2) This figure has been adjusted to include the salt content of brine, estimated at 500,000 tons, exported to the United States during 1958.

(3) Tonnage not available.



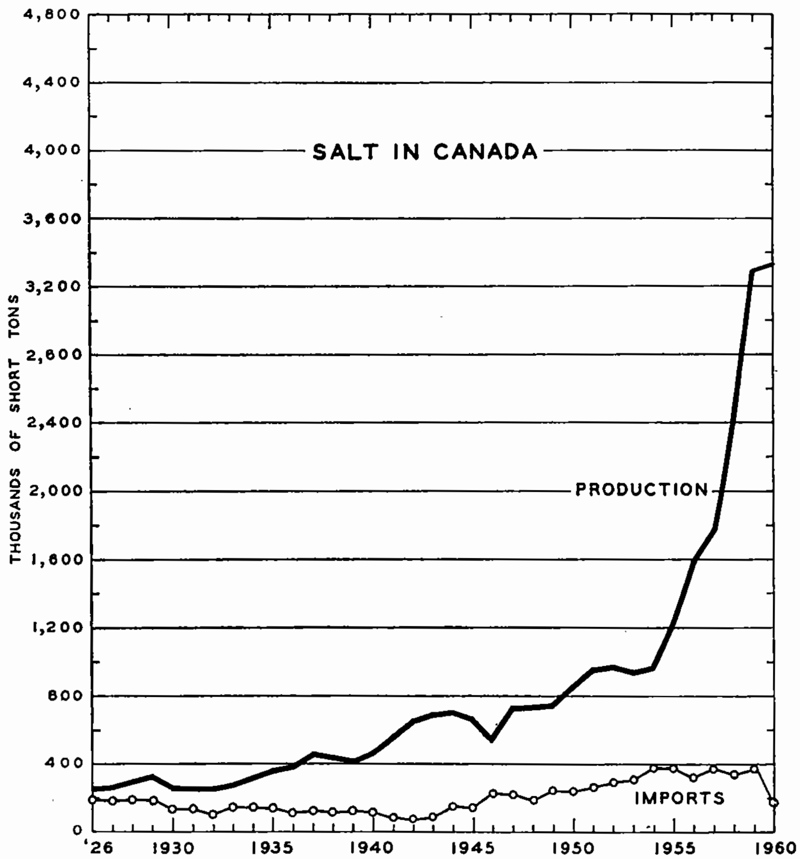
One of the many Le Tourneau Westinghouse machines used underground in the Ojibway rock salt mine. ***Courtesy of the Canadian Rock Salt Company Limited.***

World Production, 1960

('000 short tons)

United States	25,479
China	15,400
Russia	8,300
United Kingdom	6,454
West Germany	4,375
France	4,056
India	3,786
Canada	3,315
Other countries	23,035
Total	94,200

Source: U.S. Bureau of Mines, Mineral Trade Notes, September 1961.



SOURCE: D.B.S.

MINERAL RESOURCES DIVISION, DEPT. M.T.S.

at Goderich and Sarnia. The Canadian Salt Company Limited also operates a fusion plant at Sandwich. Fine salt from the evaporator plant is fused, cooled, crushed, and sized to produce a coarse salt.

Coarse rock salt is produced at Ojibway, near Windsor, by The Canadian Rock Salt Company Limited, a subsidiary of the Canadian Salt Company Limited, and at Goderich, by Sifto Salt Limited. The salt bed mined at Ojibway is at 980 feet; that mined at Goderich is at 1,760 feet.

Brine from company-owned wells is used by Dow Chemical of Canada, Limited, to produce caustic soda, chlorine, and related chemicals at Sarnia. At Amherstburg, Brunner Mond Canada, Limited, produces industrial salt, soda ash, calcium chloride, and other chemicals, using brine from local wells.

Canadian Brine Limited, a subsidiary of The Canadian Salt Company Limited, supplies brine from wells at Sandwich to a chemical plant in Detroit. The brine is pumped to Detroit through pipelines running under the Detroit River.

At Watford, Warwick Salt and Chemicals Limited produces a coarse evaporated salt for use in agriculture, ice control, water-softening, and salting hides.

Nova Scotia

Fine salt is produced by Sifto Salt Limited at a plant at Nappan, near Amherst. Brine for this operation is obtained from salt beds 1,100 to 1,800 feet below the surface.

Malagash Salt Company Limited, a subsidiary of The Canadian Salt Company Limited, operates a rock-salt mine at Pugwash. The salt, obtained from a bed at 630 feet, is crushed and screened to give a coarse product for use in ice and dust control on highways, in fisheries, and by the chemical and agricultural industries.

Prairie Provinces

Fine salt, obtained by vacuum-pan evaporation of brine from salt beds 1,000 to 3,500 feet below the surface, is produced by The Canadian Salt Company Limited at Neepawa, Manitoba, and Lindbergh, Alberta, and by Sifto Salt Limited at Unity, Saskatchewan. Part of the Lindbergh output is fused, crushed, and screened to give a coarse salt for various uses.

Western Chemicals Limited, of Calgary, Alberta, uses brine obtained from salt beds 3,600 feet below the surface to produce caustic soda, chlorine, and hydrochloric acid at its chemical plant near Duvernay, Alberta.

Other Occurrences

Salt beds occur at depth on the west coast of Cape Breton Island; under Hillsborough Bay, Prince Edward Island; and in the area south of Moncton, New Brunswick.

Beds of salt varying from a few feet to several hundred feet in thickness underlie large sections of the Prairie Provinces. The beds occur in a huge southwesterly-dipping basin that extends from northeastern Alberta southeasterly through central Saskatchewan and thence into southwestern Manitoba. These beds vary from less than 400 feet below the surface in northern Alberta to 6,000 feet or more in southern Saskatchewan.

Uses and Technology

Salt is important chiefly as a raw material for the chemical industry, which uses salt brine for the production of sodium hydroxide, chlorine, and hydrochloric acid. These, in turn, are employed in the manufacture of soda ash and a variety of other chemicals.

Fine salt, produced by the vacuum-pan evaporation of brine, is used in food- and leather-processing, the salting and curing of meats and fish, textile-dyeing, and chemical manufacture, for dairy purposes, and in cattle and stock feed.

Salt is also used as a soil stabilizer, a glazing agent in the manufacture of sewer pipes and drain tile, and a drilling-mud ingredient when drilling is done through underground salt seams.

The coarser grades of salt are generally preferred for fish-curing, ice and dust control on highways, dairy and food purposes, the regeneration of calcium and magnesium zeolites in water softeners, refrigeration, meat-packing, and the curing and tanning of hides and skins.

The coarser grades of salt are usually obtained by mining, crushing, and screening rock salt. The four standard sizes produced are:

No. 2	-3/8 + 1/2 inch
No. 1	-1/2 + 1/4 inch
C.C.	-1/4 + 1/8 inch
F.C.	-1/8 inch

One of the major problems encountered in rock-salt-mining is the excessive production of fines (i.e. minus 1/8 inch material), which, although useful as a source of salt for chemical purposes, have limited commercial application. These fines are formed into briquettes or are pressed between rolls to form a thin ribbon of salt. They are then crushed and screened to give salt of the coarser, more useful varieties.

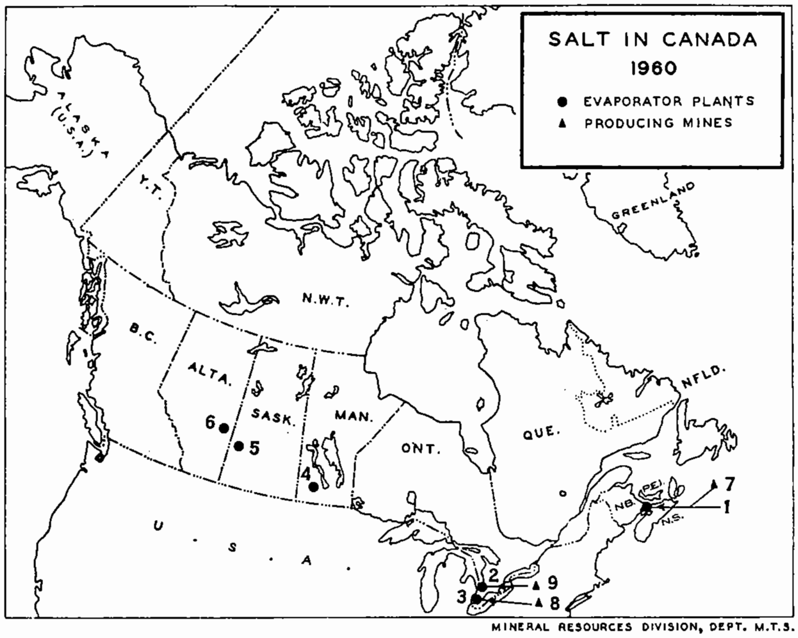
Fine salt from evaporator plants is also pressed to form blocks or briquettes, which in turn are crushed and screened to produce the coarse variety. Coarse salt may also be obtained from fine by fusion, the salt being melted at about 1,500°F in large furnaces similar to those employed by the glass industry. The molten salt is discharged into conveyor-mounted metal briquette moulds, where it quickly hardens. The briquettes are then crushed and screened to the desired sizes.

Mined rock salt, although sometimes of high purity, usually contains such mineral impurities as gypsum, limestone, and dolomite, the removal of which is generally difficult. Great promise for their removal, however, is shown by a 'thermoadhesive' beneficiation method recently developed by International Salt Company, of Cleveland, Ohio. The separation technique is based on the fact that pure salt crystals transmit infrared rays of a certain wave length, whereas the gangue minerals (gypsum, limestone, and dolomite) absorb the rays and hence become heated. If salt containing the gangue minerals is subjected to infrared rays before being discharged to a conveyor belt coated with a heat-sensitive polystyrene resin, the heat-absorbing gangue minerals will adhere to the belt. Thus the salt crystals are discharged at the end of the conveyor, while the gangue minerals travel around the end roller and are removed from the underside of the conveyor belt by a scraper.

Available Data on Consumption of Salt in Specified Canadian Industries, 1959(1)
(short tons)

Chemical products (dry salt and salt content of brine)	1,078,404
Slaughtering and meat-packing	62,784
Pulp and paper mills	47,765
Food preparation	35,993
Fish-processing	18,517
Stock and poultry feed	27,664
Leather tanneries	7,272
Soaps and cleaning preparations	1,824
Dyeing and finishing textiles	1,692
Breweries	924
Artificial ice	60
Other industries(2)	1,103,000(e)

Source: Dominion Bureau of Statistics.
(1) Latest year for which all data are available.
(2) Apparent consumption (1959) less the amount used by specified industries. Includes coarse rock salt for winter maintenance of roads and railways, refrigeration, chemical use, etc., as well as fine salt.
(e) Estimated.



Evaporator Plants

1. Sifto Salt Limited (Nappan)
2. Sifto Salt Limited (Goderich and Sarnia)
   Warwick Salt and Chemicals Limited (Watford)
3. Canadian Salt Company Limited, The (Sandwich)
   Brunner Mond Canada, Limited (Amherstburg)
4. Canadian Salt Company Limited, The (Neepawa)
5. Sifto Salt Limited (Unity)
6. Canadian Salt Company Limited, The (Lindbergh)

Producing Mines

7. Malagash Salt Company Limited (Pugwash)
8. Canadian Rock Salt Company Limited, The (Ojibway)
9. Sifto Salt Limited (Goderich)

Tariffs

	British Preferential	Most Favored Nation	General
Canada			
Fishery salt...............	free	free	free
Bulk salt	"	3¢ per 100 lb	5¢ per 100 lb
Salt in bags, barrels, etc...	"	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

SAND, GRAVEL AND CRUSHED STONE

F.E. Hanes*

The production of all types of crushed stone and natural sand and gravel amounted in 1960 to 230.0 million short tons valued at $157.0 million. This represents an increase in volume and value of 2.4 and 4.0 per cent over the output of 1959.

Sand and gravel increased by 6.6 million short tons and crushed stone decreased by almost 1.3 million, or 3.6 and 3.1 per cent. Their values rose by 5.7 and 0.4 per cent respectively. In 1960, the production value of the whole Canadian mineral industry showed an increase of nearly 3.5 per cent.

Sand and Gravel

The 1960 production of fine sand, sand, and gravel, including crushed gravel, amounted to 188,954,340 short tons valued at $109,647,806.

Sand from gravel-free deposits suitable for use in mortar and concrete for building and road construction makes up 8.5 per cent of the sand-and-gravel output. Both pit-run and washed sands are produced.

Sand and gravel for concrete and road construction constitute 72.8 per cent of the total produced. The 137.6 million tons of this natural aggregate turned out in 1960 had a market value of about 50 cents a ton. It is used principally in concrete mixes for buildings and roads, as an aggregate in fill, and for many other purposes related to highway and general construction work. Much of it, generally about 90 per cent, is taken direct from the pit and classed as pit-run, or 'bank,' material. The remaining 10 per cent requires some beneficiation and is usually washed before use.

The sand and gravel produced for use as railway ballast amounts to 4.1 per cent of the total output and is 95 per cent pit-run material.

The remaining 14.6 per cent is crushed gravel from which both fine and coarse aggregate materials are produced. About a third of it requires washing.

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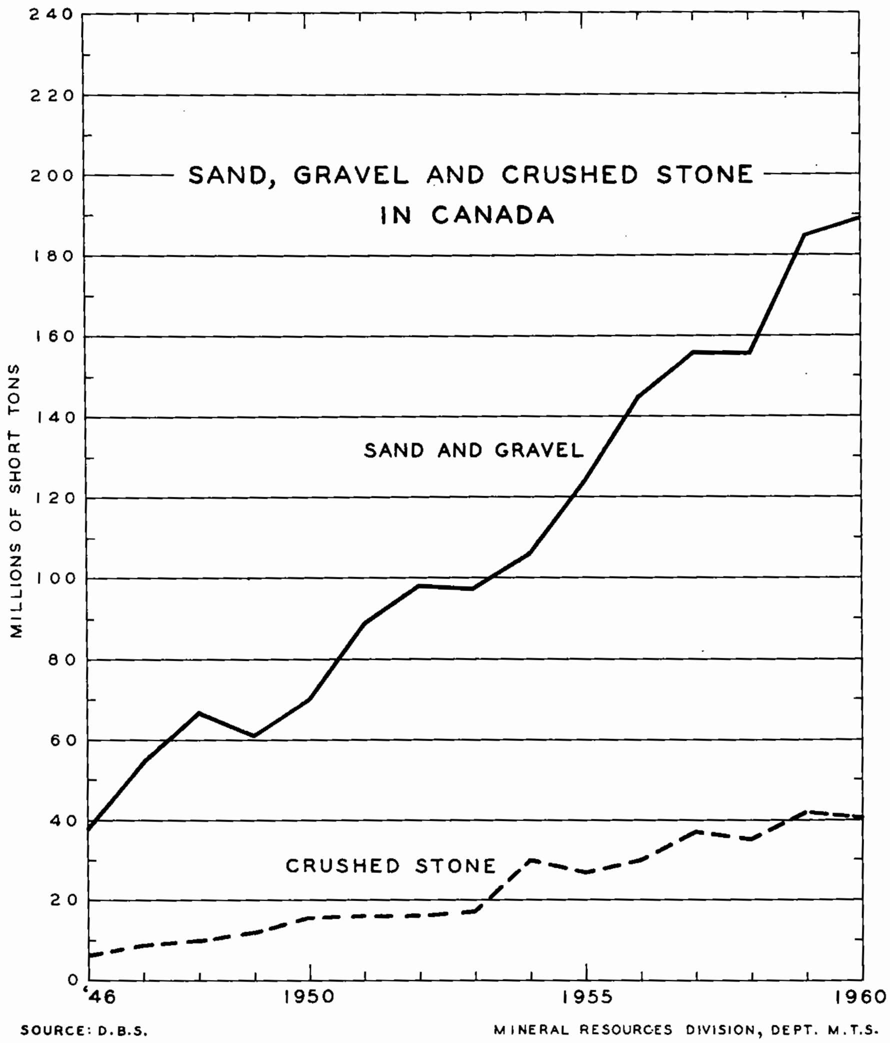
*Mineral Processing Division, Mines Branch.

Production of Sand, Gravel, and Crushed Stone

	Sand and Gravel				Crushed Stone				Total Production Sand, Gravel, and Crushed Stone			
	1960		1959		1960		1959		1960		1959	
	Short Tons	$	Short Tons	$	Short Tons	$	Short Tons	$	Short Tons	$	Short Tons	$
By province												
Newfoundland...........	3,736,112	2,939,111	4,825,724,	2,306,864	18,570	10,050	104	604	3,754,682	2,949,161	4,825,828	2,307,468
Prince Edward Island ...	474,184	422,587	5,244,968	2,859,171	750,000	750,000	1,700,000	1,700,000	1,224,184	1,172,587	6,944,968	4,559,171
Nova Scotia............	8,710,841	6,012,829	8,025,765	5,020,033	799,054	1,094,615	1,300,239	1,198,995	9,509,895	7,107,444	9,326,004	6,219,028
New Brunswick	6,179,963	2,086,784	5,087,425	2,886,647	1,805,148	955,451	2,035,731	1,296,986	7,985,111	3,042,235	7,123,156	4,183,633
Quebec.................	45,890,491	22,486,074	41,815,299	21,060,512	19,448,988	22,510,380	19,661,753	22,581,351	65,339,479	44,996,454	61,477,052	43,641,863
Ontario	75,342,010	42,757,926	71,860,435	39,029,063	16,084,089	19,749,635	15,404,760	18,199,780	91,426,099	62,507,561	87,265,195	57,228,843
Manitoba...............	10,843,601	5,897,180	9,258,632	4,683,610	365,404	349,741	169,365	154,806	11,209,005	6,246,921	9,427,997	4,838,416
Saskatchewan...........	8,895,159	4,691,204	5,888,951	2,889,865	-	-	-	-	8,895,159	4,691,204	5,888,951	2,889,865
Alberta	13,383,843	11,854,526	13,271,695	11,949,099	102,253	71,705	445,490	396,339	13,486,096	11,926,231	13,717,185	12,345,438
British Columbia........	15,498,136	10,499,585	17,055,272	11,061,014	1,707,657	1,908,033	1,658,975	1,695,643	17,205,793	12,407,618	18,714,247	12,756,657
Total	188,954,340	109,647,806	182,334,166	103,745,878	41,081,163	47,399,610	42,376,417	47,224,504	230,035,503	157,047,416	224,710,583	150,970,382
By type												
Sand												
Building road-work, etc	16,075,366	12,996,753	15,556,197	13,325,181								
Sand and gravel												
Concrete, road-work, etc	137,594,684	68,857,398	128,056,334	61,874,585								
Railway ballast........	7,765,514	3,960,814	8,303,445	2,836,993								
Crushed gravel	27,518,776	23,832,841	30,418,190	25,709,119								
Crushed stone												
Concrete aggregate					9,335,165	12,015,603	8,450,120	10,448,077				
Railway ballast........					2,561,072	2,882,592	1,958,325	1,923,369				
Road metal					23,785,760	26,184,006	26,371,980	27,904,991				
Rubble and riprap					1,770,089	1,913,810	1,853,803	2,128,901				
Terrazo, stucco and artificial stone.......					51,658	598,914	41,926	459,377				
Other uses............					3,577,419	3,804,685	3,700,263	4,359,789				
Total	188,954,340	109,647,806	182,334,166	103,745,878	41,081,163	47,399,610	42,376,417	47,224,504				



The Canadian-produced fine sand, sand, and gravel used in the construction industry comes from 8,288 pits run by 2,477 operators.

Crushed Stone

The production of crushed stone for use as concrete aggregate and railway ballast made large gains in 1960. A volume increase of 0.9 million short tons, or 10.5 per cent, raised the production value of concrete aggregate by 15 per cent to $12,015,603. The production of railway ballast increased 30.8 per cent in volume and rose in value by 50 percent to an estimated $2.88 million. Rubble and riprap decreased 4.5 per cent in volume and 10.1 per cent in value.

The 1960 production of crushed stone used as stucco, terrazzo, and artificial-stone aggregates amounted to 51,658 short tons valued at $598,914 or 23.2 per cent more in volume and 30.4 per cent more in value than the output of 1959. These gains resulted from the growing popularity of manufactured building materials and structural units containing crushed-stone aggregates.

The year brought a decrease, however, in the output of aggregate for arterial highways, municipal and secondary roads, airstrip pavement, and other related construction. Production fell from 26,371,980 short tons valued at $27,904,991 - its 1959 total - to 23,785,760 short tons worth $26.2 million. Stabilization of the annual requirements for long-term road and highway construction could be a reason for the drop in production. The number of contracts undertaken during the year for large construction projects of this nature appreciably affects the consumption of aggregate.

The production of crushed stone under 'other uses' decreased in 1960 to 3.58 million short tons of aggregate valued at $3.80 million.

Production of Crushed Stone, by Provinces

In 1959 Prince Edward Island, Nova Scotia, New Brunswick, Quebec, Ontario, and British Columbia each produced more than 1 million tons of crushed-stone aggregate.

In 1960, as in other years, Quebec ranked first in volume and value, although these decreased 1.1 and 0.3 per cent respectively. Ontario gained 4.4 per cent in volume and 8.5 per cent in value. Quebec's 1960 production, at 19.45 million short tons valued at $22.51 million, and Ontario's, at 16.08 million short tons valued at $19.75 million, together accounted for 86.5 per cent of the year's output of crushed stone. Nova Scotia decreased its volume by 38.5 per cent and its value by 8.7 per cent. Volume and value increased respectively by 2.9 and 12.5 per cent in British Columbia and decreased 11.3 and 26.3 per cent in New Brunswick.

Each of the remaining provinces produced less than 1 million tons in 1960. Manitoba, with more than double the production of 1959, increased its value by 126 per cent. Alberta's production decreased 77 per cent in volume and 82 per cent in value while Prince Edward Island's production decreased 56 per cent in both volume and value. Newfoundland produced approximately 18.6 thousand short tons valued at $10,050. Owing to its location in a large sedimentary basin area, Saskatchewan produced no crushed stone.

Production of Crushed Stone, by Rock Types

In 1960, Quebec produced approximately 17.0 million short tons of limestone, 1.6 million short tons of granite, 0.9 million short tons of sandstone, and minor amounts of marble and slate. Ontario produced 14.4 million short tons of limestone, 1.7 million short tons of granite, and minor amounts of marble and sandstone. Nova Scotia produced about 0.7 million short tons of granite and

0.1 million short tons of limestone and sandstone. New Brunswick's output of sandstone, its principal crushed-stone product, amounted to approximately 1.26 million short tons; minor amounts of granite and limestone made up the remainder of the province's crushed-stone production. British Columbia produced 0.8 million short tons of granite and some sandstone. Newfoundland produces both granite and limestone, but Prince Edward Island sandstone only. Manitoba's output is mainly limestone but includes a small amount of granite; Alberta's is mainly sandstone but includes a small amount of limestone.

Imports and Exports

Imports declined in 1960, those of sand and gravel by 211,000 short tons and those of crushed stone by 115,400 short tons. The total import volume of the two commodities was 15.1 per cent less than in 1959. Their value, however, declined by only 10.8 per cent owing to an increase in the cost of a short ton of crushed stone from the 1959 level of $1.33 to $1.40.

Sand and gravel exports declined in 1960 by 33,779 short tons. Their value, however, increased by $3,300 because of the higher evaluation placed on Canada's exported sand. Crushed-stone exports rose by 126,787 short tons, and their value per ton, which in 1959 was 95 cents, went up in 1960 to $1.58. The exports of sand, gravel, and crushed stone combined were 11.2 per cent higher in volume and 52.6 per cent higher in value than in 1959.

Sand and Gravel and Crushed Stone - Imports and Exports

	1960		1959	
	Short Tons	$	Short Tons	$
Imports				
Sand and gravel	885,604	444,292	1,096,623	571,109
Crushed stone	940,330	1,321,675	1,055,712	1,408,686
Total	1,825,934	1,765,967	2,152,335	1,979,795
Exports				
Sand and gravel	209,172	540,415	242,951	537,117
Crushed stone	715,544	1,130,248	588,757	557,733
Total	924,716	1,670,663	831,708	1,094,850

Source: Dominion Bureau of Statistics.

Consumption of Aggregate

Although activity slackened in many sectors of the construction industry in 1960, the volume of aggregate production continued to rise. This, however, did not happen in the United States, where a decrease in the demand for building construction, paving, and road-building reduced both the volume and the value of the sand, gravel,and crushed stone produced. The decline in sand and gravel, the first to occur in the United States since 1949, halted a 10-year upward trend.

Long-term contracts have probably done much to stabilize this sector of the Canadian construction industry. The advance of the northern frontier, for instance, has created a need for many new roads and for airstrips; and the need to improve communications between other parts of the country and the defence installations spread across the northern territories has stimulated activity and expansion in the highly industrialized southern areas. The roads and airstrips that unite this widely dispersed development require the use of vast quantities of aggregate; and because construction has only recently begun, the demand for this material should not only remain high but increase.

Continuing urban growth is adding to the load on already overburdened motor routes and making it necessary to build super by-pass and arterial highways to meet present and future needs. New urban and suburban roads are designed to support greater loads and accommodate more traffic and are thus thicker and wider and require more material per mile. The broader travelling surface adds to maintenance requirements, thus increasing still further the demand for materials.

Technology

Different methods of quarrying, recovery, transportation, beneficiation, and grading are continually being investigated. Through such research, industry benefits economically and the consumer obtains a product of higher quality.

Aggregate materials of greater durability are necessary to meet the rigid specifications enforced today for all classes of construction. In the highly competitive construction industry, the producer strives for both quality control and the development of new outlets for his product. A few of these developments are described in the following paragraphs.

The use of aggregate as an exposed surface on a concrete base is bringing interesting results. Both the color and the design can be varied as much as the imagination allows. One method is simple. When a design or pattern is required, the aggregate is spread or otherwise placed on freshly poured concrete and is pressed into the surface. A cement retarder is added to this surface under pressure or by another method of control and is forced to about half the depth of average-sized aggregate. Washing and scrubbing at the proper moment in the early stages of the set of the concrete remove the upper layer of the concrete matrix and leave the aggregate firmly embedded but in relief. Similar results may be obtained by other methods, each of which gives a product that is effectively distinctive. Aggregate for this purpose may consist of stone, glass, slag, or any other sound, durable material that does not react unfavorably with the chemicals in the cement.

Fine aggregate is also used in the manufacture of artificial stone. The aggregate is intimately mixed with lime or cement, coloring pigments, and other additives. The mixture is formed into blocks, bricks, tiles, or beams. Variations in the preparation and curing of the raw materials are as numerous as the artificial-stone manufactures. The products are designed to conform with qualities of strength and durability that are specified by architects or contractors or in local building codes. Virtually all colors can be produced at will, and the designs of structural units are limited only by the flexibility of the forms and the structural strength of the units being moulded.

Sand - when its natural sources are becoming depleted or when it is not available within economic hauling distance - can be manufactured from several types of igneous or sedimentary rock. Sound bedrock provides a vast source of material for crushing into fine sand sizes. Each type of stone has characteristics amenable to crushing procedures that give a suitably graded and shaped aggregate sand. The initial cost of equipment is higher, but a manufactured sand soon compensates for it, particularly where natural-sand products are becoming economically prohibitive. Moreover, the quality of manufactured sand is more easily controlled during production.

SELENIUM AND TELLURIUM

A.F. Killin*

SELENIUM

Selenium (atomic number, 34; atomic weight, 78.96) is a semimetal standing between sulphur and tellurium in Group VI on the periodic chart of the atoms. A grayish, crystalline solid with a semimetallic lustre, selenium exhibits electrical properties characteristic of the semiconductor group of metalloid elements. Although it is widely distributed in the earth's crust in the native state and in the selenides of copper, silver, lead, mercury, bismuth and thallium, selenium is never found in deposits worth working for the selenium content alone. Commercial production of selenium is obtained from the treatment of tank muds resulting from the electrolytic refining of copper anodes.

Responding to the increase that occurred in Canada's copper output in 1960, selenium production rose to a record high. Selenium production in all forms totalled 521,638 pounds valued at $3,651,466 The production of refined selenium from domestic ores treated in 1960 is estimated at 516,100 pounds valued at $3,196,600. The comparable total for 1959 was 368,107 pounds valued at $2,576,749. The production of refined selenium from all sources totalled 532,125 pounds in 1960; in 1959 it amounted to 372,410 pounds.

Canada's two copper refineries together accounted for all the primary selenium produced in 1960. A small amount of selenium is recovered from scrap left over from the manufacture of dry-plate rectifiers and from old rectifiers. The International Nickel Company of Canada, Limited, operates a copper refinery at Copper Cliff, Ontario, for the refining of blister copper recovered from the nickel-copper ores of Ontario's Sudbury district. In conjunction with this establishment, it also operates a selenium- and tellurium-recovery plant, where it processes selenium- and tellurium-bearing materials received from this Copper Cliff refinery and the company's nickel refinery at Port Colborne, Ontario. The selenium plant's annual capacity is 240,000 pounds of minus 200 mesh, 99.7-per-cent selenium powder.

Canada's largest selenium refinery is operated by Canadian Copper Refiners Limited at Montreal East, Quebec, on the tankhouse slimes obtained from the company's electrolytic copper refinery. The copper refinery treats anode copper from the Noranda and Murdochville smelters in Quebec and

*Mineral Resources Division.

Selenium - Production, Exports and Consumption

	1960		1959	
	Pounds	$	Pounds	$
Production				
All forms(1)				
Quebec	279,759	1,958,313	194,233	1,359,631
Ontario	144,500	1,011,500	101,400	709,800
Saskatchewan	73,021	511,147	57,677	403,739
Manitoba	24,358	170,506	14,797	103,579
Total	521,638	3,651,466	368,107	2,576,749
Estimated refined(2)				
Quebec	273,000	1,638,000		
Ontario	145,100	970,600		
Saskatchewan	73,196	439,176		
Manitoba	24,804	148,824		
Total	516,100	3,196,600		
Refined(3)	532,125		372,410	
Exports				
Metals and salts				
United Kingdom	213,532	1,601,638	146,359	1,114,171
United States	125,912	744,322	169,564	664,996
China (Communist)	30,547	196,592	-	-
Japan	15,432	102,622	-	-
Australia	3,710	34,398	1,220	11,229
Argentina	3,590	22,767	2,477	13,005
Italy	3,527	33,111	1,102	9,450
Union of South Africa	3,400	25,330	3,400	23,630
Brazil	3,137	23,872	1,478	9,343
Other countries	1,623	11,755	112	660
Total	404,410	2,796,407	325,712	1,846,484
Consumption	14,461		22,156	

(1) Recoverable selenium content of the blister copper produced from domestic ores, plus refined selenium as reported by Dominion Bureau of Statistics.

(2) Selenium derived from the treatment of ores mined in 1960 as reported directly by producers.

(3) Reported by Dominion Bureau of Statistics and includes production from scrap.

Selenium - Production, Exports and Consumption, 1950-60

(pounds)

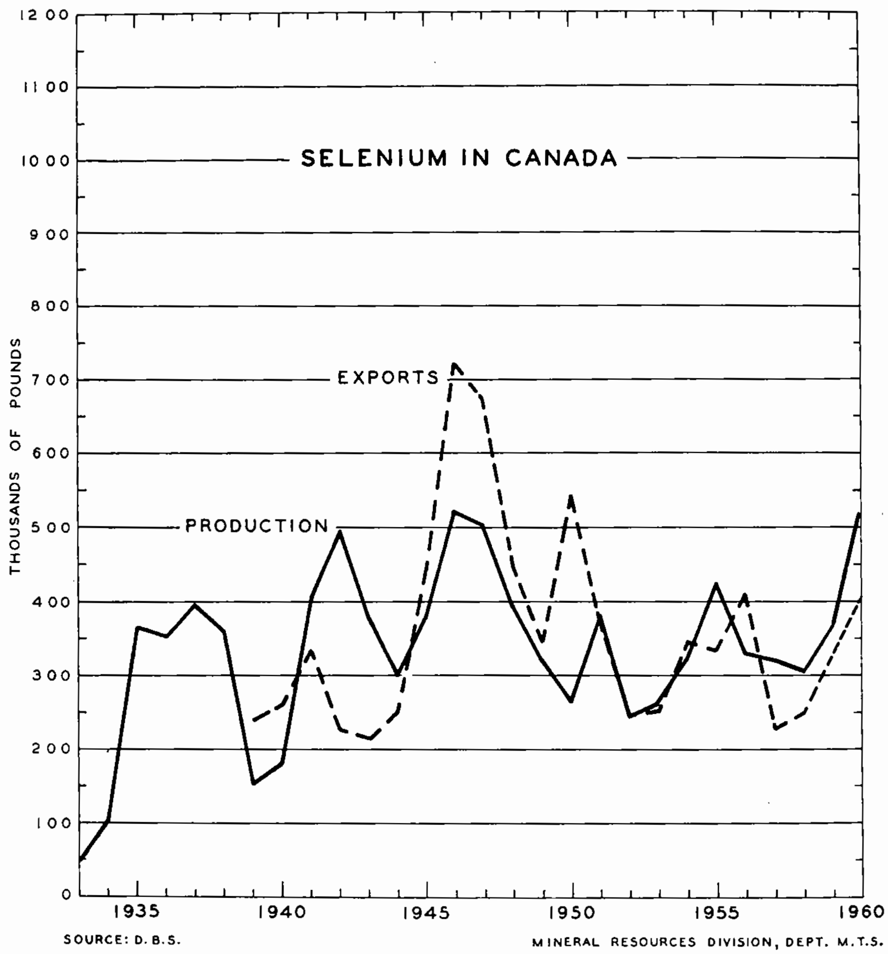
	Production		Exports	Consumption(3)
	All Forms(1)	Refined(2)	Metals and Salts	
1950	261,973	289,714	542,401	9,312
1951	382,603	371,060	370,473	13,647
1952	242,030	254,478	244,121	11,767
1953	262,346	307,903	253,620	14,465
1954	323,529	297,479	344,292	21,141
1955	427,109	422,588	334,215	34,854
1956	330,389	355,024	409,729	31,669
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(4)
1960	521,638	532,125	404,410	14,461(4)

Source: Dominion Bureau of Statistics.
(1) Recoverable selenium content of the blister copper produced from domestic ores, plus refined selenium.
(2) Includes production from scrap.
(3) Producers' domestic shipments of selenium and selenium salts (selenium content).
(4) Consumption as reported by consumers.

blister copper from Manitoba's Flin Flon smelter. The Montreal East plant, one of the largest selenium-metal-and-salts plants in the world, has a rated annual capacity of 450,000 pounds. In addition to commercial-grade selenium metal (99.5%Se) and high-purity (H.P.) selenium metal (99.9%Se), the refinery is capable of producing a wide range of metallic and organic selenium compounds. The active research department maintained by the company is concerned with studies of refinery efficiency, methods of selenium recovery, and the search for new applications and uses of the material and its compounds.

Consumption and Uses

Selenium was first used in the glass, rubber and alloy-steel industries either as selenium metal or in selenium compounds. During World War II the potential of selenium for the manufacture of dry-plate rectifiers was recognized,and after the war this use was rapidly expanded. The manufacture of dry-plate rectifiers and photoelectric cells accounts for most of the selenium consumed in the world today.



Selenium rectifiers are being challenged by those made of silicon or germanium, which have a wider field of application. Despite the inroads of newer semiconductor materials, however, the low cost, electrical efficiency, compactness, long life, and ruggedness of the selenium rectifiers, coupled with a widespread knowledge and understanding of their electrical characteristics, enable them to retain a considerable share of the market. They are used in radios, television sets, battery chargers, electroplating equipment, and magnetic brakes, shakers, and agitators. Small amounts of selenium are alloyed with tellurium and other materials for use in thermoelectric devices. The photoelectric properties of high-purity selenium are applicable in xerography, a dry printing process.

Selenium has found application for many years in the glass industry. In small quantities, it is used to neutralize the green color imparted to glass by iron in the glass sand. Larger quantities of selenium added to the glass batch produce orange-to-ruby-red colors, according to the quantity added. Selenium ruby glass, which is of a brilliant red, is used in stop lights, signal lights, automotive taillights, marine equipment, and decorative tableware. Selenium is used as an orange-to-dark-maroon pigment in the ceramics and paint industry and in the coloring of printing inks for glass containers. The pharmaceutical industry employs selenium and selenium compounds in the preparation of various proprietary medicines for the control of dermatitis in humans and animals and the correction of dietary deficiencies in animals. The chemical industry uses selenium as a catalyst in the manufacture of cortisone and nicotinic acid.

Finely ground metallic selenium and selenium diethyldithiocarbamate (selenac) are used in natural and synthetic rubber to increase the rate of vulcanization and to improve the aging and mechanical properties of sulphurless and low-sulphur rubber stocks. Selenac acts as an accelerator in butyl rubber.

The machinability and other properties of stainless steel are improved by the addition of ferroselenium (55-57% Se); and the porosity of stainless-steel castings is improved by the addition of selenium in proportions as small as from 0.20 to 0.35 per cent.

Sodium selenite and sodium selenosulphate are used in photographic solutions to impart warm brown tints to prints. Other selenium compounds are used in the preparation of supersensitive photographic dyes.

Greenhouse operators formerly used sodium selenate as a systemic insecticide, but this use is declining owing to the discovery of compounds easier to apply.

Partial Analysis of Canadian Industrial Use of Selenium, 1959

(pounds of contained selenium)

Use	Ferro-selenium	High-purity Selenium	Metal Powder	Selenium Dioxide	Sodium Selenate	Sodium Selenite	Other Selenium	Total
Electronics		8,375						8,375
Glass			6,008			1,700		7,708
Stainless steel	5,666							5,666
Other uses				350	40		17	407
Total	5,666	8,375	6,008	350	40	1,700	17	22,156

Source: Consumers' reports.

Among the more important consumers of selenium and selenium products in Canada are: Ontario - Syntron (Canada) Limited, Stoney Creek; Canadian Line Materials Limited, Toronto; Bogue Electric of Canada Limited, Ottawa; Atlas Steels Limited, Welland; Ferro Enamels (Canada) Limited, Oakville; Fahralloy Canada Limited, Orillia; Quebec - Dominion Glass Company Limited, Montreal; Consumers Glass Company Limited, Ville St. Pierre; Shawinigan Chemicals Limited, Shawinigan; Needco Cooling Semiconductors Ltd., Montreal.

Prices

Commercial-grade selenium was $7 a pound and high-purity $9.50 a pound as quoted by E & M J Metal and Mineral Markets throughout 1960.

TELLURIUM

Tellurium (atomic number, 52; atomic weight, 127.61), like selenium, is also a semimetal and stands directly below selenium in Group VI on the atomic chart of the elements. Metallic tellurium is a steel-gray, brittle substance whose semiconductor characteristics have brought it into renewed prominence. Although widely distributed in the earth's crust, tellurium is much less abundant than selenium, with which it is generally associated. Tellurium is more prone to form compounds with other metals than is selenium. Tellurides of gold, silver, mercury, bismuth, copper, and lead have been found, but not in sufficient quantities to form commercial deposits. Present commercial sources of tellurium are the anode slimes resulting from the electrolytic refining of copper and lead. No tellurium is recovered from gold, silver, or lead ores in Canada.

Tellurium is recovered with selenium at the refinery of The International Nickel Company of Canada, Limited, at Copper Cliff, Ontario, and at the Montreal East refinery of Canadian Copper Refiners Limited. The source of International Nickel's tellurium is the anode slimes produced in the Copper Cliff and Port Colborne refineries during the treatment of copper and nickel anodes smelted from the company's Sudbury-area ores. Canadian Copper Refiners treats anodes from its Quebec smelters, at Noranda and Murdochville, and blister copper from the smelter of Hudson Bay Mining and Smelting Co., Limited, at Flin Flon, Manitoba.

In 1960 the production of tellurium in all forms, as reported by the Dominion Bureau of Statistics, totalled 44,682 pounds valued at $156,388. The estimated plant production of tellurium from domestic ores treated in 1960 totalled 48,250 pounds valued at $168,875. The comparable total for 1959 was 13,023 pounds valued at $27,999. The output of refined tellurium from all sources amounted in 1960 to 41,756 pounds; in 1959 it was 8,900 pounds.

Tellurium - Production and Consumption

	1960		1959	
	Pounds	$	Pounds	$
Production				
All forms(1)				
Quebec................	29,925	104,738	1,662	3,573
Saskatchewan..........	5,482	19,187	3,552	7,637
Ontario	7,450	26,075	6,900	14,835
Manitoba..............	1,825	6,388	909	1,954
Total	44,682	156,388	13,023	27,999
Estimated plant output(2)				
Quebec	33,000	115,500		
Saskatchewan..........	5,976	20,916		
Ontario	7,250	25,375		
Manitoba..............	2,024	7,084		
Total	48,250	168,875		
Refined(3).............	41,756		8,900	
Consumption(4) (refined)....	4,238		9,677	

Source: Dominion Bureau of Statistics.

(1) Includes the recoverable tellurium content of the blister and anode copper treated, plus refined tellurium as reported by Dominion Bureau of Statistics.

(2) As reported directly by producers.

(3) Refinery output from all sources as reported by Dominion Bureau of Statistics.

(4) Consumption as reported by consumers.

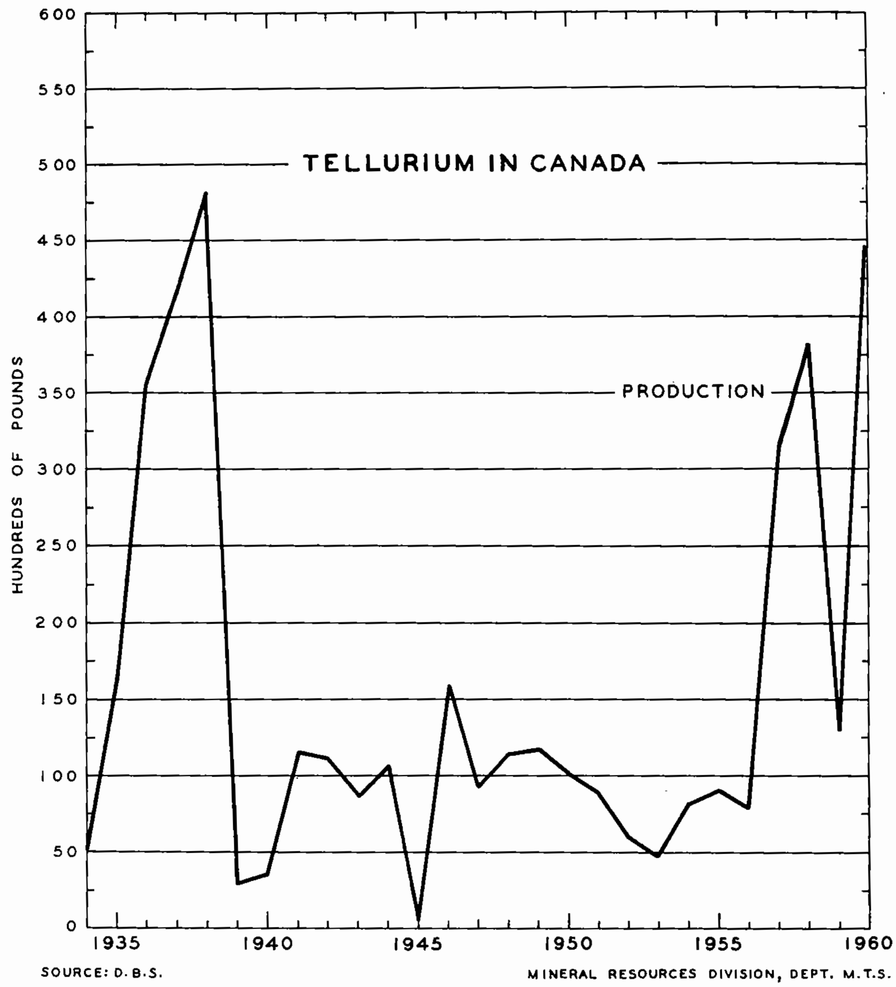
Production of Tellurium, 1950-60

(pounds)

	All Forms(a)	Refined(b)
1950	10,075	6,010
1951	8,913	6,301
1952	6,035	5,710
1953	4,694	17,295
1954	8,171	7,990
1955	9,014	6,516
1956	7,867	15,915
1957	31,524	34,895
1958	38,250	42,337
1959	13,023	8,900
1960	44,682	41,756

(a) Includes the recoverable tellurium content of blister copper, which was not necessarily recovered in the year designated. Also includes some refinery output.

(b) Refinery production from all sources.



Consumption and Uses

Three times since its discovery in 1782 tellurium has been on the verge of extensive commercial utilization. Before the development of the vacuum tube, it was used as a crystal detector in radio receivers, but the advent of the vacuum tube made the crystal detector obsolete. During the development of the high-compression internal-combustion engine, it was found that tellurium compounds were excellent as antiknock additives in gasoline. Investigation showed that the raw-material sources of tellurium were not adequate to supply the demand, and tetraethyl lead was substituted as a gasoline additive.

The most recent interest in tellurium has been aroused by the possibility of its increased use in alloys employed in the manufacture of thermoelectric couples. Thermoelectric devices for refrigeration or the direct conversion of heat into electricity are still in the laboratory-development stage, and the quantity of tellurium they will require is not yet known. The outlook favors an increase in the use of tellurium, and the producing companies and the United States Bureau of Mines are conducting surveys designed to increase the recovery of tellurium at the refineries and to find new sources of the element.

Tellurium is nontoxic, but when absorbed into the body by direct contact or inhalation, it imparts a strong odor of garlic to the breath and perspiration. Because of this adverse physiological effect, tellurium has been less widely used in industry than selenium.

In the rubber industry, tellurium powder and tellurium diethyldithiocarbamate are used to improve the aging and mechanical properties of sulphurless and low-sulphur stocks of natural and GR-S (synthetic) rubber. The tellurium carbamate also helps to reduce the porosity of thick sections. Tellurium rubber, which is resistant to heat and abrasion, is used mainly in rubber-jacketed, portable cables for mining, dredging, welding, etc. Tellurium diethyldithiocarbamate plus mercaptobenzothiazol is one of the fastest known accelerators for butyl rubber.

Tellurium powder added to molten iron acts as a carbon stabilizer and is effective in controlling the depth of chill in gray-iron castings. A 99.5-per-cent-copper and 0.5-per-cent-tellurium alloy has good hot-working properties and can also be extensively cold-worked and forged. This alloy, which has good conductivity, is used in the manufacture of welding tips and in radio and communications equipment. Lead containing from 0.02 to 0.1 per cent tellurium is corrosion-resistant and is used in marine-cable sheathing and as linings in tanks subject to chemical corrosion.

Refined Tellurium Used in Canada, 1959

(pounds of contained tellurium)

Use	Metal Pellets	Metal Powder	Oxide	Other Tellurium	Total
Rubber		100		7,130	7,230
Other uses	2,347			100	2,447
Total	2,347	100		7,230	9,677

Source: Consumers' reports.

Prices

The price of a pound of commercial-grade tellurium, as quoted by E & M J Metal and Mineral Markets, rose on January 1 from $2.50 to $3, climbed in May to $3.50, and increased in September to $4. High-purity tellurium (99.999+Te) was quoted in 1960 at $25 a pound, as reported by the United States Bureau of Mines.

SILICA

R. K. Collings*

Silicon dioxide, commonly referred to as silica, is a compound found in the free state chiefly as quartz. Quartz occurs in many forms, but only those in which the silica content is high - vein quartz, silica sand, sandstone, and quartzite - are of commercial interest. The silica produced in Canada is in the form of sand, lump sandstone, quartz, and quartzite and is mostly for use as a metallurgical flux and for the manufacture of ferrosilicon alloys.

Most of the high-purity sand required for use in glass, silicon-carbide, and silica-chemicals manufacture and for foundry purposes is imported from the United States. About 25 per cent of the sand required by these industries is produced domestically - at Lachine, Quebec, from a quartzite obtained at St. Donat de Montcalm, and at St. Canut, Quebec, from local Potsdam sandstone.

The production of silica minerals in Canada in 1960 amounted to 2,260,766 short tons valued at $3,266,705. More than 77 per cent of the 1959 output was consumed as metallurgical flux.

The exports of quartzite, sent mostly to the United States for ferro-silicon production, dropped from 147,412 short tons in 1959 to 13,057 short tons in 1960. Imports of silica sand dropped 9 per cent to 720,826 short tons, valued at $2,404,685.

Principal Producers

Nova Scotia

Dominion Iron & Steel Limited obtains quartzite from a deposit at Chegoggin Point, Yarmouth county, for use in the manufacture of silica brick at Sydney. Quarrying operations conducted during 1960 resulted in the production of a two years' supply of silica for the Sydney brick plant.

Quebec

Electro Metallurgical Company, Division of Union Carbide Canada Limited, quarries quartzitic sandstone at Melocheville, Beauharnois county, for use in ferrosilicon manufacture at Beauharnois. Fines from this operation are sized and used in foundry work, in cement manufacture, and as metal-lurgical flux.

(text continued on page 494)

*Mineral Processing Division, Mines Branch.

Silica - Production and Trade

	1960		1959	
	Short Tons	$	Short Tons	$
Production(1)				
Quartz and silica sand				
By province				
Ontario	1,659,410	998,281	1,600,352	1,363,541
Quebec	357,165	1,835,960	301,706	1,533,206
Saskatchewan	169,903	107,039	188,515	114,994
British Columbia	64,887	272,433	65,318	379,890
Nova Scotia	9,281	52,813	1,151	6,338
Manitoba	120	179	6,504	38,761
Total	2,260,766	3,266,705	2,163,546	3,436,730
By use				
Flux	1,886,590	1,342,135	1,672,224	1,109,613
Ferrosilicon	146,457	521,865	235,633	710,042
Silicon carbide	73,931	566,704	98,300	620,738
Glass	52,110	329,578	30,945	206,427
Foundry	16,790	86,996	39,833	131,840
Other uses	84,888	419,427	86,611	658,070
Total	2,260,766	3,266,705	2,163,546	3,436,730
			'000 Bricks	
Silica brick(2)			1,926	354,295
			Short Tons	
Imports				
Silica sand for glass and carborundum manufacture and for use in steel foundries, filtration plants, and sand-blasting				
United States	719,958	2,394,595	791,264	2,487,177
Belgium and Luxembourg	519	3,116	663	36,780
Norway	214	3,589	4	173
Australia	135	3,385	198	1,189
Total	720,826	2,404,685	792,129	2,525,319
Quartz				
Silex, or crystallized quartz, ground or unground(3)	10,521	161,239	13,815	184,451
Piezoelectric quartz	2	126,208	1	72,575
Total	10,523	287,447	13,816	257,026

Silica - Production and Trade (cont'd)

	1960		1959	
	Short Tons	$	Short Tons	$
Imports (cont'd)				
Flint and ground flint stones				
United States............	1,072	15,195	418	12,692
Denmark	110	4,668	259	10,578
France	50	1,540	109	3,207
Total..................	1,232	21,403	786	26,477
Firebrick containing not less than 90% silica				
United States............		945,638		1,444,320
West Germany		9,420		50,088
United Kingdom		6,709		4,619
Total..................		961,767		1,499,027
Exports				
Quartzite				
United States............	13,057	44,505	147,412	465,166

Source: Dominion Bureau of Statistics.
(1) Producers' shipments, including crude and crushed quartz, crushed sandstone and quartzite, and natural silica sands. In 1960 the quartz used to make silica brick is included.
(2) The production and value of silica brick are not separately available in the mineral-production statistics for 1960. The quartz used to make silica brick is included under production (shipments) of quartz and silica.
(3) Mostly from the United States.

Available Statistics on Consumption of Silica
by Specified Industries, 1959

Industry	Short Tons
Smelter-flux	1,672,224#
Glass-manufacturing	318,491
Foundry-sand	179,145
Ferrosilicon	62,603
Artificial-abrasives	139,955
Cement-manufacturing	77,338
Chemical	29,217
Soap-and-cleanser	2,708
Fertilizers, stock and poultry feed	30,870
Asbestos-products	2,441
Ceramics	9,345
Other industries	10,722
Total	2,535,059

Source: Dominion Bureau of Statistics.
#Includes low-grade sand and gravel as well as crushed quartz.

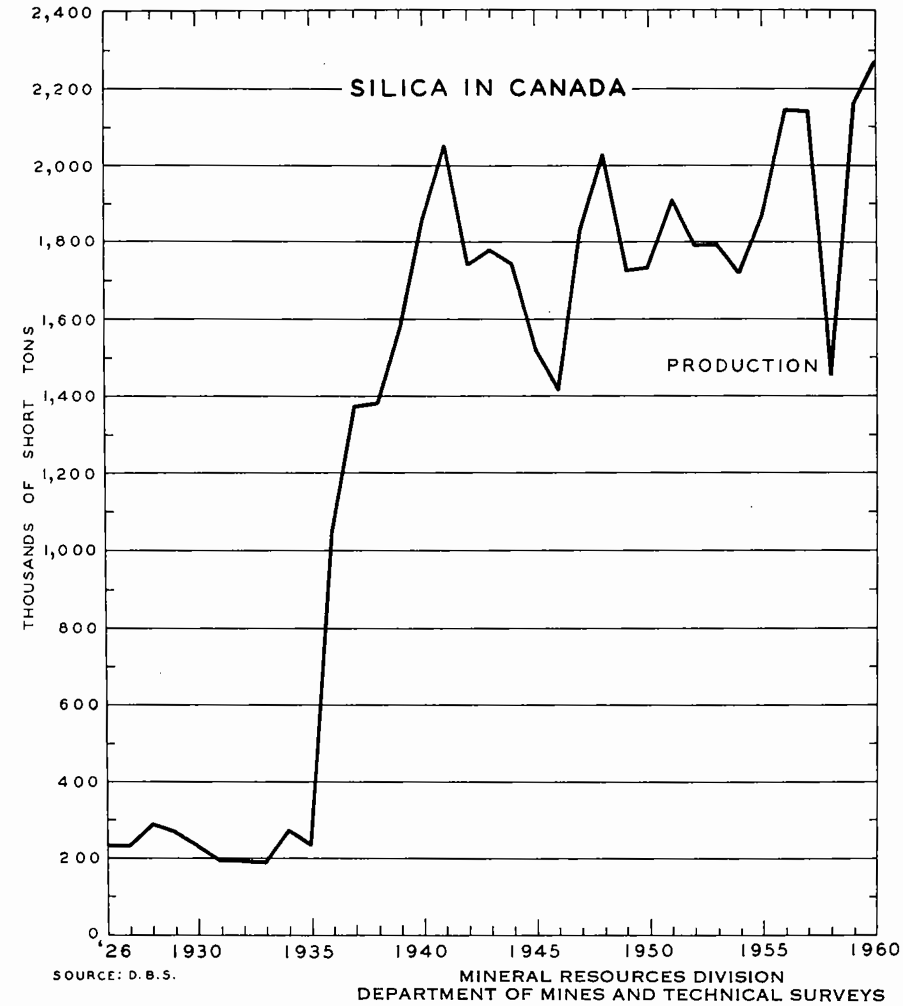
Silica - Production and Trade, 1950-60

	Production		Imports				Exports
	Quartz and Silica Sand	Silica Brick	Silica Sand	Silex, or Crystallized Quartz	Flint and Ground Flint Stones	Ganister	Quartzite
	(short tons)	('000 bricks)	(short tons)				(short tons)
1950	1,730,695	3,126	573,362	24,757	939	178	195,430
1951	1,904,885	3,510	692,937	30,398	1,231	144	281,379
1952	1,783,081	3,544	642,880	26,174	481	260	193,955
1953	1,785,574	3,720	703,221	30,534	1,106	286	200,169
1954	1,716,151	3,578	655,863	28,412	1,219	590	162,374
1955	1,869,913	4,763	735,458	24,517	803	456	87,622
1956	2,142,234	5,799	840,374	26,892	616	562	181,196
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	(1)	17,074
1959	2,163,546	1,926	792,129	13,815	786	(1)	147,412
1960	2,260,766	(2)	720,826	10,521	1,232	(1)	13,057

Source: Dominion Bureau of Statistics.

(1) Not available separately. Included with miscellaneous stone imports from January 1, 1958.

(2) Not available for 1960.



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.

Dominion Silica Corporation Limited, Lachine, quarries quartzite at St. Donat de Montcalm, for use in the manufacture of silica sand and flour at its processing plant at Lachine. Production from the Lachine plant is used in the manufacture of glass and artificial abrasives and for other products requiring high-quality silica.

Canadian Silica Corporation Limited, Toronto, produces silica sand and flour at St. Canut, Two Mountains county, from a large deposit of Potsdam sandstone. The sand is used for foundry purposes and for the manufacture of glass and silicon carbide. The flour is used by steel foundries, as a filler in asbestos-cement products, and in various cleansers.

Ontario

Canadian Silica Corporation Limited and Electro Metallurgical Company operate quarries in the quartzite formations occurring along the northwest shores of Georgian Bay. Canadian Silica Corporation has quarries at Sheguiandah, on Manitoulin Island; Electro Metallurgical Company's quarries are at Killarney, on the mainland. Much of the output is exported to the United States; the remainder is used domestically, mostly for ferrosilicon manufacture. Part of the production from Sheguiandah is used for silica-flour manufacture at Whitby, Ontario.

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 it is exported to the United States for use in the manufacture of silicon carbide and ferrosilicon.

Other Areas

Silica for metallurgical flux is obtained near Noranda, Buckingham, and Howick, in Quebec; Sudbury, Ontario; Flin Flon and Thompson, in Manitoba; and Trail, British Columbia.

Large deposits of sand, sandstone, and quartzite exist in all provinces, but most are too impure or too far from markets to warrant development.

Specifications and Uses

Lump Silica

Silica Flux

Quartz and quartzite, as well as sandstone and sand, are used as fluxes in smelting base-metal ores low in silica. The composition of the flux and the amount of silica used depend upon the composition of the ore, but the silica content should be high. In small amounts, impurities such as iron and alumina are not objectionable. Silica used as flux is generally -1, +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 and alumina less than 1 per cent each, and the total iron-and-alumina content less than 1 1/2 per cent. Lime and magnesia should each be less than 0.2 per cent. Phosphorus and arsenic are objectionable as they cause deterioration and disintegration of the manufactured product. The silica used is generally -6, +1 inch in size.

Silica Brick

Quartz and quartzite, crushed to pass an 8-mesh screen, are used in the manufacture of silica brick for high-temperature refractory furnace linings. The silica content of the quartz used should be at least 97 per cent. The iron and alumina should be less than 1 per cent each, and other impurities, such as lime and magnesia, should be low.

Other Uses

Lump quartz and quartzite, shaped to proper size, are used as lining in ball and tube mills and as lining and packing for acid towers. Naturally occurring flint pebbles are used as grinding media for the reduction of various nonmetallic ores.

Silica Sand

Glass Manufacture

Naturally occurring sand and sand produced by crushing quartz, quartzite, or sandstone are used in the manufacture of glass and fused silica-ware. The silica content should be more than 99 per cent; that of iron should be uniform and less than 0.02 per cent. Other impurities such as alumina, lime, and magnesia should be low. Uniformity of grain size is important; glass sand should be between 20-mesh and 100-mesh size with a minimum of coarse or fines.

Silicon Carbide

Sand used for silicon-carbide manufacture should have a silica content of 99 per cent. Iron and alumina should be less than 0.1 per cent each; and lime, magnesia, and phosphorus are objectionable. A coarse-grained sand is preferred for silicon-carbide manufacture, but finer sands are sometimes used. All sand should be plus 100 mesh, with the bulk of it plus 35 mesh in size.

Hydraulic Fracturing

Silica sand is used in the hydraulic fracturing of oil-bearing formations. The amount used varies greatly, but generally ranges from 5,000 to 15,000 pounds per treatment. The sand must be clean and dry, have a high compressive strength and a high silica content, and be free of all acid-consuming constituents. The grain size must be closely controlled 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 to grain size are used extensively in the foundry industry for moulding. Silica sands for this purpose vary greatly in screen size and chemical composition. Grain size is usually between 20- and 200-mesh in closely sized ranges. A sand with a rounded grain is preferred for the foundry industry.

Sodium Silicate and Other Chemicals

Sand used in the manufacture of sodium silicate and other chemicals 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. 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 closely sized sand are used in water-treatment plants as filtering media. Silica sand is used as an ingredient in the manufacture of portland cement.

Silica Flour

Silica flour, formed by grinding quartz, quartzite, sandstone, or sand to a very fine powder, 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 for paint, and as an abrasive ingredient in soaps and scouring powders.

Quartz Crystals

Quartz crystals possessing desirable piezoelectric properties are used in radio-frequency-control apparatus, radar, and other electronic devices. Crystals used for this purpose must be water-clear, perfectly transparent, and free of all visible impurities or 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.

Prices

The price of silica varies greatly depending upon the location of deposits, the purity of the product, and the purpose for which it is required. High-quality silica sand from Ottawa, Illinois, in carload lots f.o.b. Montreal, sells for approximately $10 a ton.

Tariffs

Canada

Sand and ganister	free
Silex, or crystallized quartz, ground or unground	"

United States

Sand containing 95% or more silica and not more than 0.6% oxide of iron and suitable for use in the manufacture of glass, per long ton	50¢
Quartzite, sand, not specifically provided for	free
Silica, crude, not specifically provided for, per long ton	$1.75

SILVER

J.W. Patterson*

Silver production during 1960 was the highest in Canada's history. Output at 34,016,829 ounces, was substantially higher than the 31,923,969 ounces produced in 1959 and surpassed the long-standing record of 32,869,264 ounces produced in 1910, when production from the Cobalt and Gowganda areas of Ontario was at its peak. Increases were recorded in all provinces and in the two Territories, with the exception of Saskatchewan with a small decrease of 24,000 ounces (2 per cent). British Columbia had the largest increase at almost 1,000,000 ounces (13 per cent).

Fifty-two per cent of the total output came from lead-zinc and silver-lead-zinc ores, most of which were mined in British Columbia and Yukon Territory, 25 per cent was derived from copper, copper-zinc, and nickel-copper ores, 21 per cent from the silver-cobalt ores of northern Ontario, and 2 per cent from lode- and placer-gold operations.

The principal producers of fine silver were The Consolidated Mining and Smelting Company of Canada Limited (Cominco), at Trail, British Columbia, which produced silver in refining lead and zinc ores; Canadian Copper Refiners Limited, Montreal East, Quebec, which produced silver in refining blister copper; Deloro Smelting & Refining Company, Limited, Deloro, Ontario, which produced silver in refining silver-cobalt ores; and The International Nickel Company of Canada, Limited, Copper Cliff, Ontario, which produced silver in refining nickel-copper ores. Other producers were Hollinger Consolidated Gold Mines, Limited, Timmins, Ontario, and the Royal Canadian Mint, Ottawa, Ontario, which produced silver in refining gold bullion.

World mine production of silver in 1960 was an estimated 239 million ounces, 18 million ounces higher than the estimated 1959 production, which amounted to 221 million ounces. Mexico, with 44.5 million ounces, led the world; Canada, with its 34.0 million ounces, ranked second for the second consecutive year, followed by the United States with 30.8 million ounces. Labor strikes at major silver and silver-lead-zinc mines in Idaho during the last eight months of the year were the chief reason for the United States' low output of silver.

For the third consecutive year demand increased substantially. Free World consumption is estimated to have risen to 319 million ounces.

* Mineral Resources Division.

Silver - Production and Trade

	1960		1959	
	Troy Ounces	$	Troy Ounces	$
Production				
By provinces				
Ontario	11,220,823	9,976,434	10,540,856	9,252,763
British Columbia and Alberta	8,447,459	7,510,636	7,463,304	6,551,289
Yukon Territory	7,217,361	6,416,956	7,054,632	6,192,556
Quebec	4,115,105	3,658,740	4,108,241	3,606,214
Manitoba and Saskatchewan	1,665,482	1,480,780	1,561,266	1,370,479
Newfoundland	1,271,126	1,130,158	1,125,110	987,622
Northwest Territories	79,473	70,659	70,560	61,937
Total	34,016,829	30,244,363	31,923,969	28,022,860
By sources				
Base-metal ores	26,168,303		24,622,442	
Gold ores	675,769		629,581	
Silver-cobalt and silver ores	7,155,914		6,657,162	
Placer-gold ores	16,843		14,784	
Total	34,016,829		31,923,969	
Refined silver	21,932,773		21,770,510	
Exports				
In ore and concentrates				
United States	6,809,755	6,408,677	6,286,838	5,770,882
Belgium and Luxembourg	1,123,162	990,772	326,727	270,215
Japan	596,041	548,091	32,382	29,334
West Germany	365,538	305,071	168,918	139,744
United Kingdom	2,906	2,583		
Total	8,897,402	8,255,194	6,814,865	6,210,175
Silver bullion				
United States	12,738,617	11,294,327	15,075,769	13,452,501
Brazil	20,353	18,903	-	-
Other countries	2,093	2,139	65,061	58,676
Total	12,761,063	11,315,369	15,140,830	13,511,177

Silver - Production and Trade (cont'd)

	1960		1959	
	Troy Ounces	$	Troy Ounces	$
Exports (cont'd)				
Manufactures				
United States		9,990		23,450
New Zealand		976		522
Bermuda		932		2,675
Barbados		651		-
Jamaica		526		902
Other countries		1,121		11,349
Total		14,196		38,898
Imports				
Unmanufactured				
United States	3,323,014	3,002,439	846,638	746,510
Mexico	300,000	270,000	753,943	667,950
Peru	200,596	178,530	200,257	178,229
United Kingdom	3,092	2,874	1,005,051	889,354
Other countries	22,413	19,156	1,885	2,157
Total	3,849,115	3,472,999	2,807,774	2,484,200
Manufactured articles of silver, including toilet articles of sterling silver				
United Kingdom		380,841		362,075
United States		238,306		251,568
West Germany		60,903		49,066
Denmark		27,491		31,197
Other countries		31,237		25,048
Total		738,778		718,954

Source: Dominion Bureau of Statistics.

Part of the increase is attributed to greater industrial demand in France, Japan, and Western Germany and to increased coinage requirements in several countries, notably in France and Italy.

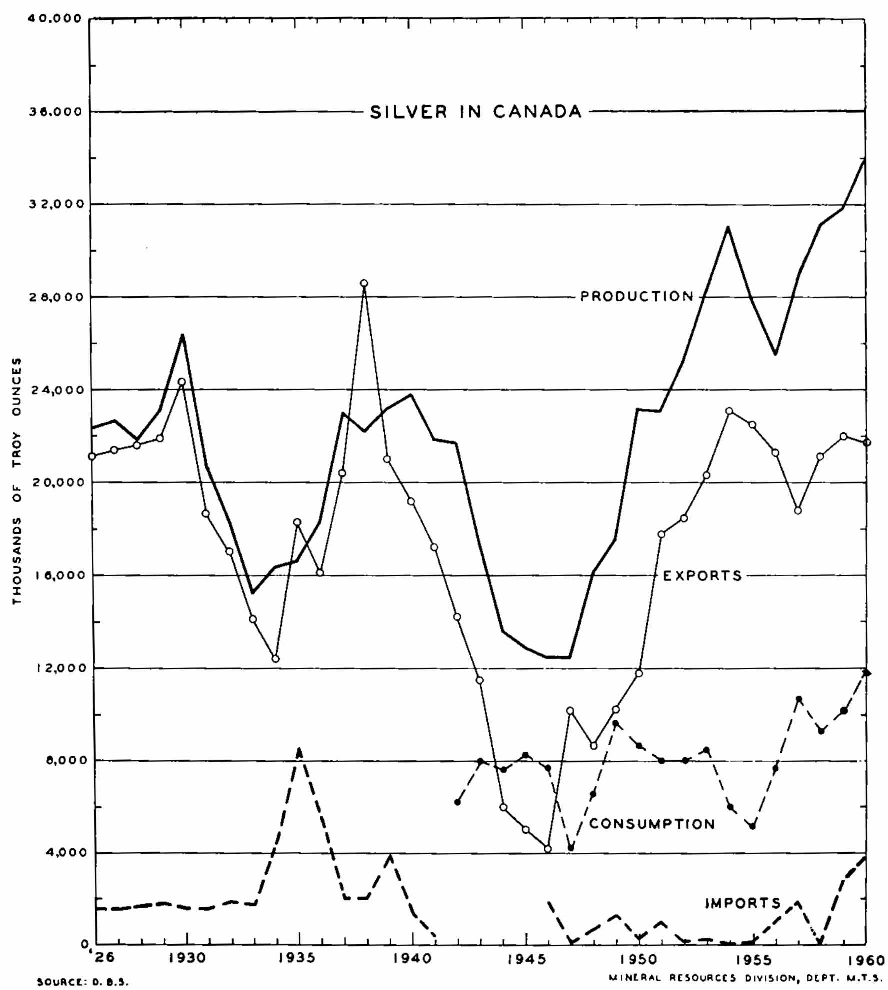
Silver - Production, Trade and Consumption, 1950-60
(troy ounces)

	Production		Exports			Imports	Consumption[b]
	All Forms[a]	Refined Silver	In Ore and Concentrates	In Bullion	Total	Unmanu-factured	
1950	23,221,431	19,435,644	3,494,107	8,355,183	11,849,290	341,605	8,668,866
1951	23,125,825	23,177,138	2,413,288	15,381,276	17,794,564	1,050,299	7,973,635
1952	25,222,227	21,045,592	3,546,448	14,928,515	18,474,963	145,898	8,031,873
1953	28,299,335	25,360,632	5,686,518	14,632,914	20,319,432	287,497	8,518,441
1954	31,117,949	19,424,154	8,672,340	14,467,015	23,139,355	60,165	5,996,563
1955	27,984,204	19,354,223	5,873,873	16,598,577	22,472,450	87,128	5,161,445
1956	28,431,847	21,599,798	6,924,414	14,341,753	21,266,167	1,010,180	7,710,925
1957	28,823,298	20,004,360	5,979,459	12,799,990	18,779,449	1,859,131	10,730,255
1958	31,163,470	24,620,142	5,098,788	16,026,550	21,125,338	2,701	9,299,809
1959	31,923,969	21,770,510	6,814,865	15,140,830	21,955,695	2,807,774	10,202,769
1960	34,016,829	21,932,773	8,897,402	12,761,063	21,658,465	3,849,115	11,742,064

Source: Dominion Bureau of Statistics.

(a) 1. Recoverable silver in ores, concentrates, and matte shipped for export.
2. Silver in crude gold bullion produced.
3. Silver in blister and anode copper made at Canadian smelters.
4. Silver in base bullion made by The Consolidated Mining and Smelting Company of Canada Limited at Trail, British Columbia.
5. Silver bullion produced from the treatment of cobalt-silver ores.

(b) Includes consumption for coinage.



Developments at Producing Mines

Yukon Territory

From the Calumet, Elsa, and Hector mines in the Mayo district during the fiscal year that ended on September 30, 1960, United Keno Hill Mines Limited mined 176,745 tons of ore with a recoverable silver content of 7,249,101 ounces. The company's highest annual production was the 7,307,815 ounces produced in the preceding fiscal year. Annual production was formerly about 6 million ounces.

Northwest Territories

As in previous years, practically all silver production came from four gold mines in the Yellowknife and Giauque Lake areas.

British Columbia

The principal source of silver in British Columbia was the 2,522,554 tons of lead-zinc-silver ore extracted from the Sullivan mine at Kimberly by The Consolidated Mining and Smelting Company of Canada Limited. In recent years more than 3 million ounces have been produced annually from Sullivan ore. Substantial amounts of silver were also produced by Cominco from 255,571 tons of ore from its Bluebell lead-zinc mine at Riondel and from 464,408 tons of ore from its H.B. zinc-lead mine near Salmo. Altogether, Cominco recovered 8,690,244 ounces from its own ore and from ore purchased for the most part from Canadian shippers. Silver was recovered also on a custom basis from domestic and foreign ores and concentrates, the principal shippers being in British Columbia and Yukon Territory.

Highland-Bell Limited, at Beaverdell, milled 18,204 tons of silver-lead-zinc, from which 903,614 ounces of silver were recovered in lead and zinc concentrates.

ViolaMac Mines Limited milled 6,227 tons of silver-zinc-lead ore from its Victor mine, near Sandon, in the 150-ton mill of a subsidiary, Carnegie Mining Corporation Limited. Silver production in lead and zinc concentrates was 99,176 ounces.

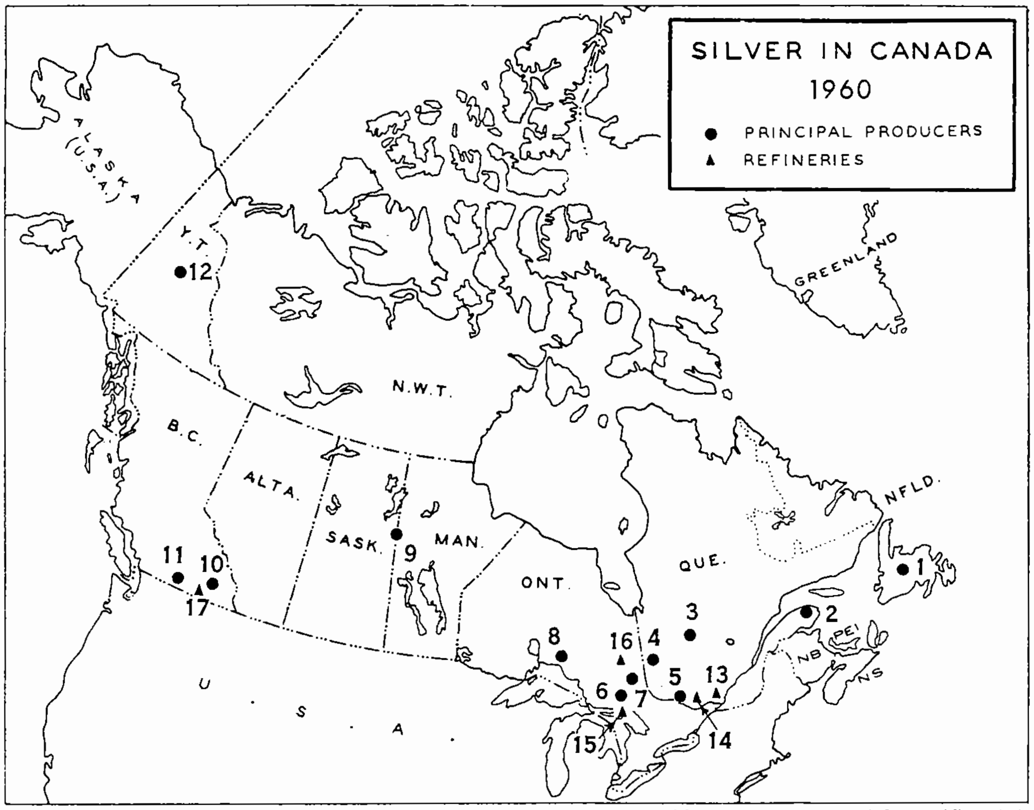
Sheep Creek Mines Limited milled 194,607 tons of zinc-lead ore from which 198,635 ounces of silver were recovered in lead and zinc concentrates.

Silver was also recovered from lead-zinc ores by Canadian Exploration, Limited, near Salmo, and Reeves MacDonald Mines Limited, at Remac. Other operators including Bermah Mines Ltd., near Stewart, New Cronin Babine Mines Limited, near Smithers, and Silver Ridge Mining Company Limited, near Sandon, mined small quantities of high-grade ore. Some of this ore was concentrated on a custom basis in mills operated by Yale Lead & Zinc Mines Limited and Carnegie Mining Corporation Limited; most of the remainder was smelted without prior concentration other than hand-sorting.

Some production was obtained from copper ores by Consolidated Woodgreen Mines Limited and Phoenix Copper Company Limited, in the Grand Forks area, by Howe Sound Company (Britannia Division) at Howe Sound, by Texada Mines Ltd., on Texada Island, and by Cowichan Copper Co. Ltd., on Vancouver Island.

Manitoba and Saskatchewan

Hudson Bay Mining and Smelting Co., Limited, produced 1,645,544 ounces of silver contained in blister copper from copper-zinc mines in the Flin Flon area and from the Chisel Lake zinc-copper mine at Snow Lake, Manitoba. Production at the Chisel Lake mine began on September 1 at about 1,000 tons a day.



Principal Producers

1. American Smelting and Refining Company (Buchans Unit)
2. Gaspe Copper Mines, Limited
3. Campbell Chibougamau Mines Ltd.
   Opemiska Copper Mines (Quebec) Limited
4. Manitou-Barvue Mines Limited
   East Sullivan Mines Limited
   Noranda Mines, Limited
   Quemont Mining Corporation, Limited
   Waite Amulet Mines, Limited
   Normetal Mining Corporation, Limited
5. New Calumet Mines Limited
6. Silver Miller Mines Limited
   Agnico Mines Limited
   Deer Horn Mines Limited
   Langis Silver & Cobalt Mining Company Limited
   McIntyre-Porcupine Mines Limited, Castle Division
   Siscoe Metals of Ontario Limited
7. International Nickel Company of Canada, Limited, The
   Falconbridge Nickel Mines, Limited
8. Geco Mines Limited
   Willroy Mines Limited
9. Hudson Bay Mining and Smelting Co., Limited
10. Consolidated Mining and Smelting Company of Canada Limited, The
    Bluebell mine
    Sullivan mine
    Sheep Creek Mines Limited
    ViolaMac Mines Limited
11. Mastodon-Highland Bell Mines Limited
12. United Keno Hill Mines Limited

Refineries

13. Canadian Copper Refiners Limited
14. Royal Canadian Mint
15. International Nickel Company of Canada, Limited, The
16. Hollinger Consolidated Gold Mines, Limited
17. Consolidated Mining and Smelting Company of Canada Limited, The

In Manitoba, small amounts of silver were recovered as a by-product of nickel-copper ore produced by Sherritt Gordon Mines, Limited at Lynn Lake and of gold produced by San Antonio Gold Mines Limited and Forty-Four Mines, Limited at Rice Lake.

Ontario

Silver-cobalt mining companies in the Cobalt-Gowganda area produced about 50 per cent of the province's output. Most of this silver passed through the sampling plant of Temiskaming Testing Laboratory, at Cobalt, as the accompanying table shows. A large part of the Cobalt-Gowganda production was treated at the Deloro refinery of Deloro Smelting & Refining Company, Limited. Since mid-1960, however, shipments to other plants both in Canada and abroad have increased, the company having announced in May that it intended to close the plant. The Deloro plant is expected to be permanently closed early in 1961.

Shipments via Temiskaming Testing Laboratory

Company	Silver Bullion	Silver Concentrates	Total
	(ounces)	(content in ounces)	(ounces)
Agnico Mines Limited	452,030	416,653	868,683
Deer Horn Mines Limited	141,527	308,298	449,825
Langis Silver & Cobalt Mining Company Limited	79,577	919,887	999,464
McIntyre-Porcupine Mines, Limited, Castle Division	197,865	921,209	1,119,074
Silver Miller Mines Limited	117,677	219,324	337,001
Siscoe Metals of Ontario Limited	218,817	763,825	982,642
Temiskaming Testing Laboratory	27,347	45,978	73,325
Total	1,234,840	3,595,174	4,830,014

Source: Department of Mines, Ontario.

The International Nickel Company of Canada, Limited, at Copper Cliff, recovered 1,510,000 ounces of silver from the treatment of nickel-copper ores.

In the Manitouwadge area, 1,391,177 ounces of silver were recovered in copper concentrates produced by Geco Mines Limited from 1,294,077 tons of copper-zinc ore. From 429,309 tons of zinc-copper-lead ore milled at the adjacent Willroy mine, operated by Willroy Mines Limited, copper and lead concentrates were produced containing 592,000 ounces of silver.

The rest of Ontario's production was from Falconbridge Nickel Mines, Limited, Temagami Mining Co. Limited, and numerous lode-gold mines.

Quebec

All production was by-product derived mainly from copper ores. At Noranda, copper concentrates from a number of mines in the Noranda-Val d'Or and Chibougamau areas are converted into anode copper in the smelter operated by Noranda Mines, Limited. The anode copper is refined by Canadian Copper Refiners Limited, Montreal East, where the silver is recovered. Canadian Copper Refiners also recovers silver from blister copper produced by Gaspé Copper Mines, Limited, in the smelter at Murdochville on the Gaspé Peninsula. Silver is also contained in lead and zinc concentrates from several mines. These concentrates are shipped abroad for treatment.

The principal producers in 1960 were: Noranda Mines, Limited, Manitou-Barvue Mines Limited, Normetal Mining Corporation, Limited, Quemont Mining Corporation, Limited, East Sullivan Mines Limited, and Waite Amulet Mines, Limited - all in the Noranda-Val d'Or area of western Quebec; New Calumet Mines Limited, 70 miles northwest of Ottawa; Gaspé Copper Mines, Limited, at Murdochville; and, in the Chibougamau area, Campbell Chibougamau Mines Ltd., Opemiska Copper Mines (Quebec) Limited, Copper Rand Chibougamau Mines Ltd., and Merrill Island Mining Corporation, Ltd.

In western Quebec some by-product silver was obtained from lode-gold mines.

Newfoundland

At Buchans, American Smelting and Refining Company treated 386,000 tons of zinc-lead-copper ore and produced zinc, lead, copper, and gravity concentrates containing silver. These concentrates were exported to the United States and Europe for recovery of the contained metals.

Other Developments

British Columbia

A revival of interest was shown in several small mining properties in the southeastern part of the province. These included the Ptarmigan mine, in the Windermere district, and the Ottawa, Lone Bachelor, and Black Fox mines in the Slocan district.

Ontario

Exploration in the Cobalt and Gowganda areas was at a high level. Among the more active companies in these areas were Coballoy Mines &

Refiners Limited, Norgold Mines, Limited, Realm Mining Corporation Limited, Siconor Mines Limited, and United Cobalt Mines Limited.

Quebec

A six-compartment shaft was completed to a depth of 1,185 feet on the Mattagami Lake zinc-copper property of Mattagami Lake Mines Limited and lateral development was started on three main levels. Some 23 million tons of ore averaging about 12.5 per cent zinc, 0.7 per cent copper, and 1.3 ounces of silver per ton have been outlined. New Hosco Mines Limited and Orchan Mines Limited, also in the Mattagami Lake area, have reported substantial reserves of copper and zinc ores containing recoverable values in silver.

Early in 1961, the federal government authorized construction of a 60-mile branch railway to serve the Mattagami Lake area.

In the Bachelor Lake area, The Coniagas Mines, Limited completed underground development of its silver-zinc-lead property and began the construction of a 350-ton mill, which it planned to have in operation early in 1961.

Consolidated Vauze Mines Limited did extensive exploratory drilling from levels recently developed in its copper-zinc property north of Noranda. Appreciable quantities of silver are present in the ore. Surface and underground exploration by East Sullivan Mines Limited and Solbec Copper Mines, Ltd., in an area some 50 miles northeast of Sherbrooke has revealed two base-metal deposits containing about 1.3 ounces of silver per ton in addition to sizable amounts of copper and zinc. Shaft-sinking on the Solbec property was started in September 1960.

Yukon Territory

Ketzakey Silver Mines Limited was active on a 44-claim silver prospect 26 miles northwest of Ross River. About 36 miles of access road have been constructed from the Ross River area.

Uses and Consumption

Silver finds its greatest use in coinage. It is also used extensively in the manufacture of silverware and plating and in photography. Large amounts are used in solders, brazing alloys, and wire by manufacturers of electrical instruments, aircraft, and household appliances. Silver is one of the main components of highly efficient jet-aircraft and missile batteries, and its use in the purification of water is increasing.

Consumption of Silver
(troy ounces)

Use	1960	1959
Coinage	7,481,617	5,737,347
Silverware	1,645,647	1,513,929
Photography	1,410,166	1,376,004
Wire and rod	46,257	21,143
Silver alloys and solders	129,946	140,223
Miscellaneous*	1,028,431	1,414,123
Total	11,742,064	10,202,769

Source: Dominion Bureau of Statistics.
*Includes sheet, anodes for electroplating, and silver used in the manufacture of electrical equipment and jewelry.

Prices

There was almost a daily fluctuation in the Canadian price of silver, which ranged from a low 87.13 cents an ounce in March to a high of 91.38 cents in December. The opening and closing prices for 1960 were 87.38 cents and 91.38 cents respectively.

SODIUM SULPHATE

C. M. Bartley*

Production and shipments of sodium sulphate, which is derived from natural deposits in Saskatchewan, increased substantially in 1960 to an all-time high of 214,208 tons worth $3,449,155. An increase in orders from kraft-paper manufacturers, who are the main consumers, was the principal cause of the rise in sales. A small total of sales to glass manufacturers is reported, and a future consumption increase is expected in this market and in the markets for such products as detergents, mineral feed supplements, and textile-dye baths. Exports, at 63,831 tons, were 33 per cent higher than in 1959; imports, at 25,857 tons, were 8 per cent lower.

Sodium sulphate was first produced in Saskatchewan in 1919, when 15 tons valued at $450 were marketed. Although production has fluctuated widely from year to year, shipments have increased on an average of more than 5,000 tons a year over the past 40 years. The Royal Commission on Canada's Economic Prospects (1957) estimated that pulp-and-paper requirements would more than double between 1954 and 1980, and this estimate is supported by more recent studies. It is probable that the demand for sodium sulphate will continue to rise as the output of kraft paper grows and markets in glass and detergents expand.

Deposits

The Saskatchewan sodium-sulphate deposits occur in lakes or ponds in closed drainage basins. Normal precipitation dissolves sulphate contained in the soil, and the solutions collect in depressions. Evaporation during the summer reduces the water content and concentrates the solution, and the cooler fall and winter temperatures cause crystallization of the contained salts, which sink to the bottom and accumulate as a bed of crystals. The repetition of this process over a long period has built up considerable thicknesses of sodium sulphate in many lakes and depressions throughout central and southern Saskatchewan. The total of the reserves is very large.

Sodium sulphate occurs in nature as the mineral Glauber's salt, or mirabilite ($Na_2SO_4 10H_2O$), and to a lesser extent as anhydrous sodium sulphate, or thenardite (Na_2SO_4). Mirabilite is soluble in water, and the solubility rises with temperature. Conversely, a concentrated solution of sodium sulphate in water crystallizes as the temperature falls and forms crystals of Glauber's salt. This behavior, together with the wide variation between summer and winter temperature in Saskatchewan, facilitates the recovery of the mineral from natural occurrences.

*Mineral Processing Division.

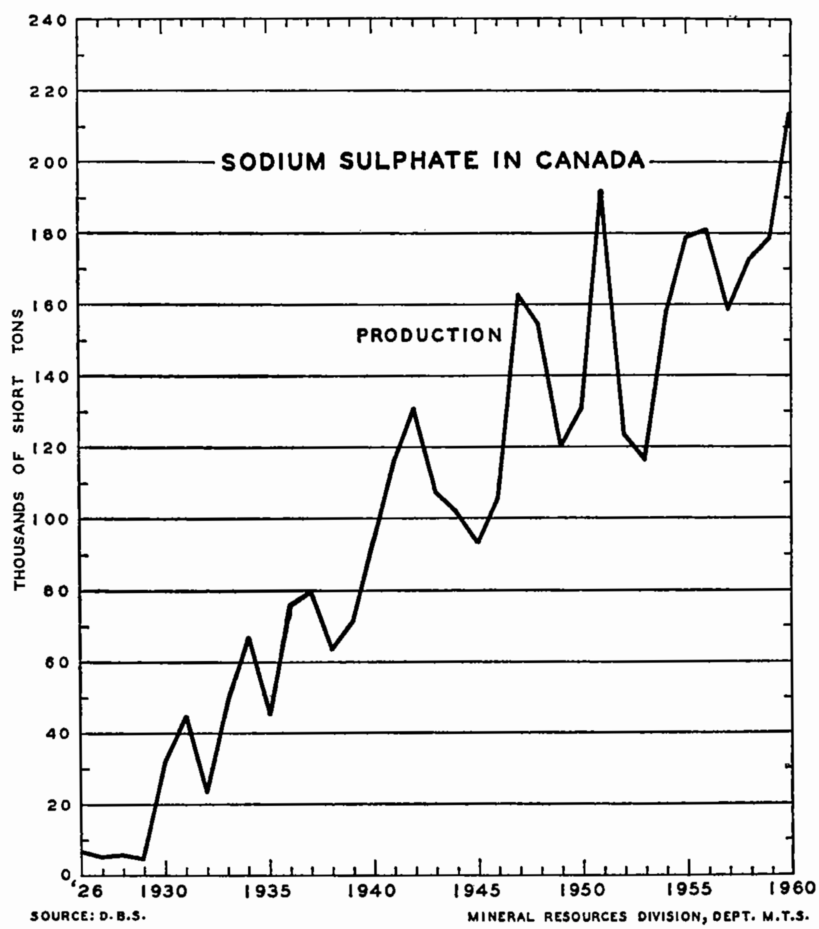
Production, Trade and Consumption

	1960		1959	
	Short Tons	$	Short Tons	$
Production (shipments)	214,208	3,449,155	179,535	2,881,861
Imports				
Crude sodium sulphate, or salt cake				
United States	14,270	247,451	18,058	311,554
United Kingdom	10,419	224,247	9,099	199,608
West Germany	17	386	-	-
Total	24,706	472,084	27,157	511,162
Glauber's salt				
West Germany	871	21,409	562	17,373
United States	277	16,407	403	22,224
United Kingdom	3	534	1	310
Total	1,151	38,350	966	39,907
Exports				
Crude sodium sulphate				
United States	63,831	1,025,632	47,922	752,116
	1959		1958	
Consumption				
Pulp and paper	145,501		164,556	
Glass, including glass wool	3,135		2,357	
Medicinals	-		52	
Soaps	2,733		814	
Other products	460		288	
Total	151,829		168,067	

Source: Dominion Bureau of Statistics.

Recovery and Processing

Early attempts at the recovery of sodium sulphate from these deposits consisted in collecting the solid crystallized mineral from dry lake bottoms in the winter. Mechanical equipment such as scrapers and loaders was used, and the material recovered included muds and debris which made processing and grade control difficult. Under the method now practised, the mineral-bearing solution is pumped from the lakes into reservoirs, where its concentration by evaporation can be controlled more closely. In cold weather, when the concentrated solution



crystallizes and the mineral precipitates, any liquid remaining is pumped back to the lake, and what is left is pure sodium sulphate. This is then collected mechanically with little danger of contamination.

Another method, used by Ormiston Mining and Smelting Co. Ltd., consists in excavating sodium-sulphate crystals from the lake bed by means of a floating dredge and pumping them and sodium-sulphate solution through a 10-inch pipeline to the plant.

Natural sodium sulphate is made marketable by being dehydrated to a granular or powdered anhydrous salt. Removal of the water of crystallization reduces the weight by more than 50 per cent. This not only lowers transportation charges but gives greater consistency and uniformity in the physical and chemical characteristics.

Dehydration is carried out by several methods, which range from slow drying in large rotary kilns operated on low-grade coal, oil, or gas, to more elaborate processes requiring stainless-steel convection evaporators or submerged-combustion evaporators and the use of gas as fuel. In recent years efficiency has been increased and maintenance costs have been reduced by changing from coal or oil to natural gas.

Even the product of the simpler dehydration processes is suitable for the manufacture of kraft paper, but attempts are being made to serve additional markets, such as those of glass and detergents, by producing a whiter product and maintaining closer control of grain size to make handling easier. Its higher degree of chemical purity often makes natural sodium sulphate more desirable than the artificial or by-product material.

Production, Trade and Consumption, 1950-60
(short tons)

	Production(1)	Imports		Exports(2)	Consumption
		Salt Cake	Glauber's Salt		
1950	130,730	15,705	2,256	28,375	115,937
1951	192,371	19,432	3,234	63,179	144,144
1952	122,590	19,576	4,577	27,144	116,786
1953	115,565	32,802	5,493	20,132	129,698
1954	158,417	30,235	5,134	66,049	138,275
1955	178,888	29,927	3,888	76,894	142,055
1956	181,053	30,319	2,768	60,579	161,273
1957	157,800	28,088	1,512	37,023	163,743
1958	173,217	25,813	1,217	39,763	168,067
1959	179,535	27,157	966	47,922	151,829
1960	214,208	24,706	1,151	63,831	161,159

Source: Dominion Bureau of Statistics.
(1) Producers' shipments of crude sodium sulphate.
(2) Exports to the United States from 1950 to 1954 inclusive are taken from United States import statistics.

Production and Trade

Because more than 90 per cent of the output of sodium sulphate - or 'salt cake,' as it is commercially known - is consumed in the manufacture of kraft paper, production and sales are closely related to the rate of activity of this industry in Canada and the United States. Salt cake is also a by-product of certain chemical processes and, as such, it competes successfully with natural sodium sulphate in areas where it has a freight-cost advantage. Artificial salt cake from the United States and Europe is particularly competitive in eastern Canada. For example, it partially excludes Saskatchewan salt cake from this market.

By-product salt cake is obtained largely in the manufacture of rayon and Mannheim-process hydrochloric acid. As these industries seem to be declining while the production of other forms of synthetic fibre and other sources of hydrochloric acid expand, the amounts of by-product sodium sulphate available in the future may be smaller. This long-term trend encourages natural-salt-cake producers to improve their product, expand operations, and search for additional markets.

The main problem facing Saskatchewan sodium-sulphate producers is the relatively high cost of transporting their product to the larger markets on the east and west coasts and to the United States. The railways have reduced their rates to a certain extent, but for the present it seems unlikely that there will be any further improvement.

Producing Companies

All four producers in Saskatchewan operated at higher rates than in 1959, and production and shipments reached their highest in the history of the industry. During the year several companies made changes in equipment or method to improve efficiency and reduce operating costs.

Sybouts Sodium Sulphate Co., Ltd.

This producer, operating at Gladmar, near the southern boundary of the province, has a plant capacity of 30,000 tons a year. Production was at a high level during 1960, and demand is expected to increase in 1961.

Ormiston Mining and Smelting Co. Ltd.

With a plant on Horseshoe Lake, south of Moose Jaw, Ormiston had a capacity of 50,000 tons a year in 1960 and plans to expand during 1961. Operation in 1960 was near capacity. During the year, a natural-gas pipeline was laid to the plant, and dehydration was changed from a coal- to a gas-heat basis, with consequent improvements in costs and efficiency. In 1961 submerged-combustion equipment will be installed and drying by rotary kiln will be discontinued. These changes are expected to bring marked improvements in output and operating costs.

Ormiston's method, already mentioned, of recovering crystals and concentrated brine from the lake by dredging and pumping is unique in the industry. Although the production thus obtained is satisfactory, improvements are being made continually as operating experience grows.

Saskatchewan Minerals, Sodium Sulphate Division

Operating at Chaplin, about 40 miles west of Moose Jaw, this company recovers sodium sulphate from Chaplin Lake. The Chaplin plant has a capacity of 150,000 tons a year, and an additional 100,000 tons could be produced at a currently inactive plant at Bishopric. The company estimates that reserves of 15 million tons of crystalline sodium sulphate are available in Chaplin Lake in addition to reserves in four other deposits.

The year's production, at more than 80,000 tons, was the largest in Saskatchewan and was substantially greater than that of 1959. Improvement is expected to continue during 1961. Recovery consists in controlled evaporation in artificial reservoirs, mechanical collection of the precipitated crystal, and dehydration in evaporators and rotary kilns. Gas is used as fuel, and stainless-steel equipment is effectively used to reduce corrosion, thereby contributing to operating efficiency.

During 1960, the company conducted a grade-improvement research program to increase sales to glass and detergent industries. It plans to expand its facilities to meet an expected increase in orders from kraft-paper producers and other industries. Although most of the output is consumed in Canada, substantial amounts are being exported to the United States. The appointment of a sales agent in the eastern United States has increased sales.

Midwest Chemicals Limited

Near Palo, on Whiteshore Lake, in west-central Saskatchewan, Midwest operates a plant with a capacity of more than 100,000 tons a year. In 1960 production and shipments were greater than in 1959.

Plant changes made in 1960 included the installation of a third submerged-combustion unit and the construction of additional product-storage capacity to a total of 6,000 tons. Midwest Chemicals Limited has found submerged combustion a satisfactory processing method because operating efficiency and production have increased with its use. Sales were made largely to kraft-paper manufacturers, about two thirds of the sodium sulphate sold going to Canadian buyers and one third being exported. The company expects to increase its sales in 1961.

Outlook for the Canadian Industry

Over the past three years the outlook for Canada's natural-sodium-sulphate industry has improved, and the betterment seems to be based on long-term trends that will bring further improvement.

In Canada, pulp and paper manufacturers consume about 95 per cent of the salt cake sold. This market fluctuates with the kraft-paper demand, but it has increased from 137,000 tons in 1955 to 200,000 tons in 1960. The amount of sodium sulphate used per ton of pulp has decreased markedly, but the kraft-paper industry has so expanded its production capacity that the consumption of salt cake has nevertheless increased. Besides, the glass, soap, and other industries have been using larger amounts in recent years, and producers hope that the growing sales to these consumers will result in a larger and a more diversified market. By-product sodium sulphate is produced by Courtaulds (Canada) Limited, at Cornwall, Ontario. Shipments are normally less than 5 per cent of the natural-salt-cake output, but sales are assured by proximity to the markets of eastern Canada.

In the United States, where 30 per cent of the salt cake produced in Canada is exported and where more than half the sodium sulphate consumed is derived from by-product sources, the growth in demand, together with the decline in such by-product sources as rayon-manufacturing and the production of Mannheim- and Hargreaves-process hydrochloric acid, gives reason to expect an expansion in sales of natural salt cake. The present United States sources of natural sodium sulphate are mostly in California and Texas. Salt cake from California is exported to the west coast of Canada, but that state's resources, although large, are not as well situated geographically as the Saskatchewan deposits to serve the industries of the eastern United States.

In the United States the consumption pattern is more diversified than in Canada. Since 1950 the apparent consumption has averaged more than a million tons a year used in the manufacture of kraft paper (70 per cent), glass manufacture (10 per cent), and detergents (7 per cent) and for the other industrial purposes and export (about 13 per cent). The recent efforts of Canadian producers to improve the chemical and physical specifications of their product so as to increase their sales to industries manufacturing products other than kraft paper should widen their markets in Canada and, at the same time, enable them to increase their sales to such industries in the United States. Evidence that the supply of sodium sulphate for United States consumers is becoming restricted appeared late in 1960 when a price increase of $2 a ton became effective.

Prices

Canada

The Canadian price of sodium sulphate (salt cake), bulk, carload, f.o.b. works, as reported by Canadian Chemical Processing in October 1960, was $16.50 a ton.

United States

According to Oil, Paint and Drug Reporter of December 26, 1960, United States prices of sodium sulphate were as follows:

Anhydrous	Per short ton, technical-grade, bags, car lots	$ 54.00
Detergent	Per short ton, rayon-grade, car lots	
	Bags, f.o.b. works	$ 38.00
	Bulk	$ 34.00
Crude (salt cake)	Per short ton, 100% Na_2SO_4, domestic, bulk, f.o.b. works	$ 28.00

Tariffs

	British Preferential	Most Favored Nation	General
Canada			
Crude, or salt cake, per lb	1/5¢	1/5¢	3/5¢
United States			
Crude, or crude salt cake	free		
Anhydrous, per long ton	$1.27		
Crystallized, or Glauber's salt, per long ton	$1.00		

BUILDING AND ORNAMENTAL STONE

F.E. Hanes*

The production of all types of building and ornamental stone amounted in 1960 to 200,496 short tons valued at $5.5 million. This volume represents a 16.8-per-cent increase over that of 1959. The decrease in value, amounting to $1,032,876, or 15.8 per cent, can be accounted for by the lower average value prevailing during the year for stone from Ontario and Quebec, the principal stone-producing provinces.

Although Ontario increased its production by 32,586 short tons, the average value of its stone per short ton decreased from $15.55 in 1959 to $8.66 in 1960. For the same years, the output of both rough and dressed sandstone products for building-stone construction in Ontario increased from 21,306 to 71,101 short tons but decreased in value from $632,661 in 1959 to $400,004.

Granite production in Quebec was 810 tons greater in volume than in 1959, but the average value per short ton decreased from $74.91 to an estimated $62.81. Lower values for dressed monumental and rough building-stone granite products were another factor in the general value decrease. Both Quebec and British Columbia products were thus affected.

Ontario produced the largest volume of all types of stone, 118,939 short tons. Quebec, the second-ranking producer, shipped 60,483 short tons The two provinces combined account for 89.5 per cent of Canada's output. Ontario led in limestone and sandstone, and Quebec in granite.

British Columbia produced only granite, in which it ranked second to Quebec in volume, with Ontario and New Brunswick following. Nova Scotia and Manitoba, the remaining granite-producing provinces, ranked fifth and sixth respectively in volume of output. Quebec, whose output was worth $2.7 million in 1960, is far ahead of all other provinces in terms of production value and has no real competitor in the Canadian granite industry. The remaining provinces, in order of importance for 1960, were Nova Scotia, Ontario, New Brunswick, British Columbia, and Manitoba.

The three principal limestone-producing provinces were Ontario, Quebec, and Manitoba. Quebec led in value at $910,706 while the value of Ontario's and Manitoba's shares amounted to $492,640 and $466,951 respectively. New Brunswick's small limestone production had a low value per ton and was worth a little less than $7,000.

(text continued on page 520)

*Mineral Processing Division, Mines Branch.

Production of Building and Ornamental Stone, 1960

	Granite		Limestone		Marble		Sandstone		Slate and Shale		Total	
	S. Tons	$	S. Tons	$	S. Tons	$	S. Tons	$	S. Tons	$	S. Tons	$
Building stone												
Rough	16,123	355,736	35,237	348,011	32	1,485	69,811	350,968	-	-	121,203	1,056,220
Dressed	15,860	1,595,754	25,204	1,505,045	45	1,500	1,290	49,016	-	-	42,399	3,151,315
Total	31,983	1,951,490	60,441	1,853,056	77	2,985	71,101	400,004	-	-	163,602	4,207,535
Monumental and ornamental												
Rough	11,276	276,939	-	-	-	-	-	-	-	-	11,276	276,939
Dressed	8,806	887,823	-	-	-	-	10	900	-	-	8,816	888,723
Total	20,082	1,164,762	-	-	-	-	10	900	-	-	20,092	1,165,662
Flagstone	849	11,886	7,517	24,179	-	-	7,676	84,154	-	-	16,042	120,219
Curbstone	261	3,908	-	-	-	-	-	-	-	-	261	3,908
Paving blocks	233	8,874	-	-	-	-	266	12,000	-	-	499	20,874
Total	1,343	24,668	7,517	24,179	-	-	7,942	96,154	-	-	16,802	145,001
Grand total	53,408	3,140,920	67,958	1,877,235	77	2,985	79,053	497,058	-	-	200,496	5,516,198

Production of Building and Ornamental Stone, 1959

	Granite		Limestone		Marble		Sandstone		Slate and Shale		Total	
	S. Tons	$	S. Tons	$	S. Tons	$	S. Tons	$	S. Tons	$	S. Tons	$
Building stone												
Rough	14,765	295,014	51,772	520,489	256	8,232	19,906	479,821	-	-	86,699	1,303,556
Dressed	20,619	2,290,643	34,956	1,546,104	525	45,275	1,400	152,840	-	-	57,500	4,034,862
Total	35,384	2,585,657	86,728	2,066,593	781	53,507	21,306	632,661	-	-	144,199	5,338,418
Monumental and ornamental												
Rough	9,923	250,715	-	-	-	-	-	-	-	-	9,923	250,715
Dressed	5,954	831,306	-	-	-	-	4	4,386	-	-	5,958	835,692
Total	15,877	1,082,021	-	-	-	-	4	4,386	-	-	15,881	1,086,407
Flagstone	800	10,000	3,716	11,297	-	-	6,033	75,002	-	-	10,549	96,299
Curbstone	505	17,366	50	250	-	-	-	-	-	-	555	17,616
Paving blocks	181	1,934	-	-	-	-	307	10,400	-	-	488	12,334
Total	1,486	29,300	3,766	11,547	-	-	6,340	85,402	-	-	11,592	126,249
Grand total	52,747	3,696,978	90,494	2,078,140	781	53,507	27,650	722,449	-	-	171,672	6,551,074

Source: Dominion Bureau of Statistics.

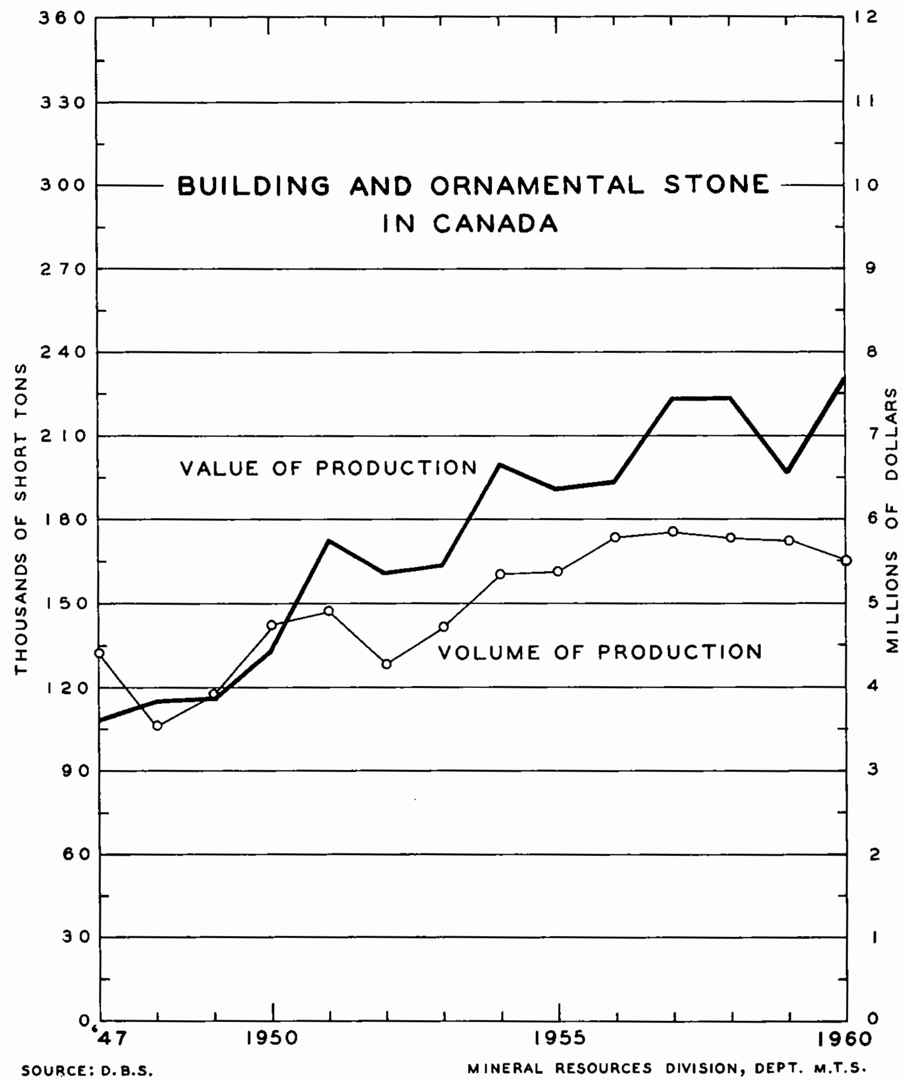
Production of Building and Ornamental Stone, by Province, 1960

	Granite		Limestone		Marble		Sandstone		Slate and Shale		Total	
	S. Tons	$	S. Tons	$	S. Tons	$	S. Tons	$	S. Tons	$	S. Tons	$
Nova Scotia	818	196,737	-	-	-	-	2,240	62,816	-	-	3,058	259,553
New Brunswick	1,939	100,171	1,102	6,938	-	-	-	-	-	-	3,041	107,109
Quebec	42,699	2,681,932	17,707	910,706	77	2,985	-	-	-	-	60,483	3,595,623
Ontario	3,566	112,535	38,914	492,640	-	-	76,459	424,695	-	-	118,939	1,029,870
Manitoba	58	686	10,235	466,951	-	-	-	-	-	-	10,293	467,637
Alberta	-	-	-	-	-	-	354	9,547	-	-	354	9,547
British Columbia	4,328	48,859	-	-	-	-	-	-	-	-	4,328	48,859
Total	53,408	3,140,920	67,958	1,877,235	77	2,985	79,053	497,058	-	-	200,496	5,518,198

Production of Building and Ornamental Stone, by Province, 1959

	Granite		Limestone		Marble		Sandstone		Slate and Shale		Total	
	S. Tons	$	S. Tons	$	S. Tons	$	S. Tons	$	S. Tons	$	S. Tons	$
Nova Scotia	1,748	246,595	-	-	-	-	1,884	58,477	-	-	3,632	305,072
New Brunswick	2,704	193,864	1,726	8,546	-	-	1,275	125,400	-	-	5,705	327,810
Quebec	41,889	3,138,117	21,069	1,054,729	781	53,507	-	-	-	-	63,739	4,246,353
Ontario	1,989	57,832	60,028	751,490	-	-	24,336	533,922	-	-	86,353	1,343,244
Mantioba	17	170	7,671	263,375	-	-	-	-	-	-	7,688	263,545
Alberta	-	-	-	-	-	-	155	4,650	-	-	155	4,650
British Columbia	4,400	60,400	-	-	-	-	-	-	-	-	4,400	60,400
Total	52,747	3,696,978	90,494	2,078,140	781	53,507	27,650	722,449	-	-	171,672	6,551,074

Source: Dominion Bureau of Statistics.



Ontario, Nova Scotia, and Alberta shipped all the sandstone produced in Canada during 1960, Ontario's share being 96.5 per cent of the volume and 84.2 per cent of the value.

Only Quebec produced marble. No slate or shale was produced in 1960.

Newfoundland, Prince Edward Island, and Saskatchewan do not produce building or monumental stone. Either they lack suitable deposits, or the deposits of potential dimension stone that do exist - those in Newfoundland, for instance - are not within economic transportation distance of markets.

Imports and Exports

An increase of almost 3.4 per cent raised the value of the building, ornamental, and monumental stone imported from its 1959 level of $2,749,390 to $2,842,490 for 1960. Granite, marble, and slate imports, both rough and finished, increased while limestone imports decreased. Marble, the principal import, accounted for 44.1 per cent of the total value paid for foreign stone. Limestone made up 26.5 per cent of the value, granite 25.9 per cent, and slate 3.5 per cent.

Because the quantities of unwrought granite and marble block exported were much larger than in 1959 and worth $108,475 more, the value of exports increased in 1960 by 13.4 per cent. A rise of $1,913 in the value of the exports of unwrought limestone and other building stones helped to offset a decrease of $72,533, or 67.6 per cent, in the value of dressed-stone products of all types, which accounted for only 10.8 per cent of the year's export total.

Dimension Stone

The term 'dimension stone' is applied to blocks or slabs quarried from massive deposits of natural rock. The rock may be composed of igneous, metamorphic, or sedimentary materials, but the assemblage of minerals contained therein must be well indurated to ensure the recovery of large blocks in sound condition. Dimension stone is used for the construction of buildings, memorials, and ornamented columns or statuary. It is therefore essential that a deposit be carefully examined so that any weakness or defect that could result in structural failure or low-quality material may be detected before quarrying is started.

Structural failure in blocks quarried from near the surface or at depth often goes unnoticed until the blocks are lifted from the quarry. Some defects, not seen on the surface, show up only after sawing and polishing and result in downgrading of the finished stone product.

Many of these hazards may be avoided before a large capital investment has been made by careful consideration of the following points in the order of their presentation:

1. A deposit of potentially marketable stone should be assessed for its probable production capacity from surface showings. The general and local geological association of the type of stone must be considered.

2. Outcrops not only of the main deposit but of similar deposits in the same area, should be amply sampled by surface channelling or other suitable methods to detect surface expressions of deep-seated faults or defects.

3. When the information referred to in Nos. 1 and 2 has been analyzed, the opinion of an experienced geologist or quarryman should be obtained.

4. The deposit must be investigated at depth, and the most economical method of doing this is core-drilling.

Ornamental and Building Stone - Imports and Exports

	1960		1959	
	Quantity	$	Quantity	$
Imports				
Granite				
Rough, not hammered or chiselled		331,396		294,151
Sawn		96,041		115,146
Manufactures		307,850		298,816
Total		735,287		708,113
Marble				
Rough, not hammered or chiselled		62,833		58,437
Sawn or sand-rubbed, not polished		760,549		757,749
Not further manufactured than sawn for the manufacture of tombstones		34,102		45,737
Ornamental or decorative		200,328		166,948
All other marble manufactures		196,174		144,352
Total..................		1,253,986		1,173,223
Slate				
Roofing (squares).......	1,194	30,112	1,185	21,779
Manufactures		70,541		43,163
Total		100,653		64,942
Building stone other than marble or granite (short tons)	29,477	752,564	32,512	803,112
Total, building, ornamental, and monumental stone ...		2,842,490		2,749,390
Exports				
Granite and marble, unwrought (short tons)	16,135	280,598	8,540	172,127
Freestone, limestone, and other building stone, unwrought (short tons)...	227	5,838	142	3,925
Stone of all kinds, dressed		34,771		107,304
Total		321,207		283,356

Source: Dominion Bureau of Statistics.

5. A coring pattern suited to the particular conditions of the area and rock should then be outlined.

6. Detailed study of cores is the best assurance against unnecessary expenditure in premature full-scale quarrying. From them, structural and textural information should be obtained by a study of the following:

(a) the type and character of all sheeting or bedding planes, fracture zones, and joint systems;

(b) the nature and extent of intrusive bodies, interbedded and fracture-filling foreign material, inclusions, and concretions;

(c) local variations in massive phases of the rock caused by differential heat during formation; also color permanence, mineralogical associations, and zones of porosity and permeability;

(d) the presence and variety of such deleterious materials as iron-staining oxides and sulphides, chert and some siliceous minerals, clay and carbonaceous material;

(e) the extent and shape of large fracture-free zones of thick-bedded, massive rock of uniform composition, even texture, and pleasing, even-colored continuity;

(f) any interruption of normal drilling progress and core recovery, as indicated by a careful examination of drill logs;

(g) the weatherability and durability of cores from different locations and depths as shown by specified physical and chemical test procedures;

(h) a thorough petrographic record of all cores.

Building and Ornamental Stones, by Types

Granite

The term 'granite' includes both true granites and most other igneous and metamorphic rock types such as syenites, diorites, and fine- and coarse-grained rocks of the diabase-gabbro-basalt class. Some quartzites have made excellent building-stone material. Ferromagnesian rocks containing plagioclase feldspar, augite, pyroxene, and hornblende are referred to as 'black granite.' They make suitable and popular building and monumental stone.

Nova Scotia

Gray granite is produced in the Halifax, Middleton-Nictaux, and Shelburne areas. Black diorite is quarried in the Shelburne area. A hard, siliceous type of stone referred to as 'iron stone' is sporadically produced in the Halifax area, while quartzitic rocks sometimes 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, gray-brown granite is produced near St. Stephen, and fine-to-medium-grained, gray, pink, and blue-gray granites are quarried in the Hampstead (Spoon Island) district. A brown, pink-gray, coarse-grained granite is sporadically quarried near Bathurst. A light-pink to salmon-colored, medium-grained granite comes from the Antinouri Lake district. Black granite is quarried in the Bocabec River area.

Quebec

Numerous quarries south of the St. Lawrence River supply fine-to-medium-grained gray and gray-white granites. These quarries are located in the Stanstead, Stanhope, St. Samuel-St. Sebastien, and St. Gerard areas. Fine- and medium-grained, dark gray-blue essexite is quarried on Mount St. Gregoire. A coarse-grained, dark-green nordmarkite is quarried in the Lake Megantic mountain area. A fine-grained, green granite is also produced in the St. Gerard area. A potential source of medium-grained, black granite with a slight reddish-brown cast has been found in the Stanstead area.

Various granite rocks of many colors and textures are quarried north of the St. Lawrence River. Red, brown, and black (anorthosite) granites are quarried in the Lake St. John-Chicoutimi area; blue-gray, rose-gray, deeper pink-gray and black-and-white gneissic granites come from the Rivière-a-Pierre district; pink, fine-grained granite is quarried in the Guenette area; 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; and an augen-type, coarse-grained, rose-pink granite is obtained from south of the Mont Tremblant area. A potential source of fine-quality labradorite is being quarried from an island in northern Labrador.

Ontario

A salmon-pink, medium-grained granite is quarried in the Vermilion Bay area, and a black anorthosite is produced in the River Valley area. Rough building blocks are quarried near Parry Sound from a multicolored, gneissic rock.

Manitoba

A small quantity of stone is quarried in the Lac du Bonnet area.

British Columbia

A light-gray and blue-gray, even-grained granite is produced on Nelson Island. Haddington Island is a source of fine-grained, bluish-gray and buff andesite.

Limestone

Most of Canada's limestone for building construction comes from three widely separated areas. The quarries are at St. Marc des Carrières, Quebec, near St. Davids, in Ontario's Niagara Falls area, and near Garson, Manitoba, a few miles north of Winnipeg. All three sources are ideally situated near large industrial-residential centres and are accessible by major transportation routes. Each supplies a distinctive type of rock found in buildings across Canada. All limestones, being softer than granites, are made into rough and dressed blocks and dimensioned units more cheaply than granite. Many take a good polish and can be used for decorative purposes. Building stones of limestone have a variety of surface finishes and are equally popular for interior and exterior use.

New Brunswick

A reduced quantity of limestone for building construction was produced in the Saint John area..

Quebec

A fine-to-medium-grained, fossiliferous, brownish-gray limestone is produced at several quarries in the vicinity of St. Marc des Carrières. The stone, besides being used in rough and sawn finishes, takes a high polish and is suitable for decorative use. Rough building stones are produced in small quantities from quarries located near Montreal, particularly on Ile Jésus, north of the city.

Ontario

Much of Ontario's production comes from deposits of a dense, hard, gray-blue limestone in the Niagara Falls area. A thin-bedded, dense, buff-to-buff-gray limestone is quarried on the Bruce Peninsula, near Wiarton and Owen Sound, and some dark-gray limestone is quarried near Ottawa.

Manitoba

A mottled, buff-brown-to-gray-brown dolomitic limestone is obtained from several quarries in the Garson area. It is usually used effectively in rough and sawn finishes but takes a high polish and can serve as a decorative stone.

Sandstone

Coarse-grained varieties of sandstone are used on exterior walls, sills, copings, pillars, and panelling. Finer-grained, less porous stones find their principal application in interior work, in which ornamentation can be suitably displayed. Rock-face ashlar and sawn and honed surfaces are commonly specified, but sandstone sills and corner facing blocks are often chisel-marked with various designs.

Nova Scotia

A massive-textured, fine-to-medium-grained, olive-buff stone is quarried in the Wallace area. A coarser, darker stone is sporadically quarried near Antigonish.

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 varicolored in light buff, brown, and deep brown-red. Medium-grained, buff-to-cream-colored stone is quarried near Bell's Corners. A highly colored, medium-grained, banded and mottled sandstone is produced from deposits 20 miles north of Kingston.

Alberta

A hard, very fine grained, medium-gray sandstone, sometimes referred to as 'Rundle stone,' is quarried in Alberta. It is used as rough building stone.

Marble

Marble is regarded geologically as a metamorphic rock resulting from the recrystallization of limestone. Commercially, it is considered that any dense, calcareous rock of exceptional color or textural quality capable of taking a polish can be classed as marble. Serpentine rocks containing little calcium or magnesium carbonate usually take a high polish and are classed as serpentine marbles. Varicolored stones of various patterns produce the most popular types of marble. Most of the marble used in Canada is imported.

Quebec

A small quantity of light- and dark-gray and of green-white mottled marble is quarried in the Philipsburgh area, near the United States border south of Montreal. Sporadic quarrying of a white-gray marble is carried on in the western part of the Stukely area.

SULPHUR

C.M. Bartley*

During 1960, the potential size and importance of Canada's sulphur industry became more apparent. Additional sour-gas discoveries increased sulphur reserves; formal approval of natural-gas exports to the United States assured large-scale sulphur production; and several new processing plants were completed and construction on others was started. The processing plants will recover large and increasing amounts of cleaned natural gas, liquefied petroleum gases, and elemental sulphur.

The marketing of large tonnages continues to be the industry's main problem. Canadian sulphur is obtained mainly in western Alberta and eastern British Columbia, but its principal outlets are the large markets of the central and eastern part of the continent and the markets and shipping ports of the west coast. It must therefore be moved great distances overland, and the relatively high cost of land transportation is thus more significant for the Canadian product than for the competing sulphur of the United States, France, and Mexico, whose sources are closer to big markets or are on or near the sea coast. Despite this problem, very large amounts of sulphur will certainly be produced, and the industry is confident that improvement in the methods and economics of transportation will permit it to obtain a large share of the world sulphur trade in the near future.

In Canada, where sulphur or its equivalent is obtained from several sources by various methods, the price competition caused by the impact of new French, Mexican, and United States sulphur sources on world trade has restricted the use of pyrites-sulphur; but because of technical advances in processing, the value of other elements in the pyrites concentrate, or the protection afforded by the cost of transporting elemental sulphur from distant sources, some of the pyrites-producing operations remain fully competitive. These will continue to supply appreciable amounts of sulphur or its equivalent in Canada and such other areas as western Europe and Japan.

Canadian elemental sulphur is produced from domestic natural gas, from foreign crude oils, and, by two methods, from sulphide metal ores. In addition, equivalent sulphur (gaseous or liquid sulphur dioxide) is recovered as a by-product in smelting operations or by roasting pyrite or pyrrhotite concentrate to obtain sulphur-dioxide gas for the production of sulphuric acid. This process usually results also in the production of iron ore.

(text continued on page 531)

*Mineral Processing Division, Mines Branch.

Sulphur - Production and Trade

	1960		1959	
	Short Tons	$	Short Tons	$
Production(1)				
Pyrite and pyrrhotite				
Gross weight	1,032,288	3,316,378	1,099,564	3,433,095
Sulphur content	437,790		465,611	
Sulphur in smelter gases(2).	289,620	2,854,623	277,030	2,716,416
Elemental sulphur(3).......	274,359	4,298,906	145,656	2,620,787
Total sulphur content	1,001,769	10,469,907	888,297	8,770,298
Imports				
United States	328,743	6,627,241	327,614	6,834,195
France	15	1,773	-	-
United Kingdom..........	7	225	1	338
Mexico	-	-	4,815	90,405
Total	328,765	6,629,239	332,430	6,924,938
Exports				
Pyrite				
United States		1,041,456		801,544
Netherlands		110,275		-
United Kingdom..........		73,840		217,064
Belgium and Luxembourg ..		33,580		-
Total		1,259,151		1,018,608
Other sulphur				
United States	143,040	2,762,372	26,526	504,961

Source: Dominion Bureau of Statistics.

(1) Producers' shipments of by-product pyrite and pyrrhotite from the processing of metallic-sulphide ores. Included are quantities used by companies to produce sulphur dioxide and quantities used to produce iron sinter.

(2) Includes sulphur in acid made from roasting zinc-sulphide concentrates at Arvida, Quebec.

(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.

Sulphur - Production, Trade and Consumption, 1950-60
(short tons)

	Production				Imports	Exports		Consumption
	In Pyrites Shipped (1)	In Smelter Gases (2)	Elemental Sulphur (3)	Total		In Pyrite (4)	Other Sulphur (5)	Elemental Sulphur (6)
1950	150,487	150,685	-	301,172	390,333	111,652	65	372,347
1951	215,363	156,427	-	371,790	395,928	178,039	44	415,335
1952	263,241	160,547	8,931	432,719	415,185	197,897	-	387,617
1953	186,650	172,200	18,298	377,148	359,205	129,608	4,633	352,466
1954	311,159	221,247	22,320	554,726	310,127	188,608	3,339	358,953
1955	403,986	224,457	29,093	657,536	373,373	$2,001,575	3,051	393,148
1956	473,605	236,088	33,464	743,157	474,117	$2,649,349	4,331	431,202
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	450,007
1960	437,790	289,620	274,359	1,001,769	328,765	$1,259,151	143,040	463,465

Source: Dominion Bureau of Statistics.

(1) Sulphur content of pyrite and pyrrhotite shipped by producers. The figures for 1952-55 include the sulphur content of the acid made by roasting zinc-sulphide concentrate at Arvida.

(2) Sulphur in liquid sulphur dioxide and sulphuric acid from the smelting of metal-sulphide ores. The figures for 1956 and the years following include sulphur in acid made from roasting zinc-sulphide concentrate at Arvida.

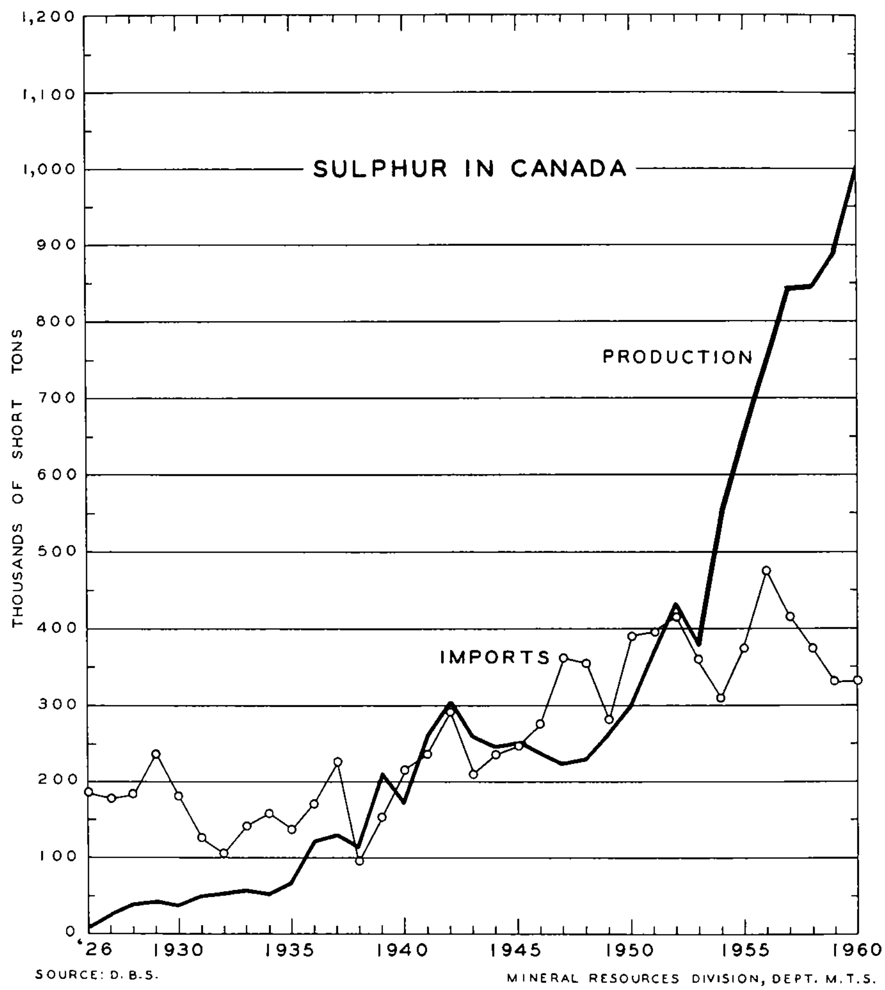
(3) Elemental sulphur produced from natural gas. The figures for the period 1952-56 refer to production. From 1957 on, the figures refer to sales. The figures for 1957 and the years following include some elemental sulphur derived from the treatment of nickel-copper sulphide matte at Port Colborne, Ontario.

(4) Exports of pyrite, sulphur content. The quantities for 1955 and the years following are not available for publication.

(5) Exports of sulphur produced from natural gas and other sources.

(6) Consumption of elemental sulphur by industries. The coverage is incomplete.

Sulphur stockpile at the gas-processing and sulphur-recovery plant, Pincher Creek, Alberta. *Courtesy of British American Oil Company Limited.*



Production and Trade

Canada's production of sulphur from all sources rose almost without interruption from 301,172 tons in 1950 to 1,001,769 tons in 1960. During this period, sulphur in pyrites made up 45 to 65 per cent of the total and sulphur in smelter gas 27 to 50 per cent. Elemental sulphur increased from nil in 1950 to 27 per cent in 1960. Large-scale expansion of sulphur production from natural-gas sources in western Canada is now in progress, and additional elemental sulphur is being recovered from foreign sour crude oils in Quebec and New Brunswick.

In 1960, the sulphur content of pyrites (pyrite and pyrrhotite concentrates) decreased about 6 per cent, that of smelter gas increased 4.5 per cent while elemental-sulphur production increased 88 per cent. Imports of sulphur decreased steadily from 474,117 tons in 1956 to 328,765 tons in 1960. Pyrite exports had been declining since 1957, but in 1960 they increased considerably over their 1959 total. In 1960, exports of elemental sulphur increased substantially to an all-time high of 143,040 tons valued at $2,762,872.

Consumption of elemental sulphur was 3 per cent greater than in 1959. With the exception of uranium processing sulphur consumers used larger amounts during 1960. Canada's per capita consumption, at about 118 pounds, is the highest in the world and is expected to increase.

Although transportation costs place limitations on marketing, several factors indicate that the recovery of sulphur as a by-product of natural-gas production is important and will continue to grow. Large reserves of sour natural gas have been found, and additional discoveries are being made each year; and cleaned natural gas has large and growing markets in eastern Canada and the central and western United States. Because the sulphur must be removed before this gas can be marketed as fuel, its production is unavoidable and is directly proportional to the quantity of gas produced. Further, the cost of obtaining sulphur from natural occurrences of gas is low: although gas-processing plants are complicated and costly, their sulphur-production facilities are relatively small. Finally, several new processes for such recovery of sulphur announced in 1960 suggest that the direct cost of removing sulphur from natural gas will decrease and that recovery will become more efficient.

Although the supply provided by the four main producing countries (the United States, Mexico, France, and Canada) was ample and competition was vigorous, the price on world markets increased during 1960 by $2 a long ton, and at the end of the year an additional increase was being predicted for 1961. In view of its necessity and wide use, sulphur is comparatively cheap. Only conditions of growing consumption and demand, such as those now prevailing, could make possible or justify an increase over the low prices of recent years.

Pyrite and Pyrrhotite

Pyrite and pyrrhotite were the first sources of equivalant sulphur in Canada, and in some areas they continue to provide substantial amounts for both domestic consumption and export. The raw material is the iron-sulphide concentrate from which base and precious metals have been removed at major base-metal sulphide mines. When strongly heated, it releases sulphur-dioxide gas, which can be converted into sulphuric acid. The residue, mainly iron, can serve as an iron ore. This process is employed in Canada to produce sulphuric acid and iron ore, and pyrite is exported to other countries for similar uses.

Sulphur thus obtained cannot compete where elemental or crude sulphur is available. Many large processing plants are in operation, however, in places where elemental sulphur is obtainable only if shipped from distant

Producers of Pyrite and Pyrrhotite Concentrates

Company	Location	Products	Uses
Consolidated Mining and Smelting Company of Canada Limited, The	Kimberley, B.C.	SO_2 Iron ore	H_2SO_4 Steel plant
Howe Sound Company*	Britannia Beach, B.C.	Pyrite concentrate	Sale
International Nickel Company of Canada, Limited, The	Copper Cliff, Ont.	SO_2 SO_2 Iron ore	H_2SO_4 Liquid SO_2 Sale
Noranda Mines, Limited*	Noranda, Que.	SO_2 Iron ore Pyrite concentrate	H_2SO_4 Sale "
Waite Amulet Mines, Limited	" "	" "	"
Quemont Mining Corporation, Limited*	" "	" "	"
Normetal Mining Corporation, Limited*	" "	" "	"

*These companies sell pyrite concentrate to consumers.

sources at considerable cost or where captive operations yield sulphide concentrates at little or no cost. Pyrites are sometimes shipped considerable distances for highly efficient processing that recovers sulphur, iron, and minor amounts of other metals for which there are ready markets. It is estimated that in 1960 world pyrite output contained 6.86 million tons of sulphur, or 4.5 per cent more than in 1959.

The 1,032,288 tons of pyrite and pyrrhotite produced in Canada in 1960 and the 437,790 tons of sulphur therein contained were about 6 per cent below their respective 1959 totals. Output comes at present from Quebec, British Columbia, and Ontario, and substantial additional amounts could be recovered in these provinces and in Manitoba, New Brunswick, and Newfoundland. For 1960, the pyrite output was valued at $3,316,378, and pyrite exports at $1,259,151.

The main companies in Canada that use pyrite and pyrrhotite concentrates for the production of sulphuric acid and iron ore are the following: Noranda Mines, Limited; The International Nickel Company of Canada, Limited; The Consolidated Mining and Smelting Company of Canada Limited; and Nichols Chemical Company Limited.

Sulphur from Sulphides

Elemental sulphur is produced from base-metal sulphides at two plants in Ontario. At International Nickel's Port Colborne refinery high-purity elemental sulphur is recovered in the electrolytic refining of nickel-sulphide matte. At Copper Cliff, an experimental plant designed and operated by Texas Gulf Sulphur Company uses sulphur-dioxide roaster gas from International Nickel's iron-ore plant to produce elemental sulphur.

At present, the Port Colborne plant produces sulphur commercially on a limited scale. To date, operations at Copper Cliff have been on a pilot-plant basis only, not for commercial production. Running at top capacity, these two plants would supply eastern Canadian consumers with large quantities of sulphur that would permit a substantial reduction in imports.

Smelter Gas

In 1960, the sulphur content of smelter gases produced in Canada totalled 289,620 tons valued at $2,854,623 about 4.5 per cent more than in 1959. Recovery takes place in British Columbia, at the Trail plant of The Consolidated Mining and Smelting Company; in Ontario, at International Nickel's Copper Cliff plant; and in Quebec, at the Arvida works of Aluminum Company of Canada, Limited. At Copper Cliff, in addition, concentrated sulphur-dioxide gas from the flash smelting of copper is used by Canadian Industries Limited to produce liquid sulphur dioxide, which is sold to pulp mills.

It is worth noting that for some purposes any one of several sources may be adequate, while for others a particular source may be required. Pyrite, smelter gas, liquid sulphur dioxide or elemental sulphur, for example, can be used to obtain sulphuric or sulphurous acids, but sulphur in elemental form is necessary for other purposes. In 1959, for the production of pulp and paper, more than 62,000 tons of liquid sulphur dioxide were consumed in addition to 252,113 tons of elemental sulphur. A substantial amount of liquid sulphur dioxide was also used for other purposes.

Late in 1960, Sherbrooke Metallurgical Company Limited, Port Maitland, Ontario, started to produce sulphuric acid. At first, the operation was based partly on elemental sulphur, but the material used would normally be sulphur-dioxide gas obtained from the roasting of zinc concentrate.

At Kimberley, British Columbia, Consolidated Mining and Smelting was completing the pyrrhotite-processing facilities needed for the manufacture of iron and steel products for sale and sulphuric acid for use in the company's fertilizer plant. A stockpile with an estimated content of 15 million tons of pyrrhotite tailings accumulated from many years of base-metal recovery will be used as a source of iron and sulphuric acid.

Consumption of Elemental Sulphur, 1959-60
(short tons)

	1960	1959
Pulp and paper	273,518	252,113
Heavy chemicals, fertilizer	172,552	184,352
Rubber goods	2,112	2,219
Medicinals	21	8
Adhesives	100	62
Starch	277	234
Sugar-refining	136	157
Petroleum-refining	183	160
Iron and steel	1,860	2,110
Asbestos products	11	80
Miscellaneous chemicals	12,204	8,127
Miscellaneous nonmetallics	491	385
Total	463,465	450,007

Source: Dominion Bureau of Statistics.

Sulphur from Oil Refineries

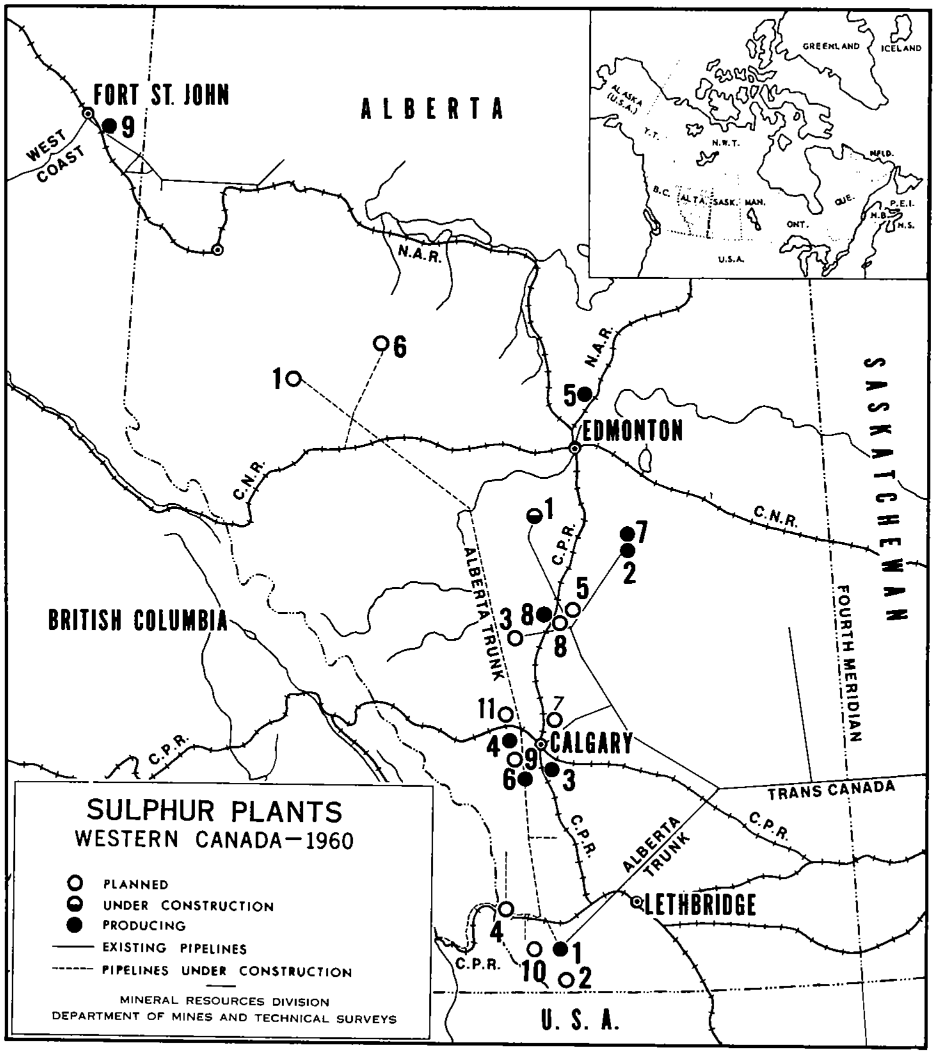
During 1960 elemental sulphur was recovered from foreign sour crude oils at two plants near oil refineries in eastern Canada. It should be noted that sulphur from this source is not included in Canadian mineral statistics because it is not derived from Canadian materials.

Laurentide Chemicals & Sulphur Ltd., operator of a plant in Montreal East, uses hydrogen-sulphide gas, separated from crude oil in several nearby refineries, as a source of sulphur. Production amounts to some 30,000 tons annually. A similar but smaller plant was operated by Irving Refining Limited at Saint John, New Brunswick, during 1960.

Sulphur production from these Canadian sources is not expected to be large. Some of the foreign crude oils that are being imported into eastern Canada contain sulphur and this must be removed, but most Canadian and United States crude oils are sweet.

Sulphur from Natural Gas

The production of sulphur from natural gas in western Canada made substantial gains in volume and value during 1960. This natural-gas industry is in fact, rapidly becoming one of the world's major sulphur sources. By the end of 1960, new discoveries of sour gas and additions to previously established reserves had increased proved reserves by about 10 per cent to 61,500,000 tons.



Reserves have been estimated at 106 million tons and are expected to total 326 million by 1989. During the year several new gas-processing and sulphur-recovery plants were completed, and work was started on others.

The comparatively low cost of obtaining sulphur as a by-product of gas-processing does not, by itself, insure sales, since the price the consumer pays also includes the cost of transportation and handling and the producer's profit. The main problem facing the sulphur producers of western Canada is that their land-transportation and handling costs are high compared with those of other major suppliers. An effort is being made to extend markets by working out cheaper recovery techniques, obtaining lower freight rates on Canadian railways, and developing methods of long-distance sulphur shipment by pipeline. The first two of these expedients would have an immediate but limited effect on costs, whereas the movement of sulphur by pipeline would

(text continued on page 539)

Sulphur Plants, Western Canada, 1960

Company	Location	Approximate Percentage H_2S	Capacity in Short Tons	
			Daily	Annual*
Producing (indicated on map by ● and number)				
1. British American Oil Company Limited, The	Pincher Creek, Alta.	10	755	264,000
2. British American Oil Company Limited, The	Nevis, Alta.	4-6	85	30,000
3. Texas Gulf Sulphur Company et al.	Okotoks, Alta.	35	415	145,000
4. Shell Oil Company of Canada, Limited	Jumping Pound, Alta.	3	110	38,000
5. Imperial Oil Limited	Redwater, Alta.	3	10	3,500
6. Royalite Oil Company, Limited	Turner Valley, Alta.	4	33	11,500
7. Standard Oil of California et al.	Nevis, Alta.	6	130	45,000
8. Canadian Oil Companies, Limited	Innisfail, Alta.	14	110	38,000
9. Jefferson Lake Petrochemicals of Canada Ltd.	Taylor Flats, B.C.	3	330	115,000
10. Steelman Gas Limited	Steelman, Sask. (not shown on map)	1	7	2,400
Total			1,985	692,400

Under construction (indicated on map by ◒ and number)					
1. British American Oil Company Limited, The, et al.		Rimbey, Alta.	2	250	87,000
Cumulative total				2,235	779,400
Prospective (indicated on map by O and number)					
1. British American Oil Company Limited, The	Pr	Berland River, Alta.	15	250	87,000
2. British American Oil Company Limited, The	Pr	Lookout Butte, Alta.	3	39	13,500
3. Home Oil Company Limited	Pl	Carstairs, Alta.	1	67	23,400
4. Jefferson Lake Petro-chemicals of Canada Ltd.	Pl	Coleman, Alta.	14	420	147,000
5. Mobil Oil of Canada, Ltd.	Pr	Wimborne, Alta.	13	165	57,500
6. Pan American Petroleum Corporation et al.	A	Windfall, Alta.	15-20	1,790	626,500
7. Petrogas Processing Ltd.	A	Calgary, Alta.	16	960	336,000
8. Shell Oil Company of Canada, Limited	Pr	Olds, Alta.	6	39	13,500
9. Shell Oil Company of Canada, Limited	Pr	Sarcee, Alta.	6	33	11,500
10. Shell Oil Company of Canada, Limited	Pl	Waterton Park, Alta.	22	1,550	542,500
11. Western Leaseholds Ltd.	Pl	Wildcat Hills, Alta.	4	117	41,000
Total				5,430	1,899,400
Cumulative total				7,665	2,678,800

Source: Oil and Gas Conservation Board of Alberta.
* Annual capacity is calculated on the basis of 350 operating days a year.
A Authorized.
Pl Planned for 1962.
Pr Proposed for 1965.

result in substantial savings. One method under investigation, that of moving sulphur in oil, might so increase traffic as to make it possible to lower the cost of transportation to eastern North America on both commodities and thus gain larger markets for each. Other methods being tested permit the movement of grains and other materials by pipeline.

At present the main problems are economic rather than technical. When the loads to be moved are sufficient to justify the capital cost of the pipelines, other bulk materials in addition to oil and gas will begin to flow in continuous streams to market areas. Bulk transportation of this kind would be particularly significant in Canada. Few parts of the world can produce large tonnages of sulphur, wheat, potash, coal, and oil that must be moved great distances over the same routes to the same markets or shipping points.

In 1960, the sulphur produced from natural gas in British Columbia, Alberta, and Saskatchewan totalled 453,142 tons. Shipments, which for the purposes of mineral statistics are considered as production, amounted to 273,189 tons.

For several reasons 1960 was a significant year for Canadian elemental sulphur. Aggresive primary interest in the development of natural gas as fuel automatically made available very large amounts of natural-gas liquids and sulphur, both of which will serve export markets and reduce imports. What is more important is that both may also form the basis of secondary industries.

The importance of these industries was brought into sharper focus in August, when gas exports to the United States were approved. Construction of pipelines to transport cleaned natural gas to the western United States was begun immediately, and at the same time work was started on several large gas-processing and sulphur-production plants. The effect of these developments on sulphur is illustrated by the plant construction now in process or already planned. On December 31, sulphur-production capacity in western Canada amounted to some 690,000 tons a year. Plants under construction and planned at that date will raise capacity to more than 2 million tons a year by 1962. This growth can be appreciated when it is remembered that no elemental sulphur was produced in Canada in 1950. The first output, excepting some produced from sulphide materials in 1939-43, was obtained in 1952 and amounted to less than 9,000 tons. Few industries, past or present, can equal the growth rate expected of western Canada's elemental-sulphur industry for the period 1952-62.

The locations and capacities of the various plants - producing, under construction, and planned - and the companies operating them are shown in the accompanying table. The list is not complete, because several companies are to expand later, and many other plants that have been proposed are in various stages of planning.

Several events or developments of 1960 affected Canadian sulphur sales. The price increase of $2 a long ton made by French and Mexican and later by United States producers, is important because it clearly indicates that the demand for sulphur is increasing and because it raises the revenue of Frasch sulphur producers, whose profits have been low under recent competition, and of Canadian producers by enabling them to sell in more distant markets. The expected continuation of the rise in world sulphur consumption has led to predictions that the price may be further increased in 1961. Such additional increases would tend to place Canada in the world sulphur market.

In Canada, rail freight rates for sulphur shipped to west-coast ports for export during 1960 were lowered to $9 a short ton, or about 1 1/2 cents a ton-mile. Efforts were made at the end of the year to obtain further reductions on the basis of the large volume of traffic expected.

The marketability of sulphur from western Canada may also be affected by the size of some of the plants now being built. Plants that recover more than 1,000 tons a day are expected to operate at a lower unit cost than those that recover 100 tons a day. Another factor is the possibility that new processes may permit the recovery of sulphur from gas at lower capital and operating costs. Several new processes announced in 1960 are believed to be substantially lower in operating costs than processes now in use.

World Review

World sulphur production in all forms is estimated to have reached an all-time high of 18 million tons in 1960. Of this amount, the United States produced about one third, and amounts of 1 million tons or more were produced by Mexico, Japan, France, Spain, and Canada.

Frasch sulphur is produced only in the United States and Mexico. Pyrites is produced as a source of sulphur in many countries, of which the chief are Japan, Spain, Cyprus, Italy, the United States, and Canada. China and the Union of Soviet Socialist Republics apparently rely on pyrites for about two thirds of their sulphur requirements, although their output of elemental sulphur is rising. Although low-priced elemental sulphur was plentiful, pyrites contributed slightly more than one third of the world's 1960 sulphur supply.

Many countries in recent years have produced varying amounts of recovered elemental sulphur from natural gas, crude oil, and sulphide materials, but France and Canada seem to be the future major suppliers of this commodity. Because almost all of this sulphur is a by-product or coproduct, its production from these sources is expected to increase at the expense of Frasch and pyrites equivalent sulphur.

In the United States in 1960 production and imports increased to satisfy rising consumption, and exports were also greater than in 1959. Operations began at three new Frasch mines, including Freeport Sulphur Company's large Grand Isle plant 7 miles off the coast of Louisiana in 50 feet of water. Two small Frasch mines were closed. Two United States producers and one Mexican were about to start large-tonnage ocean transport of liquid

Estimated Free World Production of Sulphur in All Forms[1]
('000 short tons)

	1960					1959
	Frasch	Pyrites	Elemental Recovered	Other	Total	Total
United States	5,530	466	859	545	7,400	6,900
Mexico	1,412	-	51	20	1,483	1,518
Japan	-	1,618	9	273	1,900	1,887
Canada[2]	-	437	488	290	1,215	1,034
Spain	-	1,120	23	2	1,145	1,077
France	-	129	872	9	1,010	610
Italy	-	775	4	89	868	881
Cyprus	-	576	-	-	576	660
Norway	-	391	80	-	471	444
Other countries		3,338	672	222	4,232	3,989
Total	6,942	8,850	3,058	1,450	20,300	19,000

(1) Compiled from several sources to indicate various supplies and may not be accurate in detail.
(2) Total output rather than shipments.

sulphur in special ships, thus obtaining greater efficiency and lower costs in the regular handling of large quantities. Although the United States' exports, particularly to Europe, increased, its share of world markets continued to decline. The changes in sulphur supply and trade are exemplified by the United States and Italy. In 1950, these two countries supplied 94.7 per cent of the sulphur traded throughout the world, but by 1960 this had dropped to 50.8 per cent, and three new suppliers - Mexico, France, and Canada - were contributing almost 48 per cent.

Mexican sulphur production totalled 1,430,000 tons in 1960, of which 1,375,000 tons were derived from Frasch mines and the balance from sour-gas and volcanic sources. Exports, about half of which went to the United States, totalled about 1,350,000 tons. Proven reserves are reported to amount to at least 60 million tons, and all reserves are possibly double this. Changes are being made in the mining laws to increase Mexican participation in the industry.

In Europe, a rise in industrial activity increased sulphur consumption. Supplies were obtained from the United States and Mexico, the expanding output of sour-gas sulphur at Lacq, in southern France, the growing shipments of pyrites (27 per cent higher than in 1959), the increased quantities recovered at sulphide and oil refineries, and minor amounts (33,000 tons) imported from the U.S.S.R. and East Germany.

At Lacq, about 870,000 tons were produced, and completion of the third and fourth stages of the plant early in 1961 will increase the annual capacity to 1,400,000.

In Poland, the Tarnobrzeg sulphur plant was officially opened in December 1960. It is reported to be capable of producing 125,000 tons of high-purity sulphur a year. Some 30,000 tons will be exported to Czechoslovakia, but the major part will be consumed in Poland. Plans call for a production increase to 400,000 tons a year by 1965. Poland may then have sulphur to export, but Communist-bloc demands and the large output from France make it doubtful that Polish sulphur will affect western Europe.

The world-wide increase in the demand for sulphur arises from aggressive efforts at industrialization. Sulphur finds its greatest use in the production of fertilizer, and this outlet holds promise of substantial expansion as underdeveloped countries, such as India and China, try to improve their living conditions by first increasing food supplies. It is also expected to be in greater demand for use in the manufacture of paper and plastics and in chemical and metallurgical processes.

Sulphuric Acid

Because of a reduction in the amount consumed in uranium-ore-processing, the production and apparent consumption of sulphuric acid decreased in 1960. Excess production capacity exists in some areas, but the demand for purposes other than uranium-processing continues to grow. New acid plants were built at Port Maitland, Ontario, and at Winnipeg; another is under construction at Baie St. Paul, 60 miles northeast of Quebec City; and a fourth is planned for Ville-de-Tracy, Quebec. The last two plants will supply acid for the production of titanium-dioxide pigments.

In Canada, sulphuric acid is used mainly in the production of fertilizers. Sulphur-dioxide gas recovered at the iron plant of The Consolidated Mining and Smelting Company of Canada Limited at Kimberley, British Columbia, will be used to make sulphuric acid for fertilizer production.

Sulphuric Acid - Production, Trade and Apparent Consumption, 1950-60
(short tons of 100% acid)

	Production	Imports	Exports	Apparent Consumption
1950	756,110	332	44,417	712,025
1951	820,867	1,162	57,000	765,029
1952	816,270	85	33,135	783,220
1953	822,608	70	47,889	774,789
1954	923,800	110	21,930	901,980
1955	950,277	151	29,578	920,850
1956	1,052,000	2,100	23,660	1,030,440
1957	1,290,000	1,046	29,500	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*	1,652,900	9,526	43,430	1,618,996

Source: Dominion Bureau of Statistics.
*Subject to revision.

Consumption of Sulphuric Acid*

(short tons of 100% acid)

	1959	1958
Fertilizers	687,800	673,000
Acids, alkalis, and salts	181,357	176,300
Nonferrous smelters and refiners	30,863	31,500
Coke and gas	26,102	27,100
Petroleum-refining	18,870	16,300
Leather-tanning	2,019	2,200
Iron and steel	46,045	37,300
Electrical apparatus	6,083	8,600
Plastics	19,391	17,800
Soap and washing compounds	14,328	14,300
Sugar-refining	380	300
Pulp and paper	18,487	15,300
Vegetable oils	50	100
Adhesives	550	700
Miscellaneous	96,786	68,100
Uranium-ore-processing	619,558	586,700
Total	1,768,669	1,675,600

Source: Dominion Bureau of Statistics.
*Available data.

Uses

Sulphur is essential in one aspect or another of the manufacture of almost everything produced in an industrial country. Most sulphur goes into the making of the sulphuric acid used in the production of fertilizers, uranium, chemicals, gasoline, steel, paint, plastics, and other commodities. Smaller but still appreciable amounts are used in other ways in the production of pulp and paper, rayon, chemicals, rubber, and insecticides.

Prices

In the last quarter of 1960, the Canadian price of sulphur was quoted in Canadian Chemical Processing in the following manner:

Sulphur, elemental, carloads, works, ton	$23.50

United States prices per long ton quoted by the Oil, Paint and Drug Reporter of December 26, 1960, were as follows:

Crude, domestic, bright, bulk, f.o.b. cars, mines	$23.50
Crude, export, f.o.b. vessels, Gulf ports	$25.00

Crude, U.S. and Canada, f.o.b. Gulf ports	$25.00
Domestic, dark	$ 1.00 lower
Crude, imported, Mexican, bulk, filtered, f.o.b. vessel, Coatzacoalcos	$24.00
Pyrites, Canadian, 48-50% S, f.o.b. mines	$ 4.50 to $5.00

Tariffs

Canada

Sulphur, crude or in roll or flour form	free

United States

Sulphur in any form, sulphur ore such as pyrites or sulphide of iron in its natural state, and spent oxide of iron consisting more than 25% of sulphur	"

TALC AND SOAPSTONE; PYROPHYLLITE

J. E. Reeves*

In 1960 the production of talc and soapstone in Canada was appreciably less than in 1959. The volume declined by about 13.4 per cent and the value by 16.5 per cent. Lower production in both Ontario and Quebec contributed to the decline.

Pyrophyllite production increased substantially, as it has each year since the present operator, Newfoundland Minerals Limited, started production. The 20,225 tons of pyrophyllite shipped in 1960 represent an increase of 40 per cent over the shipments of the previous year. The smaller gain in value---about 31 per cent of the value of the 1959 shipments---reflects the decision of the Newfoundland producer to ship only crude pyrophyllite.

The imports of ground talc continue to increase. Most are of high-quality grades and are relatively high-priced. The Italian talc is of select cosmetic and pharmaceutical grades.

The small quantity of ground talc shipped out of the country was lower than any of the annual amounts of this commodity exported during the 34 years covered by the graph on page 548.

During the last two decades, Canada's production of talc has not grown, although secondary industry, in which it is consumed, has experienced considerable development and expansion. Talc producers have continuously supplied secondary industries with the lower grades, but the higher grades, for which the demand has been increasing, must be imported. Hence the increase in the imports of ground talc.

Producing Companies

Quebec

Baker Talc Limited, 215 St. James Street West, Montreal, operates the Van Reet mine near the town of South Bolton, in Brome county, and produces several lower-priced grades of ground talc at a mill near Highwater, about 10 miles to the south. During the year, the company began the production of soapstone blocks for sculpturing and the marketing of soapstone carving kits.

Broughton Soapstone & Quarry Company, Limited produces some lower-priced grades of ground talc, metalworkers' crayons of soapstone, and a small

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*Mineral Processing Division, Mines Branch.

Production, Trade and Consumption

	1960		1959	
	Short Tons	$	Short Tons	$
Production (shipments)				
Quebec(1)	14,222	157,611	15,937	185,951
Ontario(2)	7,189	102,645	8,796	125,903
Newfoundland(3)	20,225	262,925	14,443	200,275
Total	41,636	523,181	39,176	512,129
Imports(4)				
United States	17,574	736,368	17,098	639,002
Italy	1,579	71,061	1,403	57,947
Total	19,153	807,429	18,501	696,949
Exports(5)				
United States	1,550	22,292	1,877	25,654
Nicaragua	45	562	47	634
Ecuador	39	859	32	415
Cuba	15	375	45	1,050
Other countries	11	184	52	2,043
Total	1,660	24,272	2,053	29,796

	1960	1959
Consumption(6)(7)		
Roofing	7,656	8,318
Paints and wall-joint sealing compounds	7,539	8,804
Ceramic products	4,022	3,758
Insecticides	2,552	2,027
Paper	2,363	1,710
Rubber	2,157	3,108
Toilet preparations	1,639	1,173
Gypsum products	922	1,347
Asphalt products	583	8
Soaps and cleaning preparations	532	325
Pharmaceutical preparations	243	1,326
Leather products	20	19
Other	228	1,788
Total	30,456	33,703

Source: Dominion Bureau of Statistics.
(1) Ground talc, soapstone blocks and crayons. (2) Ground talc. (3) Pyrophyllite.
(4) Ground talc. (5) Talc and soapstone. (6) Available data. (7) Ground talc.
(8) Not reported separately.

Production and Trade, 1950-60
(short tons)

	Production		Imports(2)	Exports(3)
	Talc and Soapstone(1)	Pyrophyllite		
1950	32,604		8,974	4,467
1951	24,846		9,283	3,743
1952	25,032		8,749	3,435
1953	27,408		11,867	2,937
1954	28,134	9	12,392	3,609
1955	27,153	7	11,382	4,428
1956	27,947	1,379	16,268	2,613
1957	29,039	5,686	14,949	2,353
1958	27,951	7,454	16,593	1,931
1959	24,733	14,443	18,501	2,053
1960	21,411	20,225	19,153	1,660

Source: Dominion Bureau of Statistics.
(1) Producers' shipments (including minor amounts of pyrophyllite shipped before 1954).
(2) Ground talc.
(3) Talc and soapstone.

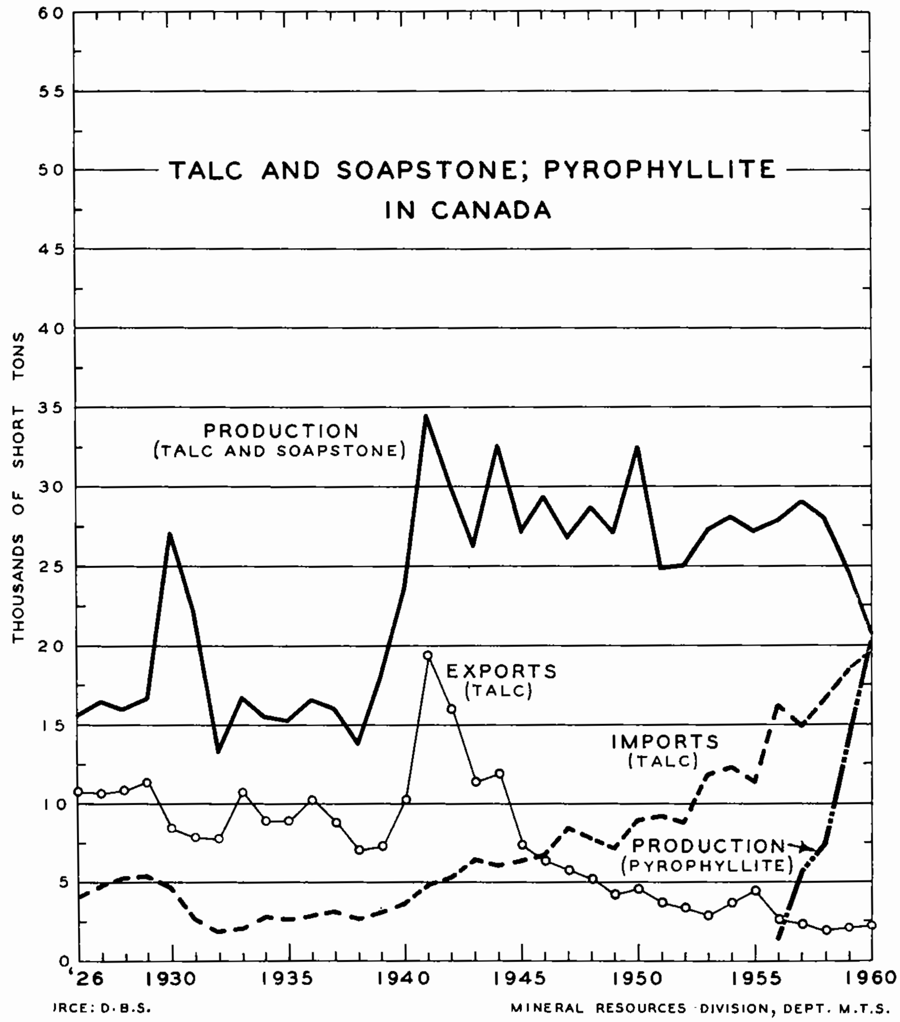
quantity of refractory soapstone blocks at a mill and plant near Broughton Station, Beauce county. Talc was mined from a deposit about 6 miles northwest of the mill, and soapstone was quarried from a deposit less than 2 miles southwest of it.

Ontario

Canada Talc Industries Limited, at Madoc, Hastings county, operates the Conley and Henderson mines and produces a variety of grades of ground talc. The latter mine yields an especially high-grade white product. A program for the further development of the mining operations was continued.

Newfoundland

Newfoundland Minerals Limited, Box 2043, St. John's, began operations in June 1956 and has continued development of the pyrophyllite deposits near Manuels, about 12 miles southwest of St. John's. Since the destruction by fire, in 1959, of the grinding and screening plant, only primary crushing has been taking place before the ore is shipped to the parent company, American Encaustic Tiling Company Inc., at Lansdale, Pennsylvania.



Occurrences

Talc and soapstone occur in many localities in Quebec, Ontario, and British Columbia.

There are several other deposits of talc in the vicinity of southern Quebec's Van Reet mine, a number of which were mined extensively for feed for the mill at Highwater before the Van Reet mine became the sole source. In the Thetford Mines area there are numerous deposits from which soapstone was quarried when blocks of it were much more widely used as refractory material.

Deposits of talc occur in many places in southeastern Ontario, and soapstone is not uncommon in the Kenora district. Refractory soapstone blocks were produced in Ontario on a limited basis many years ago, and minor amounts of talc have been obtained from several places, but for a considerable period production in this province has been confined to Madoc.

Many deposits of talc occur in British Columbia and there has been some mining there, but a limited demand in western Canada has been no encouragement to the development of a talc-mining industry.

Pyrophyllite occurs in Newfoundland near Manuels and in British Columbia near Princeton and Semlin, in the south-central part of the province, and at Kyuquot Sound, in the northwestern part of Vancouver Island. The deposits in Newfoundland appear to be the largest and have received intermittent attention for many years.

Technology

The mineral talc is a hydrous magnesium silicate. It is soft, has a greasy feel or 'slip', is flaky or fibrous according to its mode of origin, and yields a white powder on being ground. It is relatively inert chemically and has a low moisture and oil absorption, a high fusion point, and low electrical and thermal conductivity.

Many commercial talcs have an appreciable content of other minerals. The deposits in southern Quebec resulted from the alteration of serpentine rock, contain some unaltered serpentine and iron-bearing minerals such as chlorite, have a variable carbonate (magnesite) content, and yield ground products that are light gray. Such talcs are used where color specifications are not exacting. The Madoc deposits represent altered white dolomite and consist principally of talc, tremolite, and dolomite in varying proportions. They are low in iron and yield ground products of prime-white color, but because of a variable carbonate (dolomite) content these products are limited in their range of uses. Their particular use dictates the degree to which the content of these associated minerals is tolerable. Serpentine, chlorite, magnesite, and dolomite are detrimental to the production of the higher-quality talcs. Tremolite and similar fibrous minerals are considered desirable in commercial talc used for certain purposes.

Soapstone is essentially a massive, relatively impure talcose rock from which blocks and crayons can be readily sawn. The soapstone in southeastern Quebec was altered from serpentine rock and is gray because of the impurity content.

Pyrophyllite is physically very similar to talc but is a hydrous aluminum silicate. It also is an alteration product, but it has been derived from siliceous rocks and is often accompanied by sericite and quartz. The color is entirely acceptable, but the impurities must be limited.

Uses and Specifications

Commercial talc is a versatile raw material that has had scores of applications in industry, mostly as an industrial filler. Most of the talc used in Canada is consumed by nine industries.

High-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 ceramic industry. The paint industry's specifications relate principally to whiteness, particle size and shape, and oil-absorption characteristics. The paper industry requires talc of high brightness, high retention in the pulp, low abrasiveness, and freedom from chemically active substances. The ceramic trade specifies fine particle size and freedom from impurities that would discolor 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; color and impurity content are generally of little importance, although for 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 its use in cleaning compounds, polishes, 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 at least 99.8 per cent minus 325 mesh and in some cases 99.99 per cent minus 325 mesh. For rubber, ceramics, insecticides, and pipeline enamels 95 per cent minus 325 mesh is the usual minimum. In the wall-tile industry 90 per cent minus 325 mesh is usually required. For roofing grades the specification is minus 40 mesh or minus 80 mesh and a maximum of 30 to 40 per cent minus 200 mesh.

Soapstone has now only a very limited use as a refractory brick or block but is still used in the manufacture of metalworkers' crayons and for artistic carvings.

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

Prices vary considerably according to quality. Freedom from impurities, fine particle size and a high degree of whiteness command higher prices. There are no published prices for Canadian products, but a range of United States prices of ground talc is quoted periodically in E & M J Metal and Mineral Markets.

Tariffs

Tariffs in effect at the time of writing include the following:

	British Preferential	Most Favored Nation	General
Canada			
Talc or soapstone	10%	15%	25%
Pyrophyllite for use in Canadian manufacture	free	free	25%
Micronized talc	free	5%	25%

United States

Talc, steatite or soapstone:	
Crude and unground	1/8¢ per lb
Cut or sawed, or in blanks, crayons, cubes, disks, or other forms	1/2¢ per lb
Ground, powdered, pulverized, or washed (except toilet preparations):	
Not more than $14 a ton	8 3/4%
More than $14 a ton	15%

TIN

W.H. Jackson*

As tin concentrates are not smelted in Canada, all the primary tin metal needed by industry is imported. Of the 3,768 long tons# that entered the country in 1960, Malaya supplied 52.0 per cent and Belgium 31.6 per cent. This total was 9.9 per cent less than the quantity imported in 1959. Consumption amounted to 3,880 tons, 343 tons less than in 1959, and the stocks of tin metal in the hands of consumers at December 31 totalled 812 tons. The accompanying graph and statistical tables show in detail Canada's present and past position in relation to tin, but tinplate production is omitted owing to the limited number of companies engaged in it.

Exploration and Production

Canadian occurrences of tin minerals have never been of economic interest. In 1960 there was still little exploration apart from continued evaluation of a prospect near St. Stephen, New Brunswick. In this area some assays from surface outcrop and diamond-drill cores have indicated the presence of molybdenum, lead, and zinc as well as of tin.

Cassiterite is a minor constituent not only of placer deposits and deposits associated with pegmatites or other granitic rocks, but also of some lead-zinc ores. It is found in such ores in the Bathurst deposit of New Brunswick and the Sullivan mine in British Columbia. The latter, operated by The Consolidated Mining and Smelting Company of Canada Limited (Cominco), is the only Canadian source of tin concentrate. When the Sullivan ores are being milled, the zinc-circuit tailings, which contain only about 1.2 pounds of tin to a ton, are treated by flotation for the removal of iron sulphides and are then passed over blanket concentrators and shaking-tables before being sent to the waste heap. The concentrate obtained contains about 65 per cent tin. Concentrate has been produced since March 1, 1941, and from 1942 to 1952, inclusive, tin was smelted at Sullivan. For economic reasons, smelting was then discontinued and the concentrate exported. A minor amount of tin is also produced in a lead-tin alloy derived from the refining of indium. Cominco also makes, in limited quantity, Tadanac Brand high-purity tin (99.999 per cent tin) and Tadanac Brand special-research-grade tin (99.9999 per cent tin). The former contains 2 parts per million (ppm) lead and less than 1 ppm each of nickel, antimony, and copper; the latter, zone-refined, contains 0.1 to 0.2 ppm each of lead and copper, with no other impurities detectable spectroscopically.

#Long tons (2,240 pounds) are used in this review.

*Mineral Resources Division.

Tin - Production, Imports and Consumption

	1960		1959	
	Long Tons	$	Long Tons	$
Production				
Tin content of tin concentrates and lead-tin alloy	278	522,243	334	630,094
Imports				
Blocks, pigs, bars				
Malaya	1,961	4,326,843	952	2,121,381
Belgium	1,190	2,587,092	990	2,146,403
United States	357	776,309	993	2,189,168
West Germany	111	243,534	146	312,215
United Kingdom	100	220,962	707	1,535,256
Bolivia	29	60,777	-	-
Netherlands	20	42,108	395	877,249
Total	3,768	8,257,625	4,183	9,181,672
Tin plate				
United Kingdom	4,231	834,645	3,706	768,069
United States	1,359	241,140	1,270	234,257
Australia	36	7,516	-	-
West Germany	-	-	1	263
Total	5,626	1,083,301	4,977	1,002,589
	Pounds		Pounds	
Tin foil				
United States	20,584	21,411	17,428	19,333
West Germany	440	375	310	272
Other countries	208	229	208	1,767
Total	21,232	22,015	17,946	21,372
Babbitt metal				
United Kingdom	35,800	3,953	38,000	5,689
United States	29,500	24,565	27,700	24,587
Total	65,300	28,518	65,700	30,276

Tin - Production, Imports and Consumption (cont'd)

	1960		1959	
	Long Tons	$	Long Tons	$
Consumption				
Virgin tin				
Tinplate and tinning	2,112		2,278	
Solder......................	1,179		1,254	
Babbitt	255		274	
Bronze......................	158		146	
Galvanizing..................	9		12	
In other products including foil and collapsible tubes	167		259	
Total	3,880		4,223	

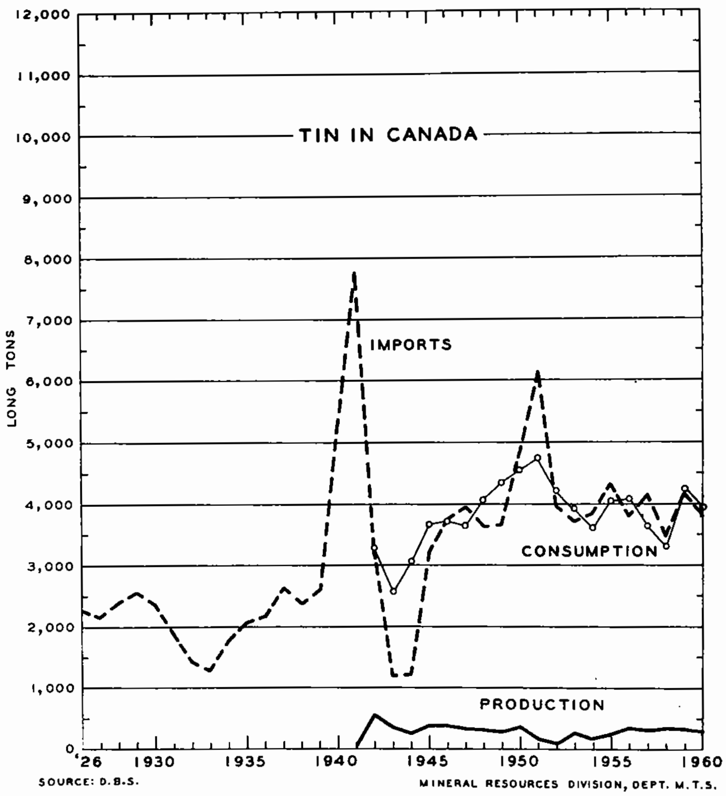
Source: Dominion Bureau of Statistics.

Tin - Production, Imports and Consumption, 1950-60
(long tons)

	Production	Imports				Consumption
	Tin Content of Concentrate	Blocks, Pigs, Bars	Tin Foil	Babbitt Metal	Tin Plate	Virgin Tin
1950	356	4,817	15	60	1,488	4,526
1951	155	6,135	4	13	1,531	4,731
1952	95	3,949	1	18	1,287	4,190
1953	287	3.702	7	22	6,442	3,903
1954	149	3,836	13	12	9,116	3,604
1955	220	4,318	15	19	9,915	4,019
1956	338	3,774	7	18	3,417	4,085
1957	317	4,155	7	17	4,884	3,622
1958	355	3,461	9	10	5,960	3,293
1959	334	4,183	8	29	4,977	4,223
1960	278	3,768	9	29	5,626	3,880

Source: Dominion Bureau of Statistics.

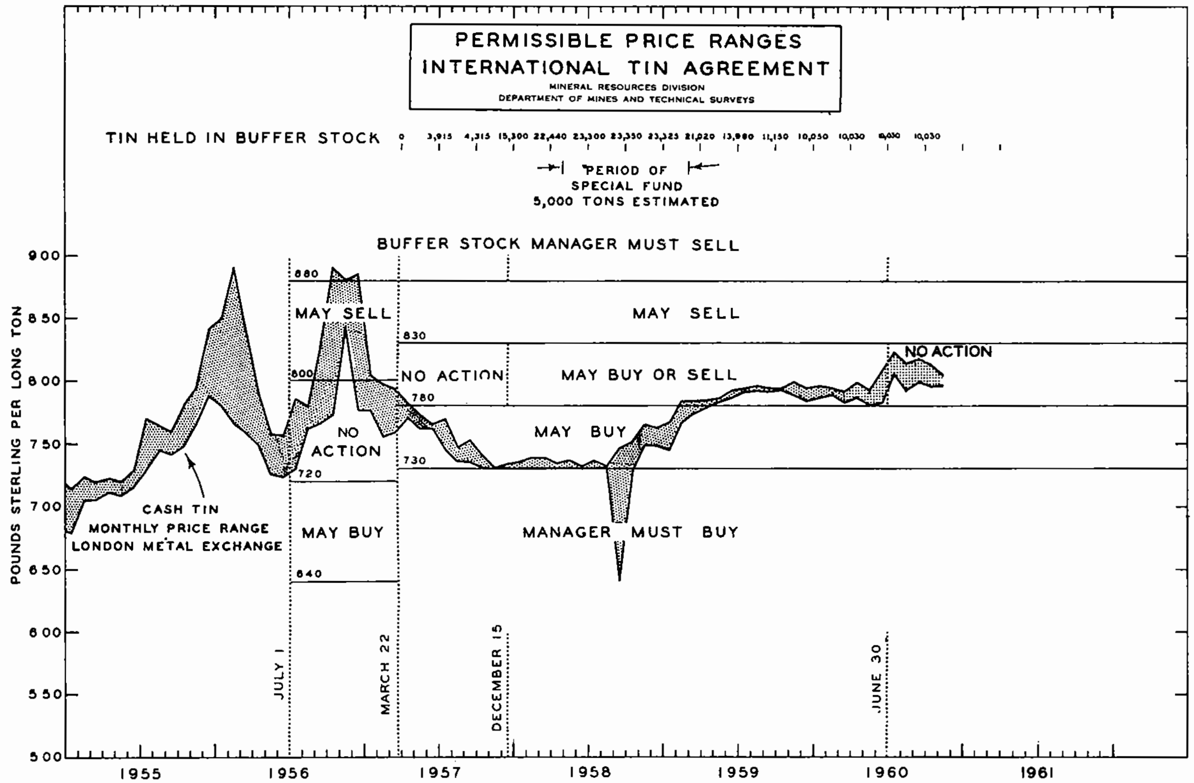
A detinning plant, the first in Canada, is expected to be in operation at Hamilton, Ontario, before the end of 1961. M & T Products of Canada Limited will treat high-quality tinplate scrap from can-making operations to produce such tin chemicals as potassium and sodium stannate, which are used in electroplating with tin and in the immersion coating of aluminum pistons for internal combustion engines. The company is an affiliate of Metal and Thermit Corporation of New York, a leading detinner.



World Production and Developments

Canada has ratified the Second International Tin Agreement, which becomes effective for five years on July 1, 1961. Delegates from 23 countries worked out details of the new agreement at the United Nations Tin Conference held in New York in May and June, 1960. The essential provisions are as follows: equal votes for consumer and producer members in the International Tin Council, which is the governing body; control of exports by producers in periods of oversupply; a buffer stock; and price control within agreed limits. Initially subject to change by the Council, the floor and ceiling prices are to be £730 and £880 a ton. The Council may not ordinarily declare a control period unless 10,000 tons of tin metal are likely to be held when the period starts. This, however, may be reduced to 5,000 tons when control is declared for the first time after a period of no control.

The graph on this page shows fluctuations that occurred in the price of tin immediately before and during the operation of the First Tin Agreement, which went into effect on July 1, 1956. It will be noted that the authority of the buffer-


PERMISSIBLE PRICE RANGES
INTERNATIONAL TIN AGREEMENT
MINERAL RESOURCES DIVISION
DEPARTMENT OF MINES AND TECHNICAL SURVEYS
TIN HELD IN BUFFER STOCK
0
3,915
4,315
15,300
22,440
23,300
23,350
23,325
21,020
13,980
11,150
10,050
10,030
10,030
PERIOD OF
SPECIAL FUND
5,000 TONS ESTIMATED
BUFFER STOCK MANAGER MUST SELL
880
MAY SELL
830
MAY SELL
NO ACTION
800
NO ACTION
780
MAY BUY OR SELL
NO
ACTION
MAY BUY
730
720
CASH TIN
MONTHLY PRICE RANGE
LONDON METAL EXCHANGE
MAY BUY
MANAGER MUST BUY
640
JULY 1
MARCH 22
DECEMBER 15
JUNE 30
POUNDS STERLING PER LONG TON
900
850
800
750
700
650
600
550
500
1955
1956
1957
1958
1959
1960
1961
SOURCE: I.T.C.

stock manager to operate within the middle price range was not extended by the Council beyond June 30, 1960. In addition, in October 1960 restrictions on production were no longer effective.

World Production of Tin-in-concentrates
(long tons)

	1960	1959
Malaya	51,979	37,525
Bolivia	19,407	23,811
Indonesia	22,607	21,616
China (mainland)	24,000	21,000
Belgian Congo and Ruanda Urundi	10,100	10,314
Thailand	12,081	9,684
Nigeria	7,675	5,523
Other countries	11,602	11,451(1)
Total	160,000(2)	141,000(2)

Source: International Tin Council.
(1) Does not include Russia.
(2) Rounded.

World Production of Tin Metal
(long tons)

	1960	1959
Malaya and Singapore	76,130	45,729
United Kingdom	27,404	27,229
China (mainland)	24,000	21,000
United States	13,500	10,700
Netherlands	6,393	9,592
Belgium	7,947	5,945
Belgian Congo	3,500	3,351
Other countries	12,188	11,771(1)
Total	171,000(2)	136,000(2)

Source: International Tin Council.
(1) Does not include Russia.
(2) Rounded.

World Tin Position*
(long tons)

	1956	1957	1958	1959	1960
Production of tin-in-concentrates	181,000	180,000	134,000	141,000	160,000
Smelter production of tin metal	182,000	175,000	140,000	136,000	171,000
Consumption of tin metal	160,000	154,000	149,000	162,000	180,000

Source: International Tin Council.
*Statistics for the Union of Soviet Socialist Republics are not included.

The foregoing table shows that in the last three years the excess of production over consumption evident in 1956 and 1957 has been reversed. In 1959, the smelter production of tin was augmented by sales from the buffer stock. Starting in May 1959, the United Kingdom sold some 2,500 tons of noncommercial stocks; and after December of that year it sold the remaining 2,417 tons. In March 1960 the government of Italy began to dispose of its 2,500-ton stockpile. Canada, in 1957, gave the Council six months' notice that it intended to get rid of its 3,000 tons but at the end of 1960 had made no sales. No tin has been released from the stockpiles held by the United States government.

Placer or quarrying methods predominate in the mining of tin ores owing to the nature of the deposits and the special problems encountered in producing an acceptable concentrate by underground mining. The prices paid for concentrate vary with the impurity content and the price of tin metal. In general, a clean concentrate assaying 76 per cent tin delivered to a smelter would be paid for at the prevailing price ex smelter on the basis of tin content less one unit and less a smelting charge of about $40 a ton. Smelting charges rise rapidly as the grade of concentrate decreases.

The lowest-grade placer deposits worked are in Malaya; they contain from 0.25 to 1 pound of cassiterite (SnO_2) per cubic yard. At Catavi, Bolivia, 0.76 per cent tin is mined by block-caving. At the Renison Bell deposits, in Australia, recovery from ore containing cassiterite with iron sulphide has averaged 50 per cent. Recent work has proved 784,000 tons grading 1.23 per cent tin.

Uses and Consumption

In Canada, tin is used much as it is in most other countries. In 1960, tinplate and tinning operations took 54.4 per cent. An additional 30.4 per cent went into the manufacture of solder and the remainder into babbitt, bronze, galvanizing, and such miscellaneous products as tin foil and collapsible tubes. The 110 companies that use tin in Canada are listed in publication 6523-650-120 of the Dominion Bureau of Statistics.

Prices

The Canadian price of Straits tin f.o.b. Montreal was 100.08 cents a pound at the beginning of 1960. This price, the low for the year, was effective on January 4. It reached a high of 109.69 cents on July 22. The year-end price per pound was 106.18 cents, and the average for the year was 104.86 cents.

Tariffs

Canada

	British Preferential	Most Favored Nation	General
Tin in blocks, pigs, bars, or granular form for use in Canadian manufacture	free	free	free
Tin-strip waste and tin foil	"	"	"
Phosphor tin and phosphor bronze in blocks, bars, plates, sheets, and wire	5%	7 1/2%	10%
Oxide of tin	free	15%	15%
Bichloride of tin and tin crystals	"	10%	10%
Sheet or strip of iron or steel, corrugated or not, and whether or not rolled with surface pattern, coated with tin	10%	15%	25%
Sheet or strip of iron or steel coated with lead or with alloy of lead and tin	free	free	15%
Manufactures of tinplate, painted, japanned, decorated or not, and manufactures of tin, not otherwise provided	15%	20%	30%

United States

Tin ore and black oxide of tin	free
Tin in bars, blocks, and pigs; alloys of tin not specifically provided for, in which tin is chief value; grain or granular scrap tin (including scrap tinplate)	"

United States (cont'd)

Tin foil less than 0.006" thick	35%
Powdered tin	12¢ per lb
Tinplate, taggers tin	0.8¢ per lb
Terneplates	1¢ per lb
Babbitt metal, type metal, solder	1 1/16¢ per lb on lead content
Chemical compounds and mixtures of tin	12 1/2 %

TITANIUM

V. B. Schneider*

The value of the titanium shipped in 1960 in ore, heavy aggregate, and titanium-bearing slag was $12,963,265. This was $4,326,551 above the 1959 value and represented an all-time high for Canadian production.

The Canadian titanium industry is based mainly on the mining of ilmenite for the production of titanium-dioxide slag used in making pigments. To a minor degree ilmenite is also used as heavy aggregate and for the manufacture of ferrotitanium. Ilmenite is mined in the Allard Lake and St. Urbain areas of Quebec. Most of the Allard Lake ore is smelted at Sorel, Quebec, to produce slag containing 72 per cent titanium dioxide (TiO_2), a high-quality pig iron, and a complex calcium-magnesium-aluminum silicate used as a slag thinner in smelting. Most of the slag is exported, mainly to the United States, for use as raw material in the manufacture of titanium-base pigments. Some is shipped to Canadian Titanium Pigments Limited, at Varennes, Quebec. In recent years most of the ore from the St. Urbain area has been used as heavy aggregate.

In 1959 pigment manufacturers increased their demand for titanium-bearing slag, and the demand continued to increase throughout 1960. Thus, the preference of pigment producers, who formerly favored ilmenite concentrate, has apparently undergone a major change. When slag is used, the capital outlay for plant to make pigment is far less and the acid consumption is about 30 per cent lower. On the other hand, the unit cost of the titanium-dioxide content of the slag is higher.

Heavy aggregate is used for shielding nuclear reactors, as a weighting material for oil- and gas-transmission lines and as Diesel-locomotive ballast. The value of aggregate varies according to size and specific gravity but is about $6 a ton for pipeline grade and $10 a ton for reactor grade, f.o.b. shipping point.

Three quarters of the refined titanium dioxide and extended titanium-dioxide pigments consumed in Canada was used in the manufacture of paints, and most of the remainder in the manufacture of pulp, paper, and oil cloth. About 250 tons of ferrotitanium are used annually by Canada's primary-iron-and-steel industry.

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*Mineral Resources Division.

Titanium - Production and Imports

	1960		1959	
	Short Tons	$	Short Tons	$
Production (shipments)				
Ore shipped from St. Urbain area and Allard Lake area to outside customers........	2,947	16,265	26,777	129,565
Titanium-dioxide slag produced from Allard Lake ilmenite and smelted at Sorel		12,947,000		8,507,149
Total		12,963,265		8,636,714
Imports				
Titanium oxide and pigments containing not less than 14% titanium oxide				
United States	16,674	3,386,029	17,682	3,545,123
United Kingdom.............	9,675	4,052,615	11,897	4,958,593
Italy......................	249	104,091	246	100,395
Belgium and Luxembourg	170	62,987	771	272,267
Czechoslovakia	106	35,972	2	629
Japan	22	6,584	-	-
Total	26,896	7,648,278	30,598	8,877,007

Source: Dominion Bureau of Statistics.

Production and Developments in Canada

Quebec Iron and Titanium Corporation (QIT)

Quebec Iron and Titanium Corporation, the sole Canadian producer of titanium-dioxide slag, operates eight electric-arc smelting furnaces at its Sorel smelter. In 1960, work was started on the rebuilding of one of the oldest furnaces and on the installation of a new kiln and a new coal-dryer. This expansion, scheduled to be completed early in 1961, will raise the plant's ore-treating capacity from 864,000 tons to 1,050,000 tons a year.

QIT owns one of the world's largest known reserves of ilmenite - 150 million tons of measured and indicated ore averaging 35 per cent TiO_2 and 40 per cent iron and many millions of tons of inferred ore. This reserve is in the Allard Lake area of Quebec about 22 miles north Havre St. Pierre, which is about 500 miles downriver from Sorel.

QIT Production

	Gross Tons	
	1960	1959
Ore treated	863,726	559,205
Titanium slag produced	345,213	217,589
Iron produced	221,945	145,990

Source: Company's annual report for 1960.

Analysis Range of QIT Titania Slag

	Pigment Grade (%)	Metal Grade (%)
TiO_2	70 - 72	74.0 - 76.0
FeO	12.0 - 15.0	8.0 - 11.0
Fe (uncombined)	1.5 max.	1.5 max.
SiO_2	3.5 - 5.0	3.5 - 5.0
Al_2O_3	4.0 - 6.0	4.0 - 6.0
CaO	1.2 max.	1.2 max.
MgO	4.5 - 5.5	4.5 - 5.5
Cr_2O_3	0.25 max.	0.25 max.
V_2O_5	0.5 - 0.6	0.5 - 0.6
MnO	0.2 - 0.3	0.2 - 0.3
C	0.03 - 0.10	0.03 - 0.10
S	0.03 - 0.10	0.03 - 0.10
P_2O_5	0.025 max.	0.025 max.
Ti_2O_3 as TiO_2	10.0 - 15.0	13.0 - 20.0

Continental Titanium Corp.

Continental Titanium Corp., formerly Continental Iron & Titanium Mining Limited, owns mining rights in the St. Urbain area about 8 miles north of Baie St. Paul, which is on the north shore of the St. Lawrence River 60 miles downriver from Quebec City. The company reports measured and indicated reserves of 12.5 million tons averaging 35 per cent iron and 37 per cent TiO_2, and inferred reserves of 8 million tons.

On October 18, work began on a $2-million pigment plant at Baie St. Paul, Quebec. The initial plant capacity will be 10 tons of technical-grade titanium dioxide a day. All the ilmenite the company sold in 1960 went to the United States, where it was to be used as heavy aggregate for nuclear shielding.

Canadian Titanium Pigments Limited

This wnolly owned subsidiary of National Lead Company, of the United States, continued full-time operation throughout 1960 of the only plant in Canada that manufactures titanium-base pigments. Its plant at Varennes, Quebec, manufactures both the rutile and the anatase type of titanium-dioxide pigment. Titanium-dioxide slag from QIT and liquid sulphur recovered by Laurentide Chemicals & Sulphur Ltd. at Montreal East from waste oil-refinery gases constituted the main raw materials for pigment manufacture. The liquid sulphur is used in the company's acid plant to produce sulphuric acid, which is used to digest the titania slag.

British Titan Products (Canada) Limited (BTP(C) Ltd.)

This wholly owned subsidiary of British Titan Products Company Limited began the construction of a titanium-pigment-manufacturing plant at Ville-de-Tracy, Quebec, in the latter half of 1960 and expects to complete construction by mid-1962. The plant, which will have an initial rated capacity of 44 million pounds of pigments a year, will use titanium-dioxide slag from QIT and will initially buy sulphuric acid. Ultimately, the BTP(C) Ltd. plant will manufacture its own acid.

Production of Ilmenite and Titanium-dioxide Slag
and Imports of Titanium Oxide and Pigments, 1950-60
(short tons)

	Production		Imports
	Ilmenite(1)	Titanium-dioxide Slag (TiO_2 content)(2)	Titanium Oxide and Pigments(3)
1950	101,970	1,596	27,125
1951	373,786	14,123	29,648
1952	266,461	30,805	24,205
1953	129,965	100,527	31,900
1954	304,550	88,408	32,106
1955	445,635	117,042	35,799
1956	630,197	157,374	37,872
1957	824,432	186,422	34,234
1958	(4)	(4)	29,439
1959	(4)	(4)	30,598
1960	(4)	(4)	26,896

Source: Dominion Bureau of Statistics.

(1) Ilmenite shipped from Allard Lake to Sorel and from the St. Urbain area to customers.

(2) Titanium-dioxide content of titanium slag produced at Sorel from Allard Lake ilmenite.

(3) Containing not less than 14% TiO_2.

(4) Not available for publication.

World Production of Titanium Ores, Concentrates, and Slags

In 1960 world production of titanium concentrates exceeded 2 million tons. The previous high was recorded in 1957, when some 1.97 million tons were produced.

Ilmenite ($FeTiO_3$), rutile (TiO_2), and sphene ($CaTiSiO_5$), which is also called titanite, are the most abundant of the titanium minerals. Sphene, which contains 41 per cent TiO_2, is mined in the Kola Peninsula, Russia. Generally, however, only ilmenite and rutile are considered to be of commercial importance. The maximum titanium-dioxide content of ilmenite is theoretically 53 per cent; that of rutile is theoretically 100 per cent.

By far the greatest percentage of ilmenite mined is used for the manufacture of titanium-dioxide pigments. Pigment-grade titanium dioxide is made principally by treating ilmenite with sulphuric acid, removing the iron of the ilmenite in solution, and grinding the titanium component to pigment size. Ilmenite mined by QIT does not readily lend itself to this process because hematite is finely disseminated throughout the ilmenite and cannot be removed by standard ore-dressing methods. Thus, the amount of sulphuric acid consumed in iron-removal would be excessive. At Sorel, a pyrometallurgical process is used to separate the iron as molten metal from the ilmenite and associated hematite. The slag contains approximately 72 per cent titanium dioxide.

According to the United States Bureau of Mines*, production of ilmenite concentrates amounted to an estimated 786 thousand tons. This was 24 per cent above 1959 output and was a record production. Rutile production was 8,809 tons, down 7 per cent from 1959.

In Japan, Hokuetsu Electric Chemical Industrial Company, Nisso Steel Manufacturing Company, and Morioka Electric Chemical Company produce titania slag from imported ilmenite ores.

Titan Co. A/S, a subsidiary of National Lead Company of the United States, has announced plans to begin production of titania slag and iron from its ilmenite deposits at Tellnes, Norway. The development of the Tellnes orebody began in May 1957, and the property came into production in October 1960. It is expected that the plant will process 1,100,000 tons of raw material a year to yield about 330,000 tons of ilmenite concentrate of 45-per-cent-TiO_2 grade and 22,000 tons of magnetite concentrate. Ore reserves at Tellnes are estimated to total 330 million tons, of which 220 million are proven.

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*U.S. Bureau of Mines, Mineral Trade Notes, August, 1961.

Production of Rutile Concentrates

(short tons)

	1960	1959	1958
Australia	100,300(e)	91,734	93,327
United States	8,809	9,466	7,406
Union of South Africa	3,695	3,381	552
Other countries	2,196(e)	1,819(e)	1,915(e)
Total	115,000(1)	106,400(1)	103,200(1)

Source U.S. Bureau of Mines, Mineral Trade Notes, August, 1961.
(e) Estimated.
(1) Does not include Russia.

Production of Ilmenite Concentrates

(short tons)

	1960	1959	1958
United States	786,372(e)	634,886	563,338
India	275,575	334,000	346,260
Canada(1)	388,339	270,477	161,312
Norway	258,283	249,274	233,585
Malaya	132,432	81,593	83,806
Finland	92,219	94,966	117,384
Union of South Africa	90,431	87,232	29,611
Other countries	202,149(e)	184,772(e)	182,704(e)
Total	2,225,800(2)	1,937,200(2)	1,718,000(2)

Source U.S. Bureau of Mines, Mineral Trade Notes, August, 1961.
(e) Estimated.
(1) Production of slag containing about 72% TiO_2 and small quantities of titanium ore.
(2) Does not include Russia.

In India, the reserves of ilmenite in beach sands along the south coast of the State of Kerala are estimated to exceed 300 million tons. Travancore Minerals Private, Limited, Hopkins and Williams, Limited, and Associated Minerals Company, Limited, are the principal ilmenite-producing companies. Hopkins and Williams is reported to have closed its ilmenite-processing plant at Chavara, Kerala, on October 1.*

The tables on page 6 list the major producers of rutile and ilmenite concentrates for 1958, 1959, and 1960.

Titanium-metal Production and Fabrication

Using technical-grade titanium dioxide as raw material, Dominion Magnesium Limited, near Haley, Ontario, produced titanium in the form of pellets weighing from 5 to 7 grams each. These are restricted in their use to shell fuses and alloying with nickel.

Commercial producers of titanium metal in the United States are: Union Carbide Metals Company, Ashtabula,, Ohio; E.I. du Pont de Nemours and Co., Inc., Newport, Delaware; Reactive Metals Inc., Ashtabula, Ohio; and Titanium Metals Corporation of America, Henderson, Nevada. Metal producers in Japan are: Osaka Titanium Manufacturing Co., Osaka; Toho Titanium Industry Co., Tokyo; and Nippon Soda Co., Ltd., Tokyo. In Great Britain, Imperial Chemical Industries Limited, Birmingham, is the principal producer. There is no available information about the titanium industry in the Union of Soviet Socialist Republics.

Sponge-metal production in the United States increased in 1960 to 5,311 tons. In 1959 it amounted to 3,898 tons and in 1958 to 4,585 tons. Sponge-metal imports into the United States, mostly from Japan, increased by more than 500 tons over those of 1959 to an estimated 2,200 tons.

Commercial production and fabrication of titanium mill products and forgings from imported ingots and billets are carried out by several Canadian companies. These include the following: in Quebec - Canadair Limited, Montreal; in Ontario - Atlas Titanium Limited, Welland; Thompson Products Limited, St. Catharines; and Canadian Steel Improvement Ltd., Toronto.

Atlas Titanium Limited began the installation of a reactive-metals-research laboratory, which was expected to be in operation by March 1961, and a production vacuum-consumable-arc furnace that will melt ingots up to 30 inches in diameter by 96 inches long. Mill shapes produced during the year consumed some 481,000 pounds of titanium metal. Much of Atlas Titanium's production was material converted for United States companies.

Macro Division of Kennametal Inc., Port Coquitlam, British Columbia, manufactures tungsten-titanium carbide and titanium-carbide powder

*U.S. Bureau of Mines, Mineral Trade Notes, Vol. 52, No. 3, March 1961.

for use in cemented-carbide alloys. Rutile and refined titanium dioxide are the company's sources of titanium.

Titanium Pigments and Other Titanium Products

Outstanding properties of titanium-dioxide pigments that recommend them for many applications include their high opacity and covering power, chemical inertness, and low specific gravity. These pigments are used in the manufacture of paint, ceramics, cosmetics, paper, and textiles.

Although ilmenite, slag, or manufactured titanium dioxide may be used as a source of titaniferous material in welding-rod coatings, titanium dioxide in the natural form of rutile is considered the most desirable material for this purpose. Artificially prepared crystals of titanium dioxide have a very high index of refraction and are used as gem stones. High-, medium-, and low-carbon ferrotitanium, the major grades of alloys of titanium with iron, are made for use as iron and steel additives. As an additive, ferrotitanium acts as a deoxidizer, provides fluxing action for some slags, prevents segregation of carbon and sulphur in rail steels, reduces grain size in cast steel, and improves ductility. In stainless steel it forms titanium carbides, thus allowing chromium to remain in solution when the steel is heated.

Canadian Consumption of Refined Titanium Dioxide, Extended Titanium-dioxide Pigments, and Ferrotitanium

	1959		1958	
	Short Tons	$	Short Tons	$
Refined titanium dioxide (TiO_2)				
Paints	15,316	7,985,330	14,400	7,568,123
Polishes and dressings	128	75,239	61	38,630
Pulp and paper			2,068	999,460
Linoleum and oilcloth			2,511	1,048,257
Rubber goods			771	387,137
Miscellaneous nonmetallic minerals			469	268,236
Total			20,280	10,309,843
Extended titanium-dioxide pigments				
Paints	14,489	3,214,999	15,515	3,352,758
Estimated TiO_2 content			4,607	
Ferrotitanium				
Primary iron and steel	252	84,683	210	76,689

Source: Dominion Bureau of Statistics.

Prices

E & M J Metal and Mineral Markets of December 29, 1960, quoted the following United States prices:

Ilmenite	Per gross ton, f.o.b. cars, Atlantic ports	
	59 1/2% TiO_2	\$ 23.00 to \$ 26.00
	54% TiO_2	\$ 21.00 " \$ 21.50
Rutile	Per short ton, 94% TiO_2, delivered within 12 months	\$ 80.00 (nominal)
Titanium metal	Per lb A-1, 99.3% max., f.o.b. shipping point	
	Max. 0.3% Fe	\$ 1.60
	Max. 0.5% Fe	\$ 1.50

E & M J Metal and Mineral Markets of December 8, 1960, quoted prices as follows:

Ferrotitanium	Low-carbon Per lb contained Ti, lots of ton or more, lump (1/2"+), packed, f.o.b. shipping destination NE. U.S.A.	
	40% Ti, max. 0.10% C	\$ 1.35
	25% Ti, max. 0.10% C	\$ 1.50
	Medium-carbon Per net ton, carload lots, lump, packed, f.o.b. destination NE. U.S.A.	
	17-21% Ti, 3-5% C	\$290.00 to \$295.00
	High-carbon Basis as for medium-carbon, 15-19% Ti, 6-8% C	\$240.00 " \$245.00

Tariffs

Canada

	British Preferential	Most Favored Nation	General
Titanium ore	free	free	free
Titanium oxide, and white pigments containing not less than 14% TiO_2 by weight	"	12 1/2%	15%
Ingots, blooms, slabs, billets of titanium, or titanium alloys for use in Canadian manufactures (expires June 30, 1962)	"	free	25%

United States

Titanium ore, crude	free
Titanium metal	20%
Ferrotitanium	12 1/2%
Titanium potassium oxalate and all compounds and mixtures containing titanium	15%

TUNGSTEN

V.B. Schneider*

Canada has produced no tungsten since July 1958, when Canadian Exploration,Limited closed its tungsten operations at Salmo, British Columbia. The operations were terminated on completion of a sales contract with the United States General Services Administration.

Canada Tungsten Mining Corporation Limited continued exploration and development work on its property near 61° 57' N. and 128° 16' W., which is just east of the Yukon-Northwest Territories boundary and 135 miles north of Watson Lake. Diamond-drilling indicated a tungsten deposit of 1.5 million tons grading 2.4 per cent tungsten trioxide (WO_3),and beneficiation tests showed that a commercially acceptable scheelite ($CaWO_4$) concentrate could be obtained from the ore.

Under an arrangement announced by Canada Tungsten early in 1961, American Metal Climax, Inc.,Dome Mines Limited, and Ventures Limited were to finance the property and bring it into production. Also, the Department of Northern Affairs and National Resources agreed to build an 80-mile development road from the Ross River to the Hyland River valley, and to contribute two thirds of the cost of a 50-mile access road from the valley to the mine site. It is expected that the roads will be completed in 1963 and that shipments of concentrate will thereupon begin.

Scheelite is found in association with gold-quartz veins at many active and long-dormant gold mines in Nova Scotia, Quebec, Ontario, Manitoba, British Columbia, and the Northwest Territories. At present these occurrences are not of economic significance. Wolframite has been found in stream gravels and in quartz veins in the Atlin area of northern British Columbia and Yukon Territory.

World Production, Trade, and Uses

The United States is the leading importer and consumer of tungsten ores and concentrates. The contained tungsten it imported in 1960 for consumption amounted to 3.525 million pounds.# This was almost 2 million pounds less than the quantity imported in 1959 and was the lowest annual import total since 1940. United States domestic shipments of tungsten concentrate

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#U.S. Bureau of Mines, Tungsten Report No. 113, July 21, 1961.

*Mineral Resources Division

Tungsten – Imports and Consumption

	1960		1959	
	Pounds	$	Pounds	$
Imports				
Scheelite[1]				
Korea	454,000	400,901	415,600	234,997
United States	200,000	214,967	106,000	58,406
Peru	134,900	101,490	110,100	42,137
Thailand	110,800	82,385	-	-
Bolivia	107,700	68,794	18,600	8,677
Argentina	94,400	57,777	-	-
Brazil	55,100	36,694	-	-
Republic of the Congo	-	-	110,000	30,724
Australia	-	-	22,400	8,434
Spain	-	-	57,300	22,133
Total	1,156,900	963,008	840,000	405,508
Ferrotungsten[2]				
United Kingdom	976,000	541,445	793,500	330,689
United States	4,700	2,075	34,100	36,782
Sweden	-	-	1,000	874
Total	980,700	543,520	828,600	368,345
Consumption[3] (W content)				
Scheelite	435,160		497,273	
Tungsten wire	7,775		6,109	
Ferrotungsten	94,000		66,000	
Tungsten metal and tungsten-metal powder	11,153		5,989	
Tungsten carbide, tungsten-carbide powder, and miscellaneous products	599,134		84,620	
Total	1,147,222		659,991	

Source: Dominion Bureau of Statistics.
(1) As reported in Trade of Canada. WO_3 content not given.
(2) As reported in Trade of Canada. Tungsten content not given.
(3) Includes tungsten chemicals.

Tungsten - Production, Trade and Consumption 1959-60
(pounds)

	Production(1) (WO3 content)	Imports(2) Tungsten Ore	Ferrotungsten	Exports(3) Scheelite (W content)	Consumption(4) (W content)
1950	284,078	55,600	214,700		251,076
1951	2,833	56,400	1,008,300		290,618
1952	1,493,111	112,200	493,100	1,700,000	595,412
1953	2,446,028	254,100	62,000	1,236,000	259,100
1954	2,170,633	7,200	85,900	1,239,187	170,980
1955	1,942,770	91,800	114,200	1,711,497	282,678
1956	2,271,437	123,800	205,500	1,763,793	284,318
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	-	1,147,222

Source: Dominion Bureau of Statistics.
(1) Producers' shipments of scheelite.
(2) As reported in Trade of Canada. Tungsten content not available.
(3) Export shipments as reported by producers.
(4) Scheelite, ferrotungsten, and other tungsten products reported by consumers. The 1950 total refers to the tungsten content of ferrotungsten and scheelite only. The 1959 and 1960 consumption surveys covered a larger number of consumers.

came to 6.5 million pounds of contained tungsten, and domestic consumption to 12.5 million pounds.

World output of tungsten in 1960 increased about 18 per cent over that of 1959. China and Russia continued as the leading producers, accounting for almost half of the output. In the United States, the price of concentrates remained fairly steady throughout the year. In Europe, however, the sale of Russian and Chinese tungsten ore at a discount resulted in a year-end lowering of prices. This in turn caused United States prices to soften slightly.

Before 1957, Korean tungsten was sold at auction, but the auction bids made in 1955 and 1956 fell lower and lower until the price of South Korean ore became a factor in the undermining of the tungsten market. The South Korean government then entered into a marketing agreement with Continental Ore Corporation, of New York, whereby Continental undertook to handle Korean tungsten on a consignment basis. On January 23, 1961, however, South Korea terminated the agreement, and the tungsten industry, believing that both the South Korean government and Continental hold large supplies that could find their way into the Free World market, is anxiously awaiting the outcome.

World Production of Tungsten Ore and Concentrates, 1959 and 1960*
(short tons)

	1960	1959
China	22,000	19,800
Russia	10,500	9,900
North Korea	5,500	4,400
South Korea	5,870	3,492
United States	7,325	3,649
Bolivia	2,370	2,671
Portugal	3,203	2,478
Other countries	12,832	12,410
Total	69,600	58,800

Source: U.S. Bureau of Mines, Mineral Trade Notes, September, 1961.
*Basis - 60 per cent WO_3.

Consumption and Uses

The use of cemented tungsten carbide increased enormously during the last decade through improvements in the technology of tungsten-carbide manufacture. One pound of tungsten in the form of carbide tools does as much work in metal-cutting as 60 pounds used in tool steel that is 18 per cent tungsten. This has changed the pattern of the end-uses of tungsten. About 15 years ago, 90 per cent of the tungsten consumed went into the manufacture of ferrous alloys and 5 per cent into the manufacture of tungsten carbides; today, in the United States, 37 per cent of all tungsten consumed is used in the manufacture of tungsten carbides, 32 per cent in ferrous alloys, 15 per cent as tungsten metal, 14 per cent in high-temperature and other nonferrous alloys, and 2 per cent in chemicals.

Tungsten carbide is used for tipping such tools as milling cutters, reamers, punchers, and drills; as dies for wire- and tube-drawing; in such wear-resistant parts as gauges, valve seats, and valve guides; and as cores in armor-piercing shells.

In the nonferrous or superalloy field, tungsten is alloyed with cobalt, chromium, nickel, molybdenum, titanium, and columbium in varying amounts to produce a series of hard-facing, heat- and corrosion-resisting alloys. The high-temperature alloys are used mainly in turbojet engines for such parts as nozzle guide vanes, turbine blades, combustion-chamber liners, and tail cones. They are also used in heat exchangers, boiler superheaters, and boiler superchargers. Stellite, a nonferrous alloy containing from 5 to 20 per cent tungsten with chromium and cobalt, is used in the production of welding rods for hard facing and in making high-speed tools.

The pure metal is used in ignition and other contact points in the automotive industry. It is also used for incandescent-lamp filament and in making certain types of bronze.

Some consumers of tungsten in Canada are: in Ontario - Atlas Steels Limited, Welland; Canadian General Electric Company Limited, A.C. Wickman Limited, Johnson, Matthey and Mallory Limited, and J.K. Smit and Sons of Canada Limited, all of Toronto; Canadian Westinghouse Company, Limited, Hamilton; Dominion Colour Corporation Limited, New Toronto; Deloro Smelting & Refining Company, Limited, Belleville; and Wheel Trueing Tool Company of Canada Limited, Windsor; in Quebec - Crucible Steel of Canada, Limited, Sorel; and in British Columbia - Kennametal of Canada Limited, Victoria, and Boyles Bros. Drilling Company, Limited, Vancouver.

Atlas Steels Limited is Canada's leading consumer of tungsten in the form of scheelite or ferrotungsten.

Macro Division of Kennametal Inc., Port Coquitlam, British Columbia, is the only manufacturer of tungsten-carbide powder in Canada. Besides pure tungsten carbide, the company manufactures pure tungsten trioxide (WO_3) powder, tungsten-metal powder, and tungsten-titanium carbide. It makes such other products as tungsten-carbide ball-mill balls and 'Kenspray,' a composition of tungsten-carbide particles bonded with a suitable matrix powder ready for application by conventional thermal spraying techniques. As raw material, the company uses wolframite, hubnerite, and scheelite concentrates of standard grade.

Prices

According to E & M J Metal and Mineral Markets of December 29, 1960, tungsten prices in the United States were as follows:

Tungsten ore	Per short-ton (20-lb) unit WO_3, basis 65%, foreign, c.i.f. U.S. ports, import duty extra	
	Wolfram	$18.50 to $19.00
	Scheelite	$18.50 " $19.00
Tungsten metal	Per lb	
	98.8% min., 1,000-lb lots	$ 2.75 " $ 2.90
	Hydrogen reduced 99.99%	$ 3.10 " $ 3.90
Ferrotungsten	Per lb contained W, 70-80%, lots 5,000 lb or more, f.o.b. destination U.S.	$ 2.15 (nominal)
Tungstic acid	Per lb, 1,000-lb lots in drums (according to Oil, Paint and Drug Reporter, Dec. 26, 1960)	$ 2.25

Tariffs

Canada

	British Preferential	Most Favored Nation	General
Tungsten ores and concentrates	free	free	free
Tungsten oxide in powder or lumps or in briquettes made with binding material used in steel manufacture	"	"	5%
Tungsten carbide, in metal tubes for use in Canadian manufacturing	"	"	free
Ferrotungsten	"	5%	5%
Tungsten rod and tungsten when used in Canadian manufacture	"	5%	25%

United States

Tungsten ore and concentrates	50¢ per lb on tungsten content
Tungsten carbide and metal and combinations or mixtures containing carbide or tungsten metals, all the foregoing in grains, lumps, or powder	42¢ per lb on tungsten content plus 25% ad valorem
Chromium-cobalt tungsten, chromium tungsten, ferrochromium tungsten, tungsten nickel, and all other alloys of tungsten not specifically provided for	42¢ per lb on tungsten content plus 12 1/2% ad valorem
Tungstic acid and all other compounds of tungsten not specifically provided for	42¢ per lb on tungsten content plus 20% ad valorem
Ferrotungsten	42¢ per lb on tungsten content plus 12 1/2% ad valorem

URANIUM

J.W. Griffith*

The structure of the uranium industry changed considerably during 1960 owing to the decision of the United States Atomic Energy Commission, Canada's principal customer for uranium, not to exercise its option to purchase additional quantities of Canadian uranium after the expiry of the sales contracts, which were to terminate between March 31, 1962, and March 31, 1963. This decision, announced on November 6, 1959, was a severe blow to Canada's uranium producers and resulted in extensive readjustment throughout the industry. Production in 1960 dropped 20 per cent to 12,748 tons valued at $270 million from the 1959 output of 15,892 tons valued at $331 million. Production over the next six years will be further curtailed as producers complete their contracts at the different times shown in the table on pages 580 and 581. World production is more than sufficient to meet the demand for some time, and the sale of uranium in the free market is not only restricted for the most part but highly competitive. Among the metallic minerals produced in Canada, uranium dropped in terms of value of production from first place in 1959 to third place in 1960, having been surpassed by nickel and copper.

By the end of 1960 there were only 11 mines in operation, as compared with 20 at the end of 1959. Most producers took advantage of the terms of the stretch-out plan announced by the Canadian Government on November 6, 1959. Under this plan producers could stretch out the remainder of their undelivered uranium under firm contract until November 30, 1966. Permission was also granted for the transfer of contracts between companies. Some companies sold their contracts to more efficient producers, thus allowing a few to continue production beyond the time allowed under the terms of their original contracts. Owing to an insufficiency of ore reserves or high operating costs, or to both, most of the mines that closed could not have fulfilled their contracts in any event. Some spent more capital than they had expected,thus making debt repayment difficult. To these mines especially, the provisions of the stretch-out plan were of great assistance.

Under the stretch-out plan, scheduled deliveries of Canadian uranium to the United States Atomic Energy Commission and the United Kingdom Atomic Energy Authority have been reported by Eldorado Mining and Refining Limited as follows:

Year	Tons U_3O_8
1961	9,718
1962	8,373
1963	6,548
1964	3,434
1965	1,464
1966	1,100

*Mineral Resources Division.

Uranium - Production and Exports

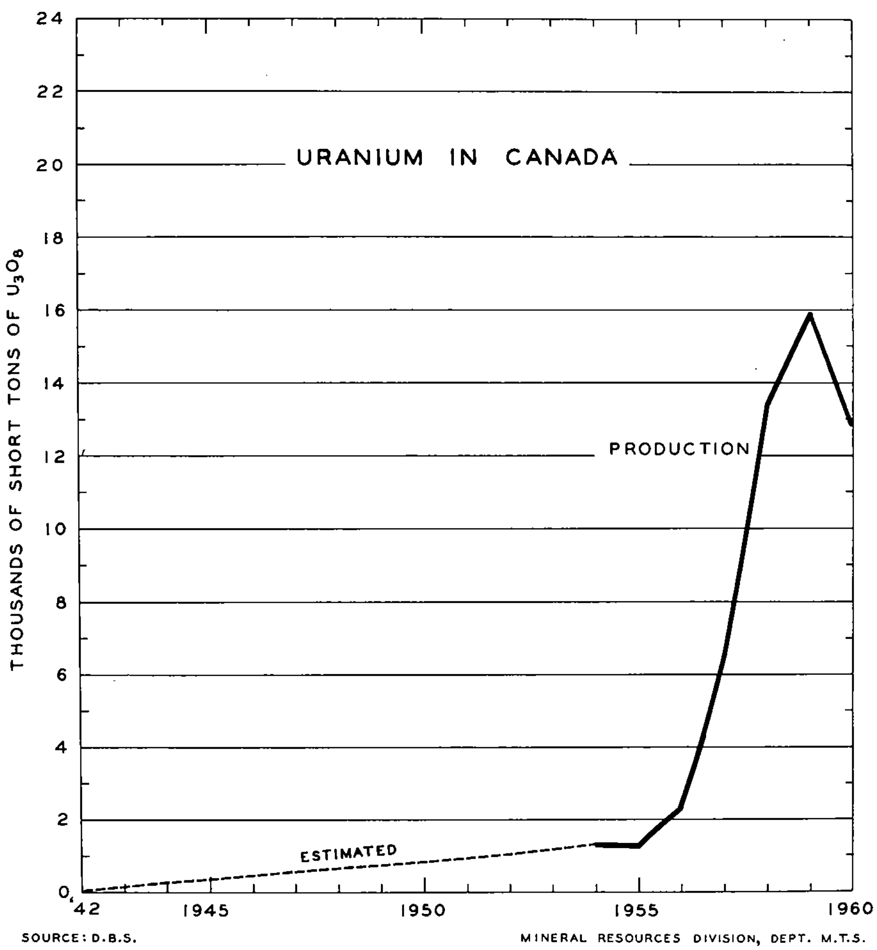
	1960		1959	
	Short Tons	$	Short Tons	$
Production (U_3O_8) - shipments (1)				
Ontario..............	9,897	211,983,533	12,746	268,529,993
Saskatchewan.........	2,312	48,722,961	2,686	54,457,321
Northwest Territories.	539	9,231,698	460	8,155,729
Total................	12,748	269,938,192	15,892	331,143,043
Exports (U_3O_8)				
United States.........	11,310(2)	236,594,407		278,912,726
United Kingdom........		25,904,553		32,602,978
India		570,480		20,000
West Germany........		293,971		129,262
Japan................		147,011		106,831
Switzerland		1,000		121,760
Other countries		29,510		10,586
Total................		263,540,932		311,904,143

Source: Dominion Bureau of Statistics except where otherwise indicated.
(1) These totals, released by the Dominion Bureau of Statistics, are based on figures supplied by the mining companies.
(2) U.S. Atomic Energy Commission, Major Activities in the Atomic Energy Programs, January-December, 1960.

The reserves of measured, indicated,and inferred ore in Canada as at the end of 1960 were estimated at 296,175,000 tons grading 0.12 per cent U_3O_8. This is equivalent to 355,410 tons of U_3O_8,of which about 320,000 tons are recoverable. Canada's reserves of uranium oxide are considered to be the largest in the world.

The number of mine employees declined from 11,792 at the beginning of 1960 to about 6,000 at the end of the year. Of this number, 4,000 were employed in the Elliot Lake district, in Ontario, and 1,000 each in the Bancroft and Beaverlodge areas, in Ontario and northern Saskatchewan respectively.

In the Elliot Lake district, four companies managed by The Rio Tinto Mining Company of Canada Limited, namely, Algom Uranium Mines Limited, Milliken Lake Uranium Mines Limited, Northspan Uranium Mines Limited, and Pronto Uranium Mines Limited, amalgamated to form a new company called Rio Algom Mines Limited. The merger of contracts under this plan resulted in the closing of Northspan's Lacnor mine in July 1960 and of Algom's Quirke mine in January 1961. Uranium production at Pronto ceased in April 1960, but the mill was converted to treat copper ore from Rio Algom's nearby



Pater property. In August, Preston East Dome Mines, Limited, which does not produce uranium but is a major shareholder in Rio Algom Mines Limited, amalgamated with Stanleigh Uranium Mining Corporation Limited to form Preston Mines Limited, and Rio Algom agreed to deliver substantially all of the balance of Stanleigh's contract. Stanleigh was closed in January 1961.

Early in the year, Can-Met Explorations Limited amalgamated with Consolidated Denison Mines Limited to form a new company called Denison Mines Limited. Can-Met transferred its sales contract to Denison and ceased operation.

Stanrock Uranium Mines Limited received offers for its contract but decided that it would be to the company's advantage to continue production under the original terms of the contract.

In the Bancroft area only two mines were in operation at the end of the year - Bicroft Uranium Mines Limited and Faraday Uranium Mines Limited. Both operated at slightly reduced production rates. Faraday negotiated a new

(text continued on page 582)

Canadian Uranium Producers

Working Results for the Year, January to December, 1960
Reserves as at December 31, 1960

Name and Location of Mine	Tons Ore Treated	Pounds U_3O_8 Produced	Pounds U_3O_8 Delivered under Contract[1]	Mill-head Grade (pounds U_3O_8 per ton)	Operating Costs per Pound U_3O_8 Recovered ($)	Estimated Ore Reserves All Categories (tons)	Grade of Reserves (pounds U_3O_8 per ton)	Approximate Date of Completion of Current Contracts	Remarks
Elliot Lake District, Ont.									
Can-Met Explorations Ltd.			Inc. in Denison						Amalgamated with Denison. Closed in Apr. 1960.
Denison Mines Ltd.	2,013,846	4,911,761	3,867,000[2]	2.70				Oct. 1963	
Preston Mines Ltd. (RT)	Nil	Nil	1,578,000	Nil	Nil	Nil	Nil	Jan. 1961	Preston does not mine or mill uranium ore.
Stanleigh mine			Inc. in Preston						Amalgamated with Preston. Closed in Jan. 1961.
Rio Algom Mines Ltd. (RT)	5,050,004	11,360,000[3]	10,276,000	2.39	3.87	51,980,844[4]	2.31	Nov. 1966	
Lacnor mine			Inc. in Rio Algom			Inc. in Rio Algom			Closed in July 1960.
Milliken mine			" " " "			15,702,100	2.11		
Nordic mine			" " " "			4,386,202	2.71		
Panel mine			" " " "			8,579,117	2.29		
Pronto mine			" " " "			Inc. in Rio Algom			Uranium production ceased in Apr. 1960.
Quirke mine			" " " "			" " " "			Closed in Jan. 1961.
Stanrock Uranium Mines Ltd.			2,144,000					Mar. 1963	
Bancroft Area, Ont.									
Bicroft Uranium Mines Ltd.	404,682		655,000	$21.27/ton	11.44/ton[5]	559,000	2.0	Mar. 1962	Value of 1960 production $8,117,008.
Canadian Dyno Mines Ltd.		137,000[1]	Inc. in Gunnar						Closed in June 1960. Contract deliveries by Gunnar.
Faraday Uranium Mines Ltd.	468,939	898,914	835,218	2.0	4.58[6]	1,124,900	2.14	Oct. 1962	

Beaverlodge Lake Area, Sask.									
Black Bay Uranium Ltd.	Nil	Nil	Nil						Shipped ore to Eldorado. Mine closed in 1960.
Cayzor Athabaska Mines Ltd.	"	"	"						Shipped ore to Lorado. Mine closed in Mar. 1960.
Eldorado Mining and Refining Ltd.	640,024	2,526,278	3,070,000(7)	3.95(8)		3,126,300	4.5	Sept. 1964	Acquired Lorado contract.
Gunnar Mines Ltd.		2,128,000(1)	2,129,000(9)					Nov. 1963	
Lake Cinch Mines Ltd.	Nil	Nil	Nil						Shipped ore to Lorado. Mine closed in Mar. 1960.
Lorado Uranium Mines Ltd.			200,000						Sold contract to Eldorado. Operations ceased in Apr. 1960.
Rix-Athabasca Uranium Mines Ltd. (RT)	Shipped 15,600	"	Nil	4.8(10)		Nil	Nil		Shipped ore to Lorado and Eldorado. Mine closed in June 1960. Value of production $381,000.
Northwest Territories									
Eldorado Mining and Refining Ltd. (Port Radium mine)	66,147	770,561	Inc. in Eldorado (Beaverlodge)	11.65(8)		"	"		Mine closed in Sept. 1960. Reserves exhausted.
Rayrock Mines Ltd.	Nil	Nil	Inc. in Gunnar	Nil	Nil	"	"		Mine closed in Aug. 1959. Gunnar to deliver remainder of contract.

Source: Company annual reports for 1960 unless otherwise indicated.

RT Member of the Rio Tinto organization.

(1) These figures, provided by Eldorado Mining and Refining Limited, are approximate only.

(2) Includes production under contracts of Consolidated Denison Mines Limited and Can-Met Explorations Limited.

(3) Approximate figure in terms of pounds of uranium concentrates.

(4) Total of the reserves for Rio Algom's six mines.

(5) Includes development, mining, milling, general mine expense, and outside exploration costs.

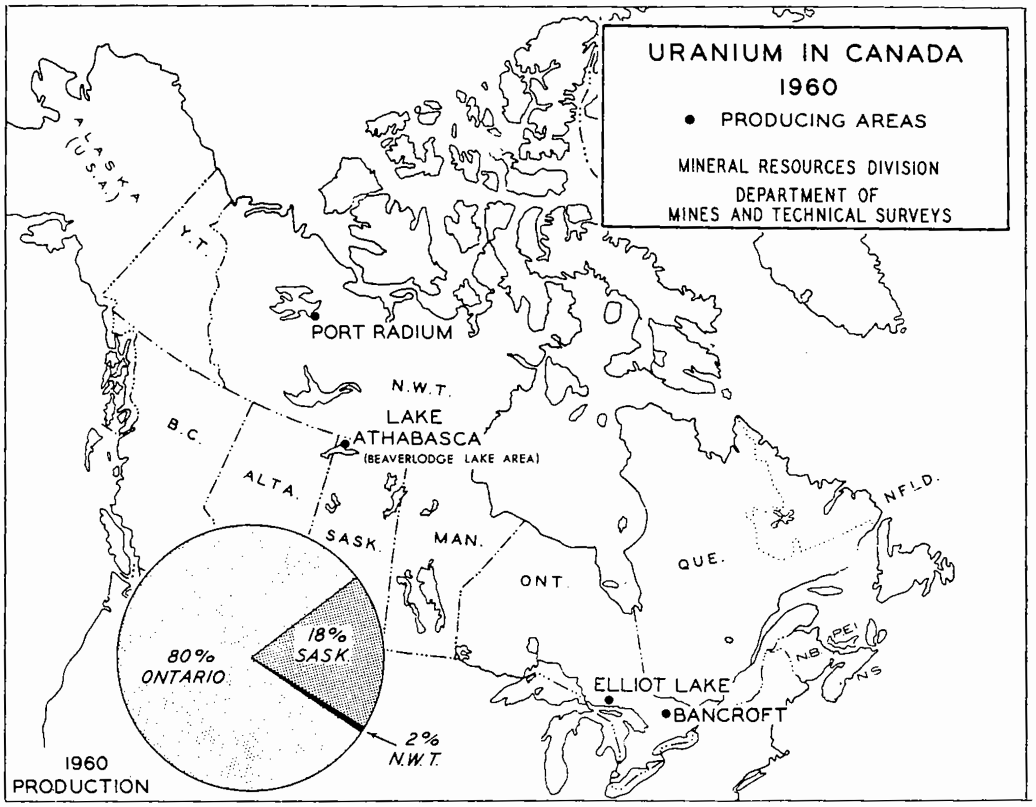
(6) Includes development, mining, milling, and ore-conveyance costs.

(7) Includes Port Radium mine deliveries.

(8) Average recovery per ton.

(9) Includes 945,000 pounds against its own contract, 738,000 against the Canadian Dyno contract, and 445,000 against the Rayrock contract.

(10) Average grade of ore shipped.



contract, effective July 1, 1960, with Eldorado Mining and Refining Limited, extending the period of contract shipments six months beyond the previous deadline,which was March 31, 1962. A third producer in the Bancroft camp - Canadian Dyno Mines Limited - operated until June 1960, when it completed arrangements to have Gunnar Mines Limited fill the balance of Dyno's contract.

The principal producers in the Beaverlodge Lake area were Eldorado Mining and Refining Limited and Gunnar Mines Limited. Other mines, which operated early in the year but closed, include Black Bay Uranium Limited, Cayzor Athabaska Mines Limited, Lake Cinch Mines Limited, Lorado Uranium Mines Limited,and Rix-Athabasca Uranium Mines Limited. Lorado was the only other mine in the Beaverlodge camp that held a government contract for the delivery of concentrates. The balance of this contract was sold to Eldorado in March, and the Lorado mine and custom mill were closed immediately. This purchase extended Eldorado's delivery period by 19 months. The rate of production at the Eldorado mine was reduced to permit a stretch-out of its contracts to September 1964.

In January, Gunnar completed arrangements with Canadian Dyno Mines Limited (Bancroft area, Ontario) and Rayrock Mines Limited (Marian River area, Northwest Territories) whereby Gunnar would supply the uranium required to fill the contracts of both companies.

The last ore at Eldorado's Port Radium mine, in the Northwest Territories, was hoisted on September 16, 1960, and the mine was closed shortly afterwards.

Prices and Marketing

The prices paid to the producers for the sale of mill concentrates (yellowcake) under government contract are confidential and vary with each company, having been originally calculated to provide a profit after allowances for the amortization of the major estimated capital costs and the estimated operating costs. Under most contracts, the maximum price paid is $10.50 per pound of U_3O_8 contained in the yellowcake. Before the announcement of the stretch-out plan, a few contracts were extended from March 31, 1962, to March 31, 1963; the price under these is either the original contract price or $8 (U.S.) a pound plus the amortization factor, whichever is the lower.

The procurement and marketing of most of the uranium produced in Canada is the responsibility of the Crown corporation, Eldorado Mining and Refining Limited. Canadian producers are permitted, however, to make small sales of surplus uranium (U_3O_8) to countries that do not hold agreements with Canada for co-operation in the peaceful uses of atomic energy. The maximum amount any such country may receive from Canada is 2,500 pounds. The amount of uranium that may be sold under permit from the Atomic Energy Control Board to a country that holds a bilateral agreement with Canada is unlimited, but sales of this nature have been very small owing to the smallness of the demand. A recent 6 1/2-ton shipment of Canadian uranium to Japan was sold for $4.37 a pound.

The United States Atomic Energy Commission has purchased, under contract, most of the uranium produced in Canada. Nearly 90 per cent of Canada's uranium production for 1960 went to the USAEC, while slightly less than 10 per cent was shipped to the United Kingdom Atomic Energy Authority. The balance was made up of small shipments to India, West Germany, Japan, Switzerland, and other countries. Sales in addition to these were made during the period 1945 to 1960 inclusive to Sweden, Italy, Austria, the Netherlands, Norway, France, and Denmark.

Consumption and Uses

In the field of nuclear energy, purchases for military uses and military stockpiles continued to dominate the uranium market, but the requirements of nuclear power plants are slowly increasing. Many experts predict that the need for large quantities of uranium for nonmilitary purposes will not begin to grow appreciably until the 1970's. One reason for this is that the United Kingdom, which has been leading all other countries in the development and use of nuclear electric power, announced in June 1960 that its nuclear-power program would be slowed down. The original plan called for the installation by 1966 of nuclear power plants having a combined capacity of 5,000 to 6,000 megawatts.

Under an extension of the time allowed, the plan now requires that the 1966 capacity be only 3,400 megawatts. Nuclear-energy goals in the United States and Europe have also been deferred. Technological advances in the field of nuclear power plants throughout the Western World have not been fast enough to offset stabilized or decreasing costs in conventional thermal power plants.

Uranium has found its most important peaceful use to date as a fuel in nuclear electric-power plants. It is also applicable, as a source of nuclear energy, in nuclear-powered ships, the production of radioisotopes, and nuclear reactors that could generate steam for industrial purposes and heat entire communities. Although radioisotopes are essentially by-products of nuclear reactors, many important uses have been found for them in agriculture, industry, and medicine.

Research on Nonnuclear Uses of Uranium

The key to more rapid improvement in the demand for uranium seems to be the development of new uses. With such development as its objective, the Mines Branch of the federal Department of Mines and Technical Surveys, in collaboration with Eldorado Mining and Refining Limited, continued its research into nonnuclear applications. The program was undertaken to help close the gap between Canada's uranium-production capacity and the demand for uranium, which had fallen with the termination of uranium contracts with the United States Atomic Energy Commission. The results, although on a laboratory scale, have been most promising. They have shown that, when added to commonly used steels in small amounts as an alloying agent, uranium considerably increases the fatigue strength of the steel, makes the steel more resistant to stress corrosion, and improves its high-temperature resistance to creep rupture. The higher fatigue strength obtained in plain carbon steels suggests good prospects for the use of uranium-bearing steels in shafting, railroad-car axles, springs, etc. The high-temperature properties of uranium-bearing steel should be attractive to manufacturers of high-temperature nuts and bolts, high-temperature steam piping, and other equipment used at temperatures of 1,000°F. Research is also being carried out on the use of uranium in such other materials as cast iron and copper-, aluminum-, magnesium-, and zinc-based alloys.

The amount of uranium needed to produce these properties ranges from half a pound to 6 pounds per ton of steel. In 1960 steel-ingot production in Canada totalled 5,686,691 tons, in the United States 99,281,601 tons, and for the whole world 379,663,292 tons.[(1)] The amount of uranium that might be consumed by the Canadian steel industry as an additive to steel, provided that the experiments on this new use prove successful, is conservatively estimated to be 1,000 tons a year.[(2)]

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(1) American Iron and Steel Institute, New York, Annual Statistical Report, 1960.

(2) Convey, Dr. John, Mines Branch, Department of Mines and Technical Surveys. Proceedings of the House of Commons Special Committee on Research, March 23, 1961.

Late in 1960 a new organization, the Canadian Uranium Research Foundation, was formed by the uranium producers. The mining companies have provided it with funds "for research in the use of the products of the uranium industry, to disseminate information relative to such products and to promote, foster and stimulate the uranium industry."

Developments in Nuclear Energy in 1960

Construction work was continued during the year on the 20,000-kilowatt experimental nuclear power plant, NPD-2, near Rolphton, Ontario. This station is nearly completed and is scheduled for operation in 1961. Work was begun during the latter part of the year on the clearing of a site at Douglas Point on Lake Huron for CANDU (Canadian Deuterium Uranium), Canada's first full-scale nuclear power station. A second plant at the same site is being considered. It has been estimated* that, if certain conditions are met, the CANDU station will produce power in a cost range of 6 to 7 mills per kilowatt hours. The addition of a second unit of equivalent power output is expected to bring the power costs down to a range of 5 to 6 mills. Subsequent stations of the CANDU type can be expected to be lower in price and thus to make nuclear power plants competitive with coal-fired plants in a power system similar to that of the Ontario Hydro Electric Power Commission.

The Whiteshell Nuclear Research Establishment, to be built by Atomic Energy of Canada Limited, will be in Manitoba, on the Winnipeg River 60 miles northeast of Winnipeg. One of the first studies will involve an experimental, organic-cooled, heavy-water-moderated reactor.

The Atomic Energy Division of Canadian Westinghouse Company Limited completed a study for Atomic Energy of Canada Limited on the cost of building and operating certain types of small reactors for possible use in northern Canada. The study showed that the reactor under consideration would cost 22 per cent a year more than a conventional plant. A larger nuclear plant of the same type would cost 2 per cent a year more than an equivalent conventional plant.

In September, the Canadian Nuclear Association was formed to represent all bodies interested in the nuclear field in Canada. The organization was founded to stimulate Canada's growing nuclear industry and to keep members informed of developments in related fields. It will also co-ordinate the common concerns of all organizations and individuals interested in Canada's nuclear progress.

*Gray, J.L. President, Atomic Energy of Canada Limited. Proceedings of of the House of Commons Special Committee on Research, May 2, 1961.

Principal World Producers of Uranium, 1960

Country	Production 1960 (short tons of U_3O_8)	Value of Production ($'000,000)	Number of Treatment Plants	Estimated Ore Reserves[1] (millions of short tons)	Grade (% U_3O_8)	Estimated Reserves of U_3O_8 (short tons)
United States	17,646[2]	330(2)	25[2]	82.0[2]	0.28[2]	229,600
Canada	12,748[3]	270(3)	17[4]	296.2[4]	0.12[4]	355,410
South Africa	6,224[5]	144(5)	16[e]	1,000 [4]	0.025[5]	260,000
Soviet Union	6,000 [e][6]					100,000
Republic of the Congo	2,110[e]		1[7]	Nil	Nil	Nil
France	1,416[e]		4[8]			60,000[9]
Australia	1,200[e]		5[10]	6.7[4]	0.15[e]	10,000
Others[11]	800[e]					

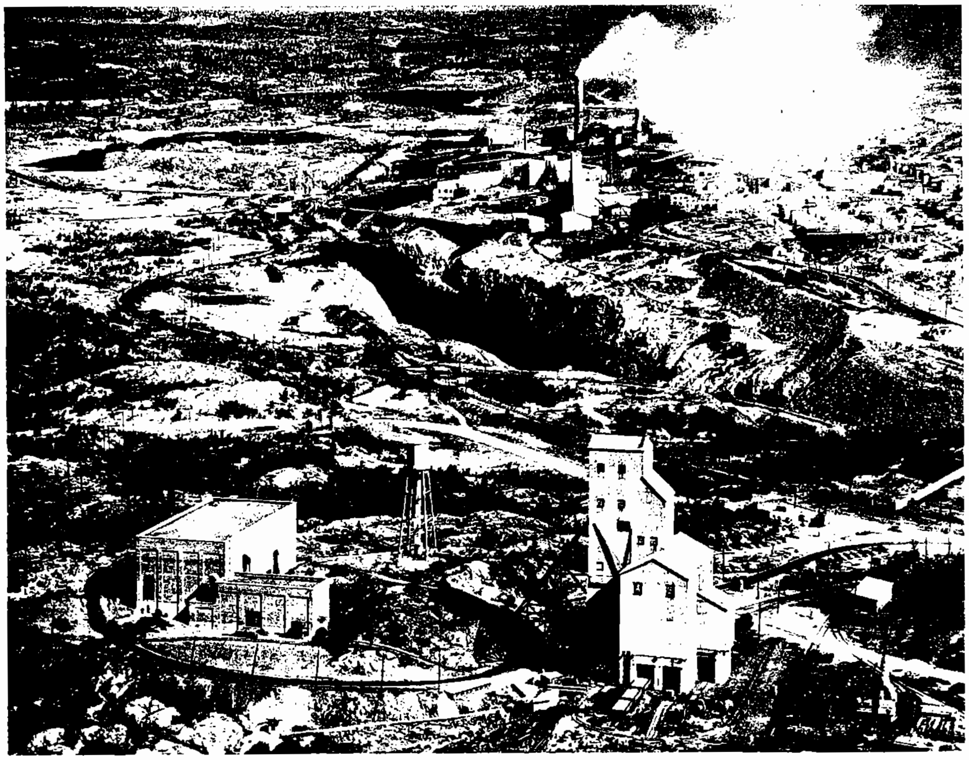
(1) Includes all categories of ore.
(2) U.S. Bureau of Mines.
(3) Dominion Bureau of Statistics.
(4) Department of Mines and Technical Surveys.
(5) Transvaal and Orange Free State Chamber of Mines.
(6) Probably a minimum figure. Includes production from East Germany and other eastern European countries.
(7) Union Minière du Haut-Katanga, annual report, 1959.
(8) Commissariat à l'Energie Atomique, France.
(9) Includes reserves in Gabon and Madagascar.
(10) The Mining Journal, London, England, April 22, 1960.
(11) Includes such countries as Argentina, Finland, India, Italy, Japan, Portugal, Rhodesia, Spain, Sweden and West Germany.
(e) Estimated.

Thorium Production

During the year the Rio Tinto Dow Limited thorium-recovery plant produced 159,320 pounds of thorium salts. The thorium was extracted from the waste liquors supplied by the uranium-treatment plant at the Quirke mine in Ontario's Elliot Lake district. When Rio Algom Mines Limited decided to close down this plant, however, it became necessary to build a thorium-sludge-recovery plant at its Nordic mine, 12 miles to the south. Shipment of the sludge in concentrated form to the Rio Tinto Dow plant at Quirke was to have begun in March 1961. A thorium market, although limited in its rate of expansion, has been established, largely in the United States and the United Kingdom.

The deposits in the Elliot Lake district probably contain the largest potential reserve of thorium in North America. Most of the thorium in these conglomeratic ores is carried in the minerals monazite, brannerite, and uraninite. The uranium deposits of both the Elliot Lake and the Bancroft areas are estimated to contain 180,000 tons of ThO_2 in ores grading an estimated 0.06 per cent ThO_2.

Thorium finds an important use in magnesium alloys. Dominion Magnesium Limited produces a magnesium-thorium alloy at its plant at Haley Station, Ontario. In the field of nuclear energy, thorium has an important potential use as a fuel for breeder reactors.



Plant of Hudson Bay Mining and Smelting Co., Limited, at Flin Flon, Manitoba. The old glory hole is in the centre with the copper-zinc smelter and zinc refinery in the background and the mine headframe in the foreground.

Diamond drilling in the Chisel Lake area of northern Manitoba.

ZINC

D.B. Fraser*

Zinc production in 1960 amounted to 406,873 short tons, or 10,865 tons more than in 1959. The output from the mines of British Columbia, at the same level as in the preceding year, came to 203,833 tons, or 50 per cent of the national total. Production from the copper-zinc mines of the Flin Flon area of northern Manitoba and Saskatchewan rose by 4,513 tons to 67,093 tons. At 34,208 tons, the zinc obtained from the Buchans mine, Newfoundland's only producer, was 8 per cent higher. Small increases were reported in Quebec and Ontario, while production in Yukon Territory showed a moderate decline.

The refined zinc produced by The Consolidated Mining and Smelting Company of Canada Limited (Cominco) at Trail, British Columbia, and by Hudson Bay Mining and Smelting Co., Limited, at Flin Flon, Manitoba, totalled 260,968 tons, exceeding the record of 1959 by 5,662 tons.

Exports of refined zinc rose 15 per cent above those of 1959 to 207,091 tons. Exports of zinc in ores and concentrates declined to 169,894 tons from the 181,084 tons exported in 1959.

Domestic consumption of slab zinc declined to 59,143 tons in 1960 from the 67,934 tons consumed in the previous year. Producers' domestic shipments of primary slab zinc were 53,457 tons.

Most of the zinc concentrates produced in British Columbia were refined at Trail. The remainder were exported to refineries in the northwestern United States. The mine output of Saskatchewan and Manitoba was refined at Flin Flon. The zinc production of mines in eastern Canada was exported in concentrates to smelters in the United States and Europe.

The history of zinc production in Canada and the importance of export markets are shown in the graph on page 596. In 1960 Canada was the second-ranking Free World producer of zinc ores and the third-ranking producer of refined zinc. The United States was the leading producer, its mine output being 432,442 tons and its refined output 867,629 tons. Other important mine producers were Mexico (299,192 tons), Australia (273,393 tons), Japan (172,524 tons), Italy (122,264 tons), and Peru. Important producers of refined zinc, in addition to the United States and Canada, were Belgium (272,889 tons), West Germany (201,091 tons), France (164,463 tons), Australia (134,656 tons), and Japan (198,920 tons).

(text continued on page 592)

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*Mineral Resources Division.

Zinc - Production, Trade and Consumption

	1960		1959	
	Short Tons	$	Short Tons	$
Production				
All forms[1]				
British Columbia........	203,833	54,423,436	203,091	49,716,804
Quebec..................	49,808	13,298,602	47,058	11,519,794
Saskatchewan	42,703	11,401,580	46,877	11,475,377
Ontario	45,230	12,076,326	44,982	11,011,498
Newfoundland	34,208	9,133,517	31,674	7,753,838
Manitoba	24,390	6,512,255	15,703	3,843,977
Yukon Territory	6,701	1,789,287	6,623	1,621,375
Total	406,873	108,635,003	396,008	96,942,663
Refined[2]..............	260,968		255,306	
Exports				
Refined				
United Kingdom	92,435	19,710,897	86,766	15,402,953
United States	75,237	18,294,936	84,592	16,854,554
India..................	13,362	2,747,404	244	40,141
Japan	10,227	2,140,592	44	10,817
Netherlands	3,417	782,477	2,577	486,891
Philippines	2,747	581,247	-	-
South Korea	2,541	556,979	3,136	554,252
West Germany	1,512	318,945	392	70,009
Brazil..................	1,437	304,316	718	116,678
Thailand	1,380	298,414	177	35,385
Other countries	2,796	618,418	906	159,972
Total	207,091	46,354,625	179,552	33,731,652
Zinc contained in ore and concentrates				
United States	137,375	13,365,830	156,552	18,851,431
Norway	8,848	883,674	6,792	532,713
United Kingdom	6,441	705,037	6,631	680,975
Belgium and Luxembourg.	5,862	586,374	6,676	563,298
West Germany	5,329	528,582	339	29,697
France..................	5,044	487,534	-	-
Netherlands	995	95,510	1,770	144,469
Japan	-	-	2,324	115,703
Total	169,894	16,652,541	181,084	20,918,286

Zinc - Production, Trade and Consumption (cont'd)

	1960		1959	
	Short Tons	$	Short Tons	$
Exports (cont'd)				
Zinc scrap				
Belgium and Luxembourg.	1,917	142,449	3,538	197,816
United States............	1,148	175,767	1,180	141,046
United Kingdom	598	39,612	-	-
Netherlands............	596	47,325	930	64,371
Japan	568	100,545	182	26,484
West Germany	505	21,260	154	17,648
Total..................	5,332	526,958	5,984	447,365
Zinc manufactures				
United States		96,662		175,139
Netherlands		28,833		310
Australia		9,963		-
United Kingdom		1,267		-
Other countries		880		2,665
Total..................		137,605		178,114
Imports				
Zinc in pigs, slabs, blocks, anodes	49	21,861	840	158,036
Zinc bars, rods, plates, sheet	943	485,784	1,172	605,070
Zinc dross and zinc scrap.	54	4,543	28	2,954
Zinc dust and granules ...	793	256,639	675	198,134
Zinc slugs, disks, shells..		172,180		191,802
Zinc manufactures not otherwise provided for ...		2,150,407		2,239,835
Zinc chloride	154	28,956	166	28,670
Zinc sulphate	886	74,981	1,021	85,478
Zinc white oxide	759	201,428	724	183,993
Lithopone	893	121,667	979	138,039
Total		3,518,446		3,832,011

Zinc – Production, Trade and Consumption (cont'd)
(short tons)

	1960			1959		
	Primary	Secondary	Total	Primary	Secondary	Total
Consumption						
Zinc used for or in the manufacture of:						
Copper alloys (brass, bronze, etc.)...	5,337	223	5,560	7,112	594	7,706
Galvanizing						
Electro	617	55	672	693	117	810
Hot-dip	32,108	717	32,825	35,748	478	36,226
Zinc diecast alloy	9,408	–	9,408	10,260	2	10,262
Other products (including rolled and ribbon zinc, zinc oxide)	8,333	2,345	10,678	10,975	1,955	12,930
Total...........	55,803	3,340	59,143	64,788	3,146	67,934
Stocks on hand at end of year ...	7,103	1,066	8,169	8,808	1,103	9,911

Source: Dominion Bureau of Statistics.
(1) Refined zinc produced from Canadian ores, plus recoverable zinc in ores and concentrates exported.
(2) Refined zinc produced from domestic and imported ores.

In 1960, Free World consumption of slab zinc rose from the 1959 [illegible] by an estimated 3 per cent. Consumption in the United States amounted to 877,884 tons, or 78,313 tons less. In the United Kingdom, it increased by 33,120 tons to 409,716 tons. Other substantial increases in the use of zinc were reported from West Germany, Italy, Japan, and India.

United States Quotas

The import quotas on unmanufactured lead and zinc imposed by the United States government by proclamation dated September 22, 1958, continued in effect throughout 1960, limiting commercial imports to 80 per cent of their annual average for the five-year period from 1953 to 1957. The quota on

Zinc - Production, Exports and Consumption, 1950-60
(short tons)

	Production		Exports			Consumption(3)
	All Forms(1)	Refined(2)	In Ore and Concentrates	Refined	Total	
1950	313,227	204,367	129,561	146,880	276,441	54,370
1951	341,112	218,578	154,593	146,132	300,725	61,023
1952	371,802	222,200	181,754	166,864	348,618	51,581
1953	401,762	250,961	192,656	158,388	351,044	50,717
1954	376,491	213,775	180,172	206,038	386,210	46,735
1955	433,357	256,542	190,585	213,837	404,422	58,062
1956	422,633	255,564	199,313	183,728	383,041	61,173
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

Source: Dominion Bureau of Statistics.
(1) Refined zinc produced from Canadian ores, plus recoverable zinc in ores and concentrates exported.
(2) Refined zinc produced from domestic and imported ores.
(3) Refined virgin zinc only.

Canadian zinc ores was 33,240 tons of contained zinc per quarter; on zinc metal it was 18,920 tons per quarter. The zinc-ore quota was filled in 41 days of the first quarter of 1960, in 36 days of the second, in 55 days of the third, and in 61 days of the fourth. The zinc-metal quota was filled in 88 days of the first quarter, in 90 days of the second, in 92 days of the third, and in 88 days of the fourth.

International Lead and Zinc Study Group

The International Lead and Zinc Study Group, organized in May 1959 under the auspices of the United Nations, held its first and second meetings at Geneva during 1960. At the first session, held from January 27 to February 3, the Group's statistical survey indicated that in 1959 world production and consumption were in approximate balance. Since it was possible that consumption would exceed production in 1960, there seemed to be no need to curtail the supply of zinc, but it was decided that the matter should be kept under close review. At the second session, which lasted from September 12 to 15, the statistical survey showed that the level of world consumption was lower in 1960 than had been expected at the January meeting. The supply, however, was not considered excessive. The Group's third session was scheduled to take place in March 1961 in Mexico City.

Principal Zinc Producers in Canada, 1960

Company	Mine	Location	Mill Capacity (short tons/day)	Grade of Ore (Principal Metals): Lead (%)	Zinc (%)	Copper (%)	Silver (oz/ton)	Ore Produced 1960 (short tons)	Ore Produced 1959 (short tons)	Zinc Produced 1960 (short tons)
Yukon Territory										
United Keno Hill Mines Limited[1]	Calumet	Mayo district	500	7.25	4.80		43.35	176,745	173,477	7,220
	Elsa	" "								
	Hector	" "								
British Columbia										
Consolidated Mining and Smelting Company of Canada Limited, The	Sullivan	Kimberley	10,000	*	*		*	2,522,554	2,440,396	*
	Bluebell	Riondel	700	*	*		*	255,571	251,366	*
	H.B.	Salmo	1,200	*	*		*	464,408	463,504	*
Canadian Exploration Limited	Jersey	Salmo	1,900	2.26	4.43		*	364,424	325,564	14,750
Highland-Bell Limited	Highland-Bell	Beaverdell	70	*	*		51.70	18,204	18,029	*
Howe Sound Company	Britannia	Howe Sound	4,500		1.29	1.79	*	409,751	300,946	4,453
Reeves MacDonald Mines Limited	Reeves MacDonald	Remac	1,000	1.15	3.59		*	411,282	421,593	12,397
Sheep Creek Mines Limited	Mineral King	Toby Creek, southwest of Invermere	500						181,495	
	Paradise	Spring Creek, southwest of Invermere		2.71(2)	4.84(2)		1.07(2)	194,607(2)		8,490(2)
ViolaMac Mines Limited[3]	Victor	Sandon	150	5.42	9.75		15.93	6,227	6,028	601
Manitoba and Saskatchewan										
Hudson Bay Mining and Smelting Co., Limited	Flin Flon	Flin Flon district	6,000		4.7	2.25	1.11	1,250,026	1,453,559	
	Coronation	Flin Flon "			0.2	4.33	0.12	192,775	Nil	67,093
	Schist Lake	Flin Flon "			7.6	4.26	0.91	114,686	98,108	
	Chisel Lake	Snow Lake, Man.		1.8	13.1	0.42	2.49	104,903	Nil	

Ontario										
Geco Mines Limited	Geco	Manitouwadge	3,300		2.74	1.76	1.36	1,294,077	1,290,279	28,362
Willroy Mines Limited	Willroy	"	1,200	0.22	7.39	1.24	2.16	429,309	371,186	27,500
Quebec										
East Sullivan Mines Limited	East Sullivan	Val d'Or	2,800		1.07	0.72	0.35	974,532	957,137	8,494
Manitou-Barvue Mines Limited(4)	Golden Manitou	"	1,300	0.69	6.08		5.11	164,690	170,575	9,381
New Calumet Mines Limited(1)	New Calumet	Calumet Island	750	1.92	7.36		4.13	100,463	103,120	6,890
Normetal Mining Corporation, Limited	Normetal	Normetal	1,000		4.19	3.28	1.99	347,164	376,360	10,313
Quemont Mining Corporation, Limited	Quemont	Noranda	2,300		2.60	1.30	0.81	856,632	850,099	16,591
Waite Amulet Mines, Limited	Waite Amulet	"	2,000		3.48	4.68	0.95	297,062	311,405	7,350
Newfoundland										
American Smelting and Refining Company (Buchans Unit)	Buchans	Buchans	1,250	7.49	12.79	1.12	*	386,000	359,000	44,738

Source: Company reports.

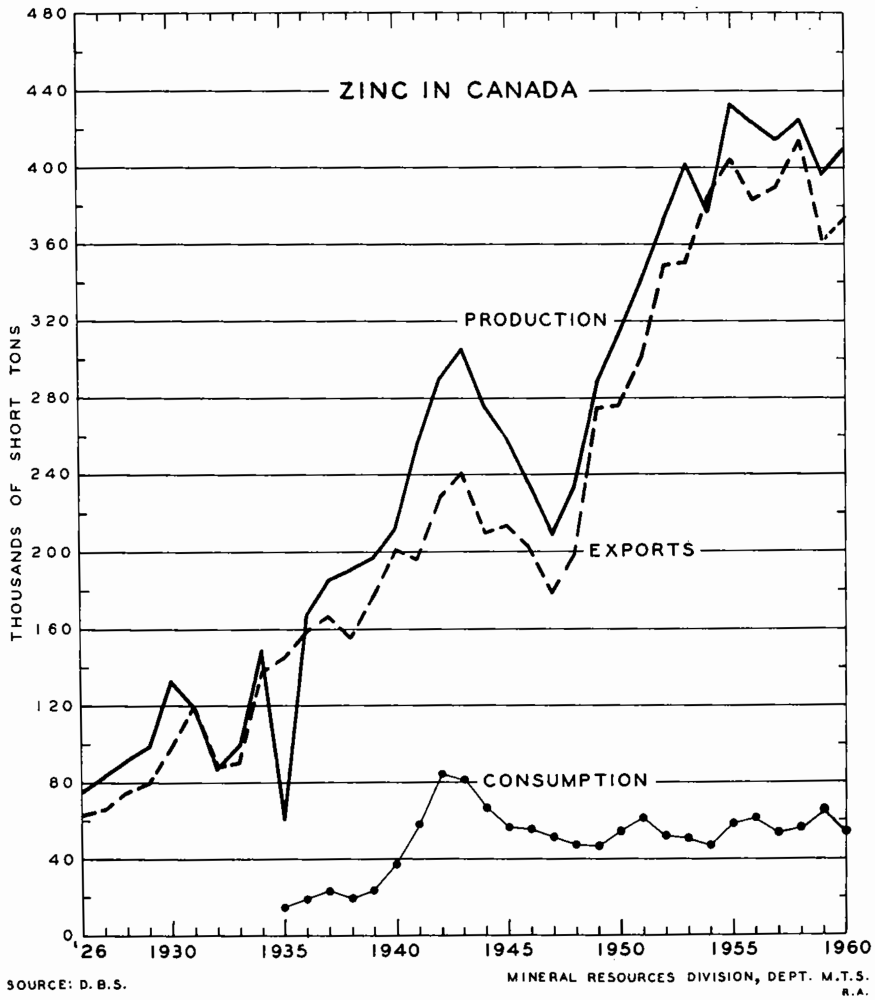
(1) Production given for the fiscal year ending September 30, 1960.

(2) This is the production of the Mineral King and Paradise mines combined.

(3) The ore was concentrated in the 150-ton mill owned by Carnegie Mining Corporation Limited, a ViolaMac subsidiary. The ore grade shown is based on metal recovered in concentrates.

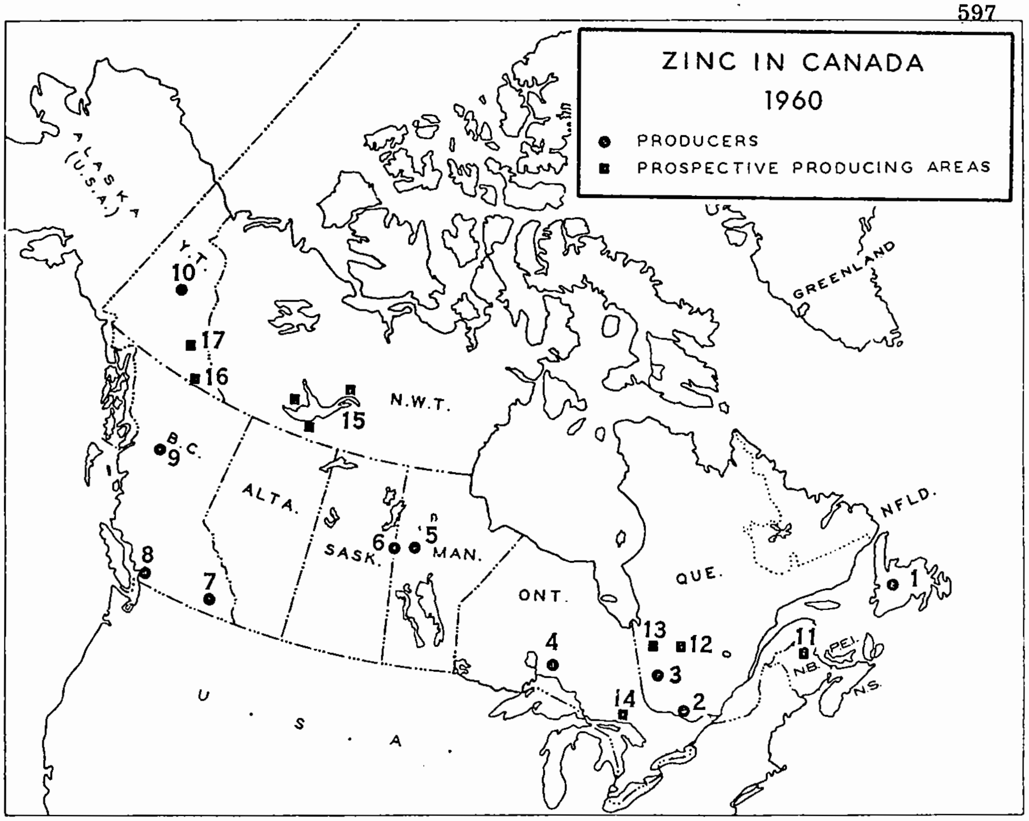
(4) Ore production does not include 292,065 tons of copper ore produced in 1960.

* Not available.



Producing Mines

Ore production from the Sullivan mine at Kimberly, British Columbia, owned by The Consolidated Mining and Smelting Company of Canada Limited, Canada's leading lead-zinc producer, totalled 2,522,554 tons in 1960 and 2,440,396 tons in 1959. Zinc concentrates from the Sullivan and the company's two other mines, the H.B. and the Bluebell, which are also in British Columbia, together with custom ores and concentrates, were treated in the electrolytic refinery at Trail. Output from all sources, including some metal sold in unrefined products, was 194,989 tons in 1960; in 1959 it was 194,499 tons. Of the combined lead and zinc production of 355,068 tons, approximately 67 per cent was derived from Sullivan concentrates, 14 per cent from concentrates from other company mines, 10 per cent from the retreatment



MINERAL RESOURCES DIVISION, DEPT. M.T.S.

Producers

1. American Smelting and Refining Company (Buchans Unit)
2. New Calumet Mines Limited
3. East Sullivan Mines Limited
   Manitou-Barvue Mines Limited
   Normetal Mining Corporation, Limited
   Quemont Mining Corporation, Limited
   Waite Amulet Mines, Limited
4. Geco Mines Limited
   Willroy Mines Limited
5. Hudson Bay Mining and Smelting Co., Limited
   Chisel Lake mine
6. Hudson Bay Mining and Smelting Co., Limited (also refinery)
   Flin Flon mine
   Coronation mine
   Schist Lake mine
7. Canadian Exploration Limited
   Consolidated Mining and Smelting Company of Canada Limited, The (also refinery)
   Sullivan mine
   H.B. mine
   Bluebell mine
   Highland-Bell Limited
   Reeves MacDonald Mines Limited
   Sheep Creek Mines Limited
   ViolaMac Mines Limited
   Western Mines Limited
   Yale Lead & Zinc Mines Limited
8. Howe Sound Company (Britannia Division)
9. New Cronin Babine Mines Limited
10. United Keno Hill Mines Limited

Prospective Producing Areas

11. Bathurst
12. Bachelor Lake
13. Mattagami Lake
14. Sudbury
15. Great Slave Lake
16. Watson Lake
17. Pelly River

of stockpiles of zinc-plant residues and lead blast-furnace slag, and 9 per cent from purchased ores and concentrates.

The zinc production of Hudson Bay Mining and Smelting Co., Limited, Canada's second-ranking producer, was 67,093 tons in 1960 and 62,582 tons in 1959. The company's main source of zinc-bearing ore was the Flin Flon mine, at Flin Flon, Manitoba. Smaller amounts came from the Coronation and Schist Lake mines, near Flin Flon, and from the Chisel Lake mine, at Snow Lake, Manitoba. The Coronation and Chisel Lake mines were brought into production in 1960, the former on April 1 and the latter on September 1. All of the ore from these mines, plus some copper ore from the Birch Lake mine, near Flin Flon, was concentrated in the 6,000-ton mill at Flin Flon. The zinc concentrate produced amounted to 129,096 tons. At the company's electrolytic plant, 116,368 tons of zinc concentrate and 52,352 tons of fume and stack dust were treated to produce 67,093 tons of slab zinc, 4,511 tons more than in 1959.

Cominco's and Hudson Bay's production and that of other principal zinc producers are summarized in the table on pages 6 and 7. Producers besides those listed included Mastodon Zinc Mines Limited, which was in production between May and October, and Lajo Mines Limited, Western Mines Limited, Yale Lead & Zinc Mines Limited, and New Cronin Babine Mines Limited, all in British Columbia.

Other Developments

Quebec

Mine development began during 1960 at the Watson Lake property of Mattagami Lake Mines Limited, in the Mattagami district. Reserves developed to the end of 1959 totalled 23 million tons averaging 12.5 per cent zinc and 0.7 per cent copper. A 1,185-foot shaft was sunk and lateral development started.

Exploration was continued by Orchan Mines Limited on a property adjoining the Watson Lake deposit to the south. Reserves at the end of 1960 were over 4 million tons averaging 12.5 per cent zinc and 1.3 per cent copper.

Consolidated Vauze Mines Limited carried out underground exploration and development in the Noranda area.

New Brunswick

In February 1960, Brunswick Mining and Smelting Corporation Limited reached an agreement with Sogemines Limited, the Canadian subsidiary of Société Générale des Minerais of Brussels, Belgium, to bring its zinc-lead mine near Bathurst into production at an initial rate of 2,000 tons of ore a day. Under the agreement, Sogemines, in 1960, carried out check drilling and examined the general development and operating aspects of the project.

Heath Steele Mines Limited began dewatering its mine 32 miles northwest of Newcastle in preparation for the resumption of operations that were suspended in March 1958.

Northwest Territories

No work was done in 1960 on the large lead-zinc deposit on the south shore of Great Slave Lake owned by Pine Point Mines Limited, a Cominco subsidiary. The Royal Commission on the Great Slave Lake Railway appointed in June 1959 to study a railway route to Great Slave Lake made its report in June 1960, detailing the merits of the western and eastern routes. On November 17, in the Speech from the Throne, the federal government announced its intention to survey the western route from Grimshaw, in northern Alberta, to Great Slave Lake.

Uses

The principal uses of zinc and the tonnage consumed in each are tabulated on page 592.

Zinc finds its greatest use in galvanizing, in which it is applied as as protective coating to iron and steel products to prevent rusting. The Steel Company of Canada, Limited, and Dominion Foundries and Steel, Limited, both of Hamilton, are the principal consumers of zinc for galvanizing. Each operates continuous-strip galvanizing lines.

Zinc-base die castings are widely used for automotive, household-appliance, and machine parts. The alloys most commonly used for die-casting 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. Schultz Die Casting Company of Canada Limited, at Lindsay, Ontario, and Barber Die Casting Company Limited and Pressure Castings of Canada Limited, in the Toronto-Hamilton area, are among the leading consumers of zinc for die-casting.

Brass, a copper-zinc alloy containing as much as 40 per cent zinc, is used in many industrial fields in the form of sheet and strips, tubes, rods and wire, castings, and extruded shapes. The principal fabricators of brass mill products are Anaconda American Brass Limited, New Toronto, and Noranda Copper and Brass Limited, Montreal.

Zinc oxide is used in compounding rubber and in making paint, rayon yarn, ceramic materials, inks, matches,and many other commodities. The principal producers in Canada are Zinc Oxide Company of Canada Limited and Durhams Industries (Canada) Limited, both in Montreal, and Canadian Felling Zinc Oxide Limited, Milton, Ontario.

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. Burgess Battery Company Limited, Niagara Falls, is the only producer, most of its output being used to make dry-cell-battery cups.

Zinc dust is used to make zinc salts and compounds, 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.

A new zinc-base alloy containing small amounts of copper and titanium was reported to have been used successfully in a number of industrial applications, particularly as sheet, in which the alloy's property of superior creep resistance was especially notable.

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; Prime Western, for galvanizing.

In Canada, the electrolytic process is used to produce Special High Grade and High Grade zinc. To meet consumer requirements for Prime Western, Canadian producers add lead in small amounts to the higher grades.

United States Consumption, by End Use, 1958-60

	1958	1959	1960
Galvanizing	381,229	361,027	371,589
Brass products	101,375	129,278	99,023
Zinc-base alloy	316,830	389,331	338,373
Rolled zinc	40,616	42,949	38,696
Zinc oxide	13,331	18,248	15,593
Other uses	14,946	15,364	14,610
Estimated undistributed consumption	-	-	-
Total	868,327	956,197	877,884

Source: U.S. Bureau of Mines, Mineral Industry Surveys, United States Zinc Industry, July, 1961, Report No. 211.

Zinc Research

Research on the hot-dip galvanizing process was continued in 1960 at the Mines Branch of the Department of Mines and Technical Surveys under the auspices of the Canadian Zinc Research and Development Committee. In this period a comprehensive study was made on laboratory-prepared galvanized coatings formed on various steel-sheet materials. These were selected on the basis of a difference in processing history or chemical composition, or in both. The results of this investigation, which will be published in due course, revealed significant differences in the galvanizing behavior of the plain-carbon and low-alloy grades of steel used.

A paper describing work in a prior phase of this project on the influence of tin, cadmium, antimony, and copper in hot-dip galvanizing has been accepted for presentation at the Sixth International Galvanizing Conference, to be held in Switzerland in June 1961.

A second research project, also in co-operation with the Canadian Zinc Research and Development Committee, was undertaken at the Mines Branch in connection with the properties of molten zinc and zinc alloys. Special equipment has been designed and built for the measurement of viscosity, density, and surface tension, and work has been started on a study of these properties in high-purity zinc.

Prices and Tariffs

The Canadian price of Prime Western zinc, on the basis of deliveries at Montreal and Toronto, was 12.75 cents a pound from October 20, 1959, to January 11, 1960. Subsequent price changes in 1960 were as follows:

	Cents a Pound
January 11	13.00
February 29	12.50
April 12	12.75
May 20	13.00
September 21	12.50
December 19	12.00

The United States price, East St. Louis, Illinois, advanced half a cent on January 8 to 13 cents a pound and remained at that level until December 13, when it dropped to 12.50 cents. On December 20 the price declined to 12 cents. At the beginning of 1960, the United Kingdom price of zinc was £94 1/2 sterling per ton of 2,240 pounds; at the end of the year it was £78 1/4 sterling.

Zinc ores and concentrates entered Canada duty-free; slab zinc was subject to a 0.75-cent-a-pound British preferential duty, a 1-cent-a-pound most favored nation duty, and a 2-cent-a-pound general duty. Varying schedules were applied to imports of zinc in semifabricated forms.

The United States tariff on the zinc content of zinc ores and concentrates was 0.6 cents a pound. On slab zinc it was 0.7 cents a pound. Varying tariffs were applied to imports of zinc in other forms.

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