CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

MINES BRANCH

# ZINC IN CANADA WITH COMMENTS ON WORLD CONDITIONS

by

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MINERAL RESOURCES DIVISION

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# ERRATA

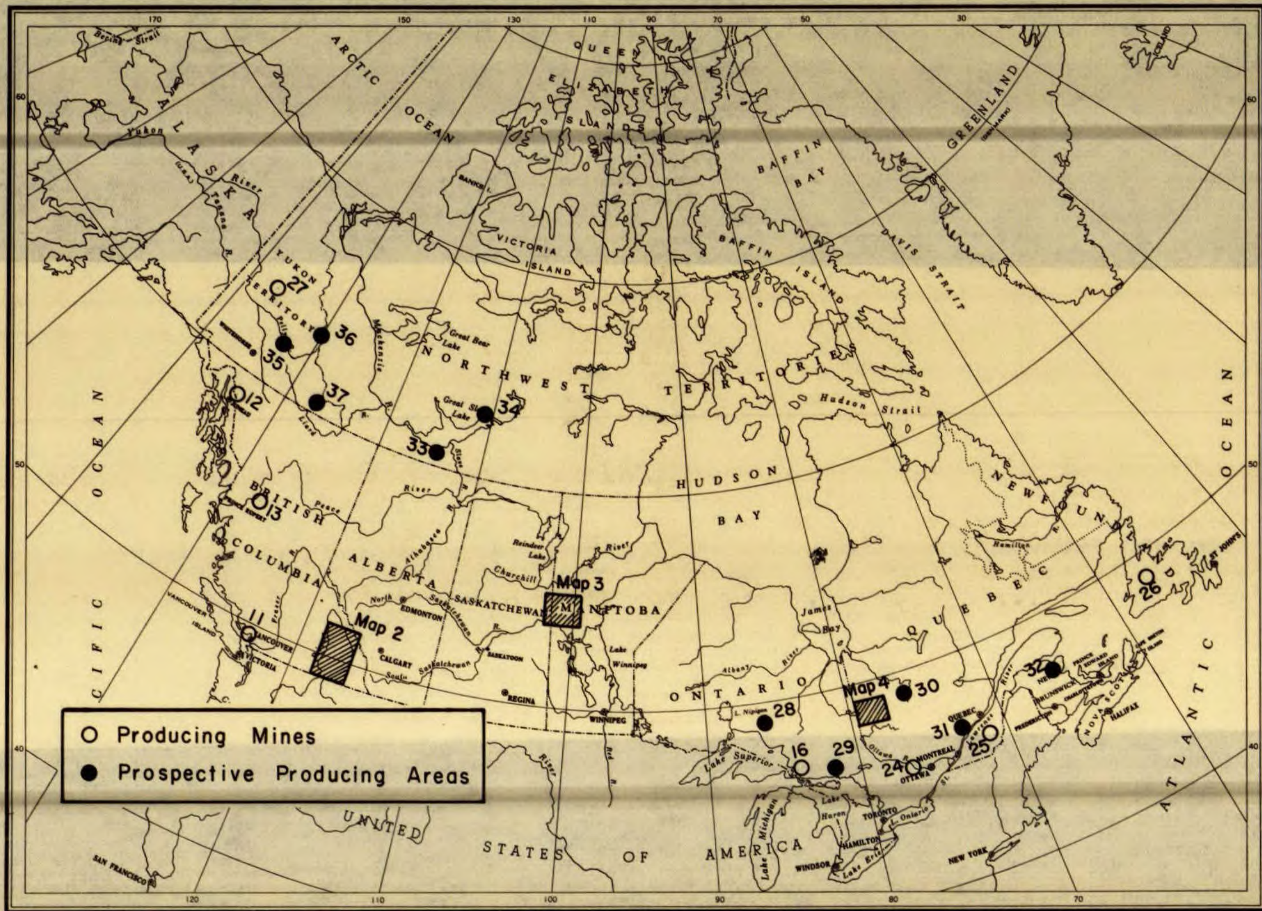
(Memorandum Series No. 137, Zinc in Canada. Cat. No. M33 - 137)

Page 40, lines 8 & 9 (from bottom), for "20,541,000 tons ...... silver." read " 15,222,000 tons averaging 3.18 per cent copper, 3.5 per cent zinc, 0.066 ounces per ton gold, and 0.95 ounces per ton silver."

Page 48, line 21, for "flotation" read "pyrite"

Page 58, line 7 (from bottom), for "levels" read "lenses"

Page 64, line 3, for "Nepisguithe" read "Nepisguit"




MAP No. I — PRINCIPAL ZINC-PRODUCING MINES AND PROSPECTIVE PRODUCING AREAS

# PREFACE

Although zinc ore was mined in Canada as early as 1898, commercial production was not achieved until twenty-five years later, when the process of differential flotation of complex ores was developed. Zinc became then and has remained a major product of Canadian base-metal ores.

In value of output zinc ranks fifth among the non-ferrous metals, after nickel, copper, gold, and more recently uranium. In volume of output it is the leading metal of the non-ferrous group. A large part of total production is refined in Canada, and smelting and refining operations are an important segment of the primary industry. About seven-eighths of Canadian zinc output is exported, mainly to the United States and the United Kingdom.

Though the main emphasis in this memorandum is upon the sources and methods of primary production, considerable attention has been given to the factors affecting Canada as a major trader in zinc. These are discussed in the concluding chapters on world production and trade, the industrial uses of zinc, and prices and tariffs.

John Convey
Director, Mines Branch
September 1957

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# ZINC IN CANADA
# WITH COMMENTS ON WORLD CONDITIONS

by

R. E. Neelands and D. B. Fraser

## CHAPTER I

## INTRODUCTION

Zinc is one of the more important metals used in modern industry and of the non-ferrous metal group is exceeded in world consumption by copper and aluminum only. Its chief uses are for coating steel products to inhibit corrosion, for die-casting, and for alloying with copper to produce brass.

Of the zinc-producing countries, Canada is second largest, both in the output of refined zinc and in over-all production, which includes zinc contained in ore concentrates exported to other countries. The United States is the principal producer and consumer of zinc. In the dollar value of metals produced from Canadian ores in 1956, zinc took fourth place at 125 million, being exceeded only by copper, nickel, and gold. Figures 1 and 2 on page 3 show Canadian production, exports and consumption from 1900 to 1955.

Occurrences of zinc in Canada are widespread and ore has been found in commercial quantities in 8 of the 10 provinces, also in the Yukon and Northwest Territories. Since zinc occurs in the form of a sulphide in association with sulphides of other metals, principally those of lead and copper, its recovery in most cases is integrally connected with the recovery of these other metals. There are very few instances of ore having been mined in Canada for zinc alone. For the most part, the principal zinc sulphide, sphalerite, occurs with the lead sulphide, galena, or with chalcopyrite, one of the principal copper minerals. In some deposits, sphalerite, galena, and chalcopyrite are all present in commercial amounts. Gold and silver are generally also present in zinc-bearing ores, silver being more usually associated with the lead-zinc type of ore, while gold often occurs with copper mineralization.

Canadian zinc production may be conveniently separated geographically into three divisions: (a) production from British Columbia and Yukon ores, a large part of which is refined at Trail, British Columbia; (b) production from Saskatchewan and Manitoba copper-zinc ores, which are refined at Flin Flon, Manitoba, and (c) production from Ontario, Quebec, and Newfoundland, all of which is exported in the form of zinc concentrates.

Refined zinc is produced at Trail, British Columbia, by The Consolidated Mining and Smelting Company of Canada Limited (hereafter referred to as Cominco in this review) and at Flin Flon, Manitoba, by Hudson Bay Mining and Smelting Company Limited. The greater part of the zinc-bearing ores mined in British Columbia and Yukon is treated at the Trail plant, which has an annual output capacity of 190,000 tons. The Flin Flon plant, with an annual capacity of 70,000 tons, treats zinc concentrate produced from the Company's copper-zinc deposit, which lies on the Manitoba-Saskatchewan boundary. A very high grade of electrolytic zinc is made at both Trail and Flin Flon.

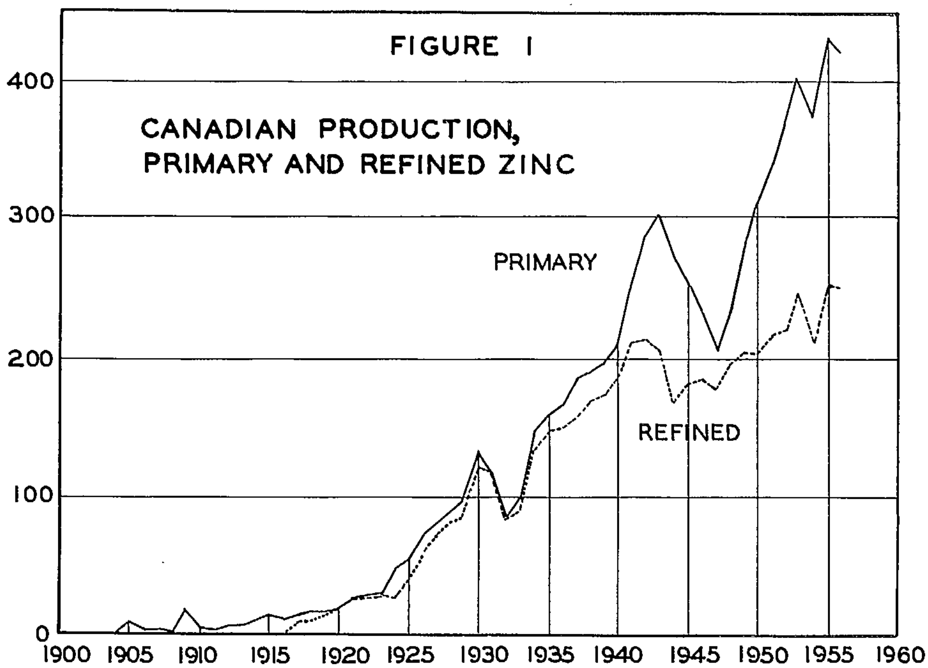
About one-third of Canada's zinc output has been contained in concentrates produced from copper-zinc and lead-zinc mines in eastern Canada. All of this material is exported, most of it to zinc smelters in the eastern and central sections of the United States. During the past two decades a number of companies have announced plans for the construction of a zinc plant to treat eastern zinc concentrate production, but none of these projects had materialized in 1956.

In 1955 the total production of zinc from Canadian ores was 433,357 tons of which 257,000 tons was refined zinc. Exports amounted to 213,837 tons of refined zinc and 190,585 tons of zinc contained in ore concentrates.

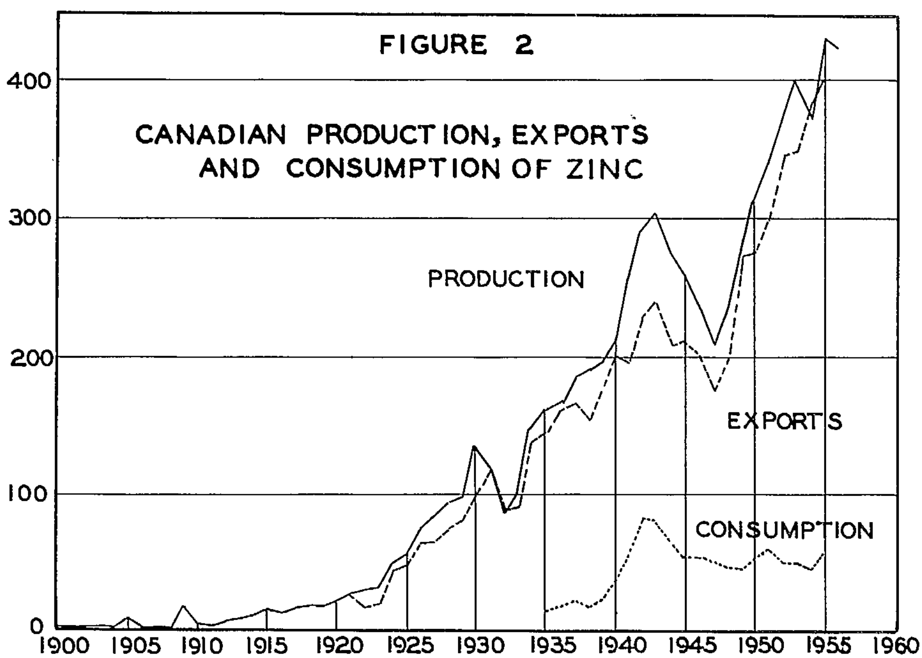
There has been a substantial increase in the consumption of zinc in Canada for peacetime uses as compared to the period prior to World War II. In 1955, about 58,000 tons of zinc, including some secondary material, was used for galvanizing, die-casting, and the manufacture of brass and zinc oxide.

Since Canada's reserves of zinc ore are, as far as known, larger than those of any other country, the outlook for the continuation of Canadian zinc production in important quantities seems assured.

The use of steel, which is the main basis of all industrial development, is marked by a period of great expansion in Canada. As the use of zinc is in many ways directly related to the use of steel, a corresponding increase of zinc consumption in Canada may be expected. The world demand will probably continue to require large amounts of zinc from Canadian sources. The object of this review is to present a general picture of Canada's position in respect of zinc.




THOUSANDS OF SHORT TONS



## CHAPTER II

### HISTORICAL SUMMARY

In contrast to copper and lead, zinc was not isolated as a separate metal until four or five centuries ago. It occurred, however, in ancient times in many alloys, notably brass, which was made by the Romans by melting copper with calamine, a natural zinc carbonate. History indicates that zinc was first made in China, from which country it was introduced into Europe by Portugese and Dutch traders in the sixteenth and seventeenth centuries. It was produced in a small way in England after 1740, but the modern zinc industry began in Belgium early in the nineteenth century. The art of zinc smelting was developed in Germany shortly after its start in Belgium and these two countries accounted for the bulk of the world's production until early in the twentieth century, when the United States took the leading place.

Prior to World War I, zinc was produced by the retort or distillation method only, and most zinc is still produced in this way. Briefly, zinc recovery by distillation involves roasting the zinc sulphide in the ore to form zinc oxide and fuming or distilling the zinc oxide in retorts under controlled temperatures, the zinc metal being condensed and recovered in muffles at the mouth of the retort. The retorts are heated by coal, and zinc smelting was naturally attracted to areas where coal was abundant such as Belgium, southern Poland, south Wales, and the mid-eastern United States. The old-fashioned retort smelters do not produce zinc of a higher purity than about 98.5 per cent, lead being the chief impurity. However, this material is very suitable for galvanizing, which was one of the earliest known uses for zinc and still utilizes the greater part of the output. It could also be used to make ordinary brass. By later advances in distillation technique, such as the use of electrothermic units and vertical retorts instead of the older horizontal type of retorts, a very high grade of zinc can now be produced by distillation.

Electrolytic refining of zinc on a commercial scale began about 1915, two of the first plants being those of the Anaconda Copper Mining Company at Butte, Montana, and Cominco at Trail, B. C. The process involves roasting to eliminate sulphur, as in the retort process, then dissolving the resulting oxide in sulphuric acid to produce zinc sulphate. After purification, the solution of zinc sulphate goes to electrolyzing tanks, where the zinc is deposited on aluminum cathodes. The process requires very large amounts of electric power and is usually economic only in areas where hydro-electric or other relatively cheap power is available. A very high grade of zinc can be produced by electrolysis, and this is largely absorbed by the die-casting industry, which has expanded greatly during the past 30 years.

Canada, in 1898, began making small shipments of zinc ore or concentrates from silver-lead-zinc mines in southern British Columbia to smelters in the United States. But high treatment and transportation charges left little profit to the producers. The total amount of zinc contained in these shipments, 1898 to 1915 inclusive, is estimated to have been 35,500 tons.

TABLE 1

Canadian Zinc Production[a] and Value
From Earliest Recorded Year

| Year | Tons | Value | Year | Tons | Value |
|---|---|---|---|---|---|
| 1898 | 394 | 36,011 | 1927 | 82,748 | 10,250,793 |
| 1899 | 407 | 46,805 | 1928 | 92,324 | 10,143,050 |
| 1900 | 106 | 9,342 | 1929 | 98,634 | 10,626,778 |
| 1901 | - | - | 1930 | 133,822 | 9,635,166 |
| 1902 | 71 | 6,882 | 1931 | 118,623 | 6,059,249 |
| 1903 | 450 | 48,600 | 1932 | 86,142 | 4,144,454 |
| 1904 | 289 | 24,350 | 1933 | 99,566 | 6,393,132 |
| 1905 | (b) | 139,200 | 1934 | 149,290 | 9,087,571 |
| 1906 | (b) | 23,800 | 1935 | 160,325 | 9,936,908 |
| 1907 | (b) | 49,100 | 1936 | 166,591 | 11,045,007 |
| 1908 | (b) | 3,215 | 1937 | 185,169 | 18,153,949 |
| 1909 | 8,234 | 242,699 | 1938 | 190,753 | 11,723,698 |
| 1910 | 2,182 | 120,003 | 1939 | 197,267 | 12,108,244 |
| 1911 | 1,173 | 101,072 | 1940 | 212,014 | 14,463,624 |
| 1912 | 2,677 | 211,774 | 1941 | 256,191 | 17,477,337 |
| 1913 | 3,535 | 186,827 | 1942 | 290,130 | 19,792,579 |
| 1914 | 4,550 | 262,563 | 1943 | 305,377 | 24,430,174 |
| 1915 | 6,115 | 554,938 | 1944 | 275,412 | 23,685,405 |
| 1916 | 11,682 | 2,991,623 | 1945 | 258,607 | 33,308,556 |
| 1917 | 14,834 | 2,640,817 | 1946 | 235,310 | 36,755,450 |
| 1918 | 17,542 | 2,862,436 | 1947 | 207,863 | 46,686,010 |
| 1919 | 16,097 | 2,362,448 | 1948 | 234,164 | 65,237,956 |
| 1920 | 19,932 | 3,057,961 | 1949 | 288,262 | 76,372,147 |
| 1921 | 26,545 | 2,471,310 | 1950 | 313,227 | 98,040,145 |
| 1922 | 28,145 | 3,217,536 | 1951 | 341,112 | 135,762,643 |
| 1923 | 30,208 | 3,991,701 | 1952 | 371,802 | 129,833,285 |
| 1924 | 49,455 | 6,274,791 | 1953 | 401,762 | 96,101,386 |
| 1925 | 54,634 | 8,328,446 | 1954 | 376,491 | 90,207,284 |
| 1926 | 74,969 | 11,110,413 | 1955 | 433,357 | 118,306,466 |
| | | | 1956 | 423,620 | 125,476,218 |
| | | | TOTAL TO 1956 | | 1,332,621,327 |

(a) Production means output of refined zinc plus recoverable zinc contained in exported concentrates.

(b) Not available.

Canadian zinc production became established with the inauguration of the Cominco electrolytic plant at Trail in 1916, with an initial rated output capacity of 60 tons a day. As the supply and grade of zinc concentrates improved, the plant was successively enlarged and expanded until in 1952 it attained a rated daily capacity of 520 tons of refined zinc.

Canada's other zinc plant, owned and operated by Hudson Bay Mining and Smelting Company Limited, is located at Flin Flon, Manitoba. Operation began in September 1930 at a rated daily capacity of 70 tons of refined zinc. From time to time the plant's capacity was increased to the present rated output of 190 tons a day.

The development of selective flotation in the years 1915 to 1925 resulted in the principal advance in the recovery of zinc from complex ores. In this process the bulk of the copper or lead in the ore is separated, leaving the zinc, which is then concentrated and separated from the remaining iron sulphides or waste material. Zinc concentrates usually average 50 to 55 per cent zinc, but may vary between 45 and 60 per cent, depending on the ore.

Another important advance in the recovery of zinc in Canada involved the treatment of zinc plant residues. These residues, containing up to 25 per cent zinc, result from the purification of the solution preparatory to electrolytic refining. The practice at Trail is to add the residues to the lead blast furnace charge; in the smelting operation, the zinc goes into the slag, from which a large percentage is recovered as zinc oxide by fuming. The first slag fuming furnace at Trail was constructed in 1930 and a second unit, completed in 1949, permitted the treatment of a large stock of accumulated residues. At the Flin Flon plant, residues from the copper smelter reverberatory furnace were first treated in 1951, following the completion of a zinc fuming plant to treat slag from the reverberatory furnace for the recovery of zinc oxide fume. At both Trail and Flin Flon zinc is recovered from oxide fume at the respective electrolytic plants.

## British Columbia

The province's silver-lead-zinc deposits have been mined steadily for over 60 years. In periods of high prices, the number of individual operations at times exceeded several hundred, ranging from medium-sized mines to small leasing operations employing only a few men. During periods when prices were low, the number of smaller operators was materially reduced. Beginning early in the century, most of the mines shipped their silver-lead ore to Trail or to other lead smelters then operating in B. C. After completion of the Trail plant, the smaller mines shipped their zinc concentrates also to Trail, and this practice continued until 1952, when it reached a peak of over 50,000 tons of contained zinc. In 1953, custom shipments to Trail dropped substantially, and exports of concentrates to plants in the northwestern United States increased. This trend continued through 1956, and in 1955 exports amounted to 30,300 tons of contained zinc.

## Manitoba and Saskatchewan

There was no production of zinc in Manitoba or Saskatchewan prior to 1930, when Hudson Bay Mining and Smelting Company's zinc plant came into operation. In addition to its own ores from the Flin Flon deposit, the Company treated zinc concentrates produced by Sherritt Gordon Mines Limited from its copper-zinc deposits at Sherridon, Manitoba, in the period 1942-1951, and by Cuprus Mines Limited, a copper-zinc producer near Flin Flon, in 1948-1954. The ore deposits at both these mines were exhausted when operations ceased. Hudson Bay commenced production from its Schist Lake copper-zinc mine in 1954, and expects a small recovery of zinc from its Coronation mine which is now under development.

## Ontario

Production of zinc in Ontario has been notably low, considering the magnitude of the total metal output of the province. In the period 1902-1909, there was a small production from the Long Lake zinc mine in Frontenac county, and in 1928-1930 about 4,500 tons of contained zinc was produced from the Errington mine near Sudbury. During World War II, the Geneva Lake zinc-lead mine in the Sudbury area was again brought into production, and between 1941 and 1944 it produced over 5,000 tons of contained zinc. Jardun Mines Limited reopened several old mines near Sault Ste. Marie and began producing zinc and lead concentrates in 1954.

## Quebec

The Tetreault mine, 60 miles west of Quebec City, was Quebec's first important zinc producer and was operated intermittently from 1913 until 1955 with a total output of about 118,000 tons of contained zinc. During the past 25 years the development of the large zinc, copper-zinc, and lead-zinc deposits in Abitibi county, northwestern Quebec, has raised the province's production of zinc concentrate to major proportions. Several mines in southern Quebec have increased the output. Most of the concentrates have been exported to plants in Pennsylvania and Illinois, and the remainder have been shipped to United Kingdom and European smelters, with the exception of shipments by two producers to Trail for several years prior to 1952.

## Maritime Provinces

Lead and zinc occur in a number of deposits in New Brunswick and Nova Scotia. There are no metalliferous occurrences in Prince Edward Island. Production of zinc concentrate began at the Stirling mine in Cape Breton Island in 1930: operations were suspended in 1938 but were resumed in 1952 and production was maintained until 1956, when ore was reported to be exhausted. In New Brunswick, the first production of zinc concentrate came from Keymet mines near Bathurst in 1954. This property was closed early in 1956 when reserves were exhausted.

In 1952 and 1953, two very large deposits of iron sulphides containing zinc and lead were outlined near Bathurst, New Brunswick. The development of these and of a similar type of deposit discovered northwest of Newcastle in 1954 is under way. In northern Cape Breton Island, scattered zinc occurrences have been found over a wide area, exploration of which was commenced in 1953 with promising results.

## Newfoundland

The only zinc deposits of importance are those of Buchans Mining Company Limited in the central part of the Island. Production here began in

TABLE 2

Canadian Production of Refined Zinc

(Short Tons)

| Year | Trail (a) | Flin Flon (b) | Total Refined (c) | Year | Trail (a) | Flin Flon (b) | Total Refined (c) |
|---|---|---|---|---|---|---|---|
| 1916 | 1,544 | | 1,544 | 1936 | 118,971 | 32,219 | 151,103 |
| 1917 | 9,984 | | 9,984 | 1937 | 124,094 | 34,486 | 158,542 |
| 1918 | 10,900 | | 10,900 | 1938 | 133,556 | 38,413 | 171,932 |
| 1919 | 15,371 | | 15,371 | 1939 | 139,520 | 38,790 | 175,641 |
| 1920 | 18,497 | | 18,497 | 1940 | 146,259 | 39,778 | 185,722 |
| 1921 | 26,494 | | 26,494 | 1941 | 168,541 | 48,510 | 213,608 |
| 1922 | 27,782 | | 28,145 | 1942 | 176,443 | 50,622 | 215,795 |
| 1923 | 30,025 | | 30,025 | 1943 | 154,555 | 54,249 | 206,510 |
| 1924 | 46,098 | | 27,444 | 1944 | 122,518 | 51,229 | 168,518 |
| 1925 | 48,955 | | 38,462 | 1945 | 135,887 | 47,469 | 182,266 |
| 1926 | 67,546 | | 61,727 | 1946 | 135,274 | 51,328 | 185,683 |
| 1927 | 73,527 | | 73,208 | 1947 | 126,589 | 52,897 | 178,264 |
| 1928 | 81,765 | | 81,765 | 1948 | 146,378 | 51,129 | 196,575 |
| 1929 | 86,048 | | 86,048 | 1949 | 157,204 | 49,174 | 206,045 |
| 1930 | 119,550 | 1,941 | 121,496 | 1950 | 156,021 | 48,943 | 204,367 |
| 1931 | 101,123 | 17,528 | 118,623 | 1951 | 164,513 | 54,684 | 218,578 |
| 1932 | 65,283 | 20,868 | 86,142 | 1952 | 161,357 | 61,783 | 222,200 |
| 1933 | 68,809 | 23,152 | 91,946 | 1953 | 185,859 | 65,730 | 250,961 |
| 1934 | 110,977 | 24,713 | 134,917 | 1954 | 147,776 | 66,922 | 213,810 |
| 1935 | 119,839 | 30,052 | 149,523 | 1955 | 190,910 | 67,355 | 257,008 |
| | | | | 1956 | 193,041 | 63,284 | 255,601 |

(a) Output reported by The Consolidated Mining and Smelting Co. of Canada Ltd., at Trail, B. C. (Some zinc sold in unrefined products is included in the table)

(b) Output reported by Hudson Bay Mining and Smelting Co. Ltd. at Flin Flon, Manitoba.

(c) Production according to Dominion Bureau of Statistics (Does not include any unrefined zinc).

1928 and has been continuous. The concentrates have been exported to the United States or Europe.

## Yukon

In the Mayo area, about the centre of the territory, high-grade silver-lead-zinc occurrences were discovered in 1906. Shipments of silver-lead ore began in 1921, but owing to high transportation costs zinc concentrate output did not begin until 1949. Several isolated zinc-lead deposits of considerable extent have been located in recent years.

# CHAPTER III

## MINERALOGY AND GEOLOGY

### Zinc Mineralization

By far the most important zinc ore mineral is the sulphide, sphalerite (ZnS), commonly known as zinc blende. It is found in greater or lesser amounts in sulphide ores throughout the world and occurs in deposits formed under a wide range of temperatures. The zinc oxides, zincite and franklinite, and the zinc silicates, willemite and troostite, are relatively rare and in commercial quantities are confined almost entirely to the deposits at Franklin Furnace, New Jersey.

The common secondary zinc minerals formed by the alteration of primary mineralization by action of surface weathering include: zinc carbonate or smithsonite; hydrated zinc silicate or calamine; and hydrated zinc carbonate or hydrozincite. The zinc silicate willemite may also be formed by alteration.

Zinc sulphate, chloride, nitrate, and carbonate are readily soluble and zinc sulphide is often oxidized to zinc sulphate where pyrite or other iron sulphides are present. The greater tendency for sphalerite to be oxidized in the presence of pyrite than lead sulphides explains why zinc sulphide is often leached out at the surface of sulphide deposits, leaving lead sulphide only slightly affected.

### Description of Zinc Minerals

Sphalerite (ZnS) is sometimes found in crystals of the tetrahedral group of the isometric system but more commonly in massive or granular form. It contains 67 per cent zinc and 33 per cent sulphur. The hardness varies from 3.5 to 4 and the specific gravity from 3.9 to 4.1. It has a resinous to adamantine lustre and a brownish streak. Its colour varies greatly but is generally dark yellow, brown, or black. Sphalerite is formed under a wide range of conditions; it is often present in contact metamorphic deposits or in veins formed at great or moderate depths.

Marmatite is a variety of sphalerite containing 10 per cent or more of iron. It is usually massive and varies in colour from dark brown to black. The ore of the Sullivan mine at Kimberley, B.C., one of the largest zinc-lead mines in the world, is largely marmatite.

Pribamite is another variety of sphalerite, green or yellow in colour, containing up to 5 per cent cadmium.

Wurtzite (ZnS) has the same composition as sphalerite, but crystallizes into hexagonal crystals.

Guadalcazarite is a sulphide of mercury containing up to 4 per cent zinc. It occurs in small amounts with cinnabar, barite, and quartz at Guadalcajar, Mexico.

Zincite (ZnO) is also known as red zinc oxide. It is a deep red or orange-yellow mineral with a hardness of 4 to 4.5 and a specific gravity of 5.43 to 5.7. It is formed under high temperature conditions in vein-like masses and, at Franklin Furnace,is associated with willemite and franklinite.

Franklinite (FeZnMnO) is an oxide of iron, zinc, and manganese with a hardness of 5.5 to 6.5 and specific gravity of 5 to 5.2. It is iron-black in colour.

Smithsonite ($ZnCO_3$) is the carbonate of zinc commonly found in altered zones of zinc-bearing veins, especially in deposits that occur in limestone. Its colour varies from white to brownish, greenish, or blue.

Willemite ($Zn_2SiO_4$) has hardness of 5.5 and specific gravity of about 4. Its colour varies from white and greenish yellow to apple-green or dark brown but its streak is uncoloured. It is found in abundance in the primary ores of Franklin Furnace.

Troostite is a reddish form of willemite containing manganese.

Calamine ($Zn_2H_2SiO_5$) a hydrated zinc silicate containing 54.2 per cent zinc is more widespread than willemite and is commonly associated with smithsonite in altered zinc deposits. It is a white mineral, but sometimes occurs with a bluish, greenish, or brownish shade, usually as orthorhombic crystals. Its hardness is 4.5 to 5 and specific gravity 3.4 to 3.5. It shows a vitreous lustre and a white streak. Calamine is found in many of the altered zones of sulphate deposits in the western United States, and in a few places in British Columbia, notably the H. B. property near Salmo.

Other zinc-bearing minerals include: Gahnite ($ZnAl_2O_4$); Hetoerolite ($ZnOMn_2O_3H_2O$); Monheimite ($ZnFeCO_3$); Hydrozincite ($ZnCO_32Zn(OH)_2$); Aurichalcite (2 $(ZnCu)CO_3$, $3(ZnCu)(OH)_2$); Clinohedrite ($H_2CaZnSiO_4$); Hardystonite ($Ca_2$, $ZnSi_2O_7$); Leucophoenicite ($(H_2MnZnCa)_7Si_3O_4$); Roepperite (FeMnZnMg)2, $SiO_4$); Jeffersonite (CA, Mn) (Mg, Fe, Zn) $(SiO_3)_2$.

## Association with Other Minerals

Zinc sulphides in significant amounts are seldom found alone; they are commonly associated with the iron sulphides, pyrite and pyrrhotite, the lead sulphide, galena, and with chalcopyrite or other copper-bearing minerals. In Western Canada, where the galena is mostly argentiferous, silver-lead-zinc deposits are numerous and fairly widespread. There is often considerable variation in the relative amounts of the respective metals present. In some instances the silver content is the most important constituent, in others lead or zinc. In the majority of productive deposits, both lead and zinc are found in economically recoverable quantities.

Where lead and zinc occur in a deposit of considerable vertical extent, the upper portions are often appreciably richer in lead; the zinc content, however, increases in relation to the lead in the lower zones. This phenomenon, which is characteristic of lead-zinc deposits throughout the world, indicates that zinc sulphides were probably formed under conditions of higher temperature and pressure than lead sulphides. Silver is generally more closely associated with lead than with zinc, which accounts for the higher silver content in the upper zones of many deposits. There is, however, much overlapping, and some zinc deposits have been found carrying a fairly high silver content with little lead.

Zinc is also found in close association with copper in deposits usually having little or no lead present, suggesting a formation under fairly high temperature conditions. Gold and silver are often present in appreciable quantities in this type of deposit, as at Flin Flon, Manitoba. There are a few deposits in Canada where copper and lead are both present but in considerably less quantity than zinc, the most important being the Buchans mine in Newfoundland.

## Types of Deposits

Ore deposits fall into two major divisions; first, those of primary origin; and second those of a secondary nature formed from primary ores. In the case of Canadian zinc deposits, the primary ores are much the more important and they in turn are classified as (a) syngenetic -- those originating at the same time as the surrounding rocks and (b) epigenetic -- those originating later than the enclosing rock. All major zinc-bearing deposits are of the epigenetic type and may be in the form of veins, stock-works, shear zones, or replacements.

Fissure veins are probably the commonest type of zinc and lead deposits occurring in Canada; examples are the galena-sphalerite veins of the Slocan district, British Columbia, and the Gaspe region of Quebec. In common with other vein formations they tend to pinch and swell and may be difficult to appraise from a viewpoint of reserves. The intrusion of mineralization into shear zones, thus forming veins or a series of veins, has been the origin of a large number of zinc-bearing deposits, many of which have lengths, depths, and widths of considerable extent.

The most important type of zinc-bearing orebody is the replacement deposit formed by the gradual replacement of one mineral by another by the action of liquid or gaseous solutions. Most replacements are thought to have been formed from heated solutions given off by cooling igneous masses and penetrating under pressure through zones of weakness. The replacement process may develop over a very extensive area, as in the case of Canada's two largest developed zinc orebodies, the Sullivan and Flin Flon. Replacement also takes place through the agency of surface waters, which dissolve minerals in the upper part of a deposit and, permeating downward through cracks and fissures, enrich the mineralization below.

## Location of Deposits

Zinc mineralization is widespread in Canada, where it has been found in five of the six major geological regions across the country. These regions are briefly described in the following paragraphs, with special reference to zinc.

### (1) The Cordilleran Region

This region comprises British Columbia and Yukon. It is generally mountainous with two principal northwesterly striking ranges, (a) the Rocky mountain range, which forms the eastern boundary of B. C., and (b) the Coast range, which follows the Pacific coast and coastal islands into Yukon and Alaska. Between these ranges the country is composed of local mountain ranges and plateaux. The rocks range from Precambrian to most recent formations. The Coast range resulted from the intrusion of complex igneous rocks during the early Mesozoic age, accompanied by widespread mineralization. These batholithic intrusions were not restricted to the Coast range but extended easterly in some areas and most of the silver-lead-zinc and other zinc ore deposits of Western Canada are thought to be associated with this period of igneous activity. Much folding took place subsequently, when the Rocky mountain range was upthrust in late Mesozoic times. A number of large zinc-lead deposits occur in the Cordilleran region, including the Sullivan deposit at Kimberley which is one of the largest known zinc-bearing deposits in the world. Other important deposits are the Jersey, the H. B., and the Reeves MacDonald, near Salmo; the numerous silver-lead-zinc zones in the Slocan area, B. C., and in the Mayo district of the Yukon. The Britannia deposits on Howe Sound, B. C., are the most important of the copper-zinc type of deposit.

### (2) The Interior Plains

The plains comprise southern Saskatchewan and Alberta, and extend down the Mackenzie River valley to the Arctic ocean. The basement rocks are generally overlain by many thousands of feet of flat-lying or gently rolling Palaeozoic sediments. Zinc-bearing mineralization has been found in commercial quantities only in the Pine Point area south of Great Slave Lake, where it occurs as a replacement.

### (3) The Canadian Shield

The Shield covers an area of about 2 million square miles surrounding Hudson Bay. Its rocks are mostly of Precambrian age; such sediments as may have formed on it since the end of the Precambrian have been largely removed by later erosion. Zinc mineralization in the Shield is more usually associated with copper than with lead, and is thought to be related to a period of mountain building accompanied by widespread intrusions of granitic batholiths. The Flin Flon deposit and those of northwestern Quebec such as Normetal, Waite Amulet, and East Sullivan are associated with these intrusions.

(4) The St. Lawrence Lowlands

In the eastern Ontario section of the region, which is partly overlain by the Grenville series of Precambrian age and partly by Palaeozoic sediments, many small veins of galena with some sphalerite have been found. Since many of these veins cut the sediments they are considered to have been formed in Palaeozoic rather than in Precambrian times. None of these occurrences have been of any commercial importance; the Long Lake mine about 35 miles north of Kingston, Ontario, now defunct, was the most important producer of zinc ore.

(5) The Appalachian and Acadian Region

In Canada this region comprises the Atlantic Provinces and that part of Quebec lying south of the St. Lawrence and east of a line from Quebec City to Lake Champlain. While Precambrian rocks occur in some regions such as Cape Breton Island and in southern New Brunswick, most of the area is underlain by rocks of early Palaeozoic age. The formations are largely limestones and shales. During the middle Devonian period the region was subjected to igneous intrusions, causing intense folding, and it was during this period that mineralization took place. Some of the largest replacement deposits in Canada appear to have originated from or to have been associated with batholithic intrusions of Devonian times in the Appalachian region. Among these are the zinc-lead deposits discovered near Bathurst, New Brunswick, in 1952, the copper orebodies of Gaspe Copper Mines Limited in North Gaspe county Quebec and the zinc-lead-copper deposits at Buchans, Newfoundland. A great number of occurrences of fissure veins and mineralized shears have been found in the area in addition to the large replacement bodies.

(6) The Arctic Archipelago and Hudson Bay Lowland

The islands in the Canadian Arctic comprise more than half a million square miles of land area. Much of this is made up of Precambrian rocks but there are vast areas covered by Palaeozoic strata of Silurian and Devonian age which in some regions assume thicknesses up to 8,000 feet.

The southwest coast of Hudson Bay is a lowland underlain by flat-lying strata ranging in age from Ordovician to Cretaceous.

No zinc or other metalliferous occurrences have been reported from either of these regions, but very little exploration has been carried out in the areas and it is possible that deposits of the Pine Point type may be found in the sediments.

# CHAPTER IV

## MINING, MILLING AND METALLURGY

### Mining

Zinc mining operations vary from small mines worked by a few individuals to large ones employing hundreds of miners and technicians. Though many small mines, especially in British Columbia, have made important contributions to Canada's zinc output, much the greater part of the production comes from the larger operations. The general trend in Canadian mining practice is to replace hand labour by the use of mechanical equipment in an effort to offset rising labour costs and to handle large volumes of ore efficiently.

While no radically new stoping methods have been developed in recent years, various improvements, particularly in drilling and blasting practice, have resulted in more efficient application of the established procedures. With the exception of the open pit of the Sullivan mine at Kimberley, B. C., very little zinc ore is presently being mined in Canada by surface operations. In the past, many, if not most, lead-zinc or copper-zinc mines in their initial stages operated open pits or side-hill excavations and no doubt this lower-cost method will be used again in the preliminary stages of new mining developments.

In common with other types of mines, zinc mines are operated from shafts that may be vertical or inclined, depending on the attitude of the orebody. In mountainous regions it is common practice to use side-hill tunnels or adits to gain access to the ore. In either case levels are established at intervals and the ore is removed between the levels by one or more standard methods such as shrinkage stoping, square-set mining, cut-and-fill mining, blast-hole mining, and trackless mining. Most zinc ore production in Canada is now carried out by some form of blast-hole mining using diamond drills or percussion drills and sectional steel. Mining at the Sullivan mine is done partly by this method.

In trackless mining the use of diesel or electrically driven heavy equipment mounted on pneumatic tires instead of the more conventional track-mounted equipment is the essential feature. The method is particularly adaptable in fairly flat-lying deposits such as at the Jersey mine of Canadian Exploration Limited, British Columbia, but it is also finding favour in the case of certain vertical orebodies such as at Barvue, Quebec.

At some mines a combination of one or more mining methods is used and there can be many ramifications involved in current practice to suit the requirements of mining various types of orebodies. Further information on the mining of zinc deposits may be gained from Chapter V, which describes operations at the producing mines.

## Milling

In most cases very fine grinding is necessary to free the zinc sulphide minerals from the associated iron, lead, or copper minerals. Crushing followed by ball mill grinding is the usual practice in order to reduce the grain size to less than would pass through a screen having 200 to 300 openings to the square inch or to about the particle size of a fine powder.

Flotation is almost universally used today to effect a concentration of the important sulphide minerals. After adding reagents to suppress the zinc the normal practice is to coat the lead or copper grains with a reagent which will cause them to float to the surface of a flotation cell upon aeration from below. The lead, copper, or both are removed from the surface of the cell by mechanical means. The residual material is then reconditioned so as to activate the zinc sulphides for flotation and these are collected by means similar to those used for copper or lead. The flotation concentrates are thickened and filtered to reduce the moisture content as much as possible. Zinc concentrates average generally 50 to 60 per cent zinc and may contain up to 12 per cent moisture.

There is, of course, considerable variation in milling flowsheets. In some mills a bulk non-ferrous metal concentrate is first recovered and this is then broken up to isolate the several economic sulphides as much as possible. At a few mills zinc is recovered first and other metals concentrated by further treatment. In almost all cases a clean concentrate cannot be made, some zinc remaining in the lead or copper concentrates, while certain amounts of these metals occur in the zinc concentrate. The object, however, is to concentrate the various metals as much as possible in order to cut down the weight of material to be shipped to a smelter and to facilitate smelting operations by the elimination of waste material.

Flotation reagents commonly used are collectors such as xanthates and aerofloat; frothers such as pine oil, cresylic acid, and dowfroth; sodium cyanide and zinc sulphate to depress zinc sulphides; copper sulphate to reactivate zinc and lime to assist in conditioning and thickening. Much information on milling, including many flowsheets, is contained in the Canadian Mining Manual published by National Business Publications Ltd. annually at Gardenvale, Quebec.

## Metallurgy

Zinc metal is recovered from ores or concentrates by either of two methods; pyrometallurgical or hydroelectrometallurgical. The pyrometallurgical method, commonly known as the "retort" process involves the reduction of zinc sulphides to zinc oxides by roasting and sintering. The oxidized and sintered material is then fired by natural or producer gas together with carbon in a retort furnace. The carbon unites with oxygen and metallic zinc is liberated as a vapour which is condensed and collected at the mouth of the retort. In the vertical retort, a development of recent years, the operation is continuous, while in the older horizontal type of retort a batch or cycle process is necessary. Ordinarily "prime western" grade zinc is produced by the retort process, but by redistilling high-purity zinc can be made.

The hydroelectrometallurgical process or electrolytic process as it is usually referred to is the method used in Canada at both Trail and Flin Flon. The process involves four principal steps; roasting, leaching and purification, electrolysis, and melting. Since zinc sulphide is insoluble in the leaching solution, concentrates must be roasted to convert the sulphide to zinc oxide or zinc sulphate.

At Trail the roasted concentrate is treated by leaching with dilute sulphuric acid to dissolve the zinc oxide, the result being a zinc sulphate solution containing small amounts of cadmium, copper, and other impurities. By means of a number of chemical procedures, the impurities are precipitated, leaving a pure zinc sulphate solution that is fed to the tank rooms. The tanks are arranged in 65 units, each of which comprises four cascades of 9 cells. Lead anodes containing a small amount of silver are used, and the zinc is deposited on aluminum cathodes, from which it is stripped every 24 hours. Sulphuric acid regenerated by the electrolysis is returned to the leaching section. The zinc sheets are melted in an induction furnace and cast into slabs weighing about 56 pounds.

The precipitates and residues from the purification of the zinc sulphate solution contain about 22 per cent zinc and 10 per cent lead. This material is fed to the lead sintering plant where it is added to lead concentrates and other material that make up the sintering charge. The sintering operation removes the sulphur by roasting and at the same time agglomerates the mixture into sizes suitable for charging the lead blast furnaces. Upon melting in the blast furnaces the charge is reduced to metallic lead and slag. The zinc enters into the slag, which is tapped from the furnaces and transferred in a molten state to slag fuming furnaces where the zinc is fumed off and recovered as zinc oxide dust. This material is treated in a section of the zinc plant by leaching and electrolysis.

The zinc refining process at Flin Flon is very similar to that used at Trail. Residues containing about 26 per cent zinc, resulting from the purification of the zinc electrolyte, are roasted together with copper concentrate to form a calcine that is charged to a reverberatory furnace. The zinc enters the furnace slag, from which it is recovered as zinc oxide by fuming. The operation at Flin Flon is also briefly described in Chapter V.

# CHAPTER V

## PRODUCING MINES

Zinc in Canadian ores is associated with both base and precious metals. Almost 50 per cent of the zinc produced in 1954, 1955, and 1956 was derived from zinc-lead ores and the remainder from copper-zinc, copper-lead-zinc, and other zinc-bearing ores. The production by provinces, including Yukon Territory, in descending order of output for the years 1954-55-56 was as follows:

TABLE 3

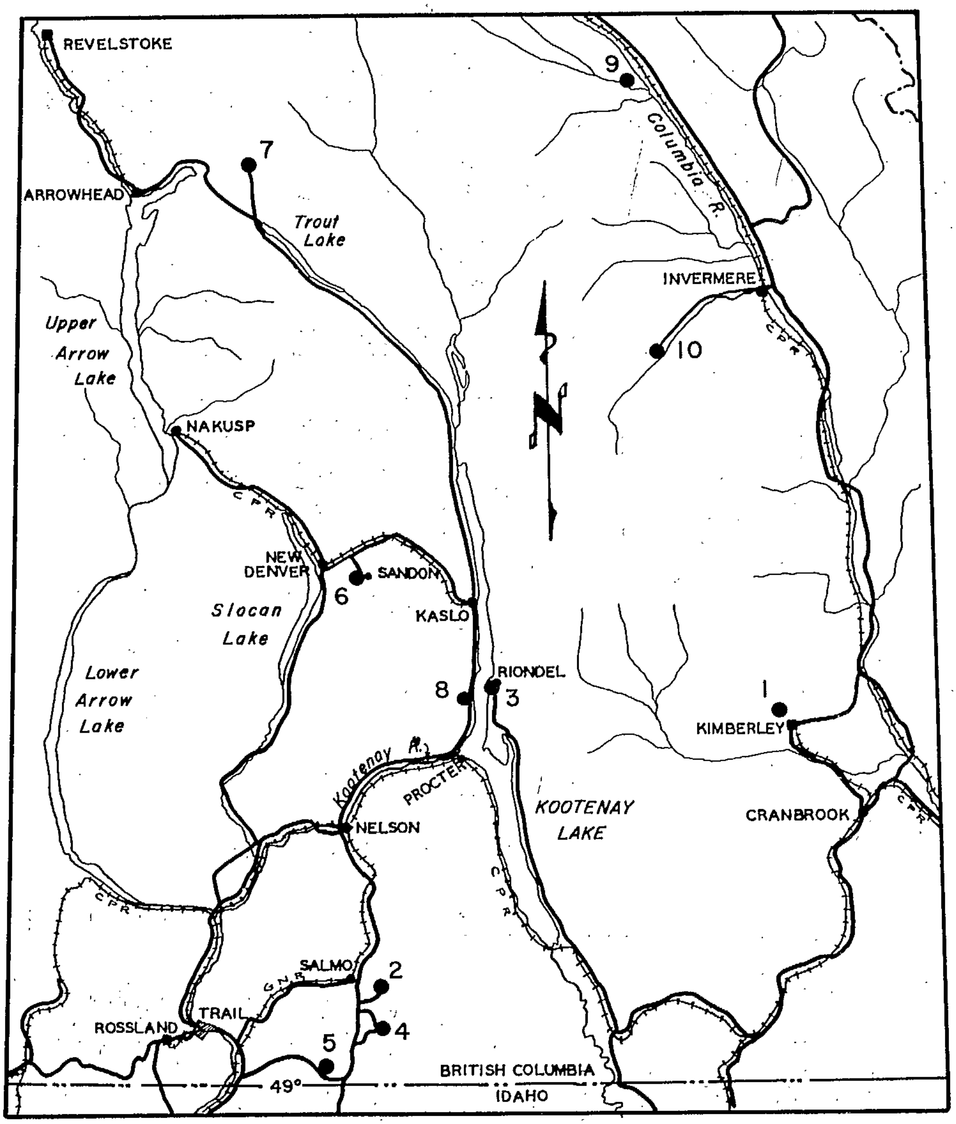
Production of Zinc in All Forms[a]

| Province | 1954 | 1955 | 1956[b] |
|---|---|---|---|
| | Short Tons | Short Tons | Short Tons |
| British Columbia | 151,539 | 215,886 | 221,855 |
| Quebec | 107,001 | 101,431 | 87,904 |
| Saskatchewan | 50,670 | 48,960 | 45,125 |
| Newfoundland | 30,002 | 28,636 | 37,140 |
| Manitoba | 16,253 | 17,966 | 18,100 |
| Yukon | 11,823 | 10,912 | 10,394 |
| Nova Scotia | 8,493 | 8,018 | 1,424 |
| Ontario | 710 | 1,548 | 1,500 |
| New Brunswick | - | - | 177 |
| Total | 376,491 | 433,357 | 423,619 |

(a) Refined zinc produced from domestic ore plus the estimated recoverable zinc content of exported concentrates.

(b) Preliminary.

## MAP No. 2




### MINES

1. SULLIVAN
2. H.B.
3. BLUEBELL
4. CANADIAN EXPLORATION
5. REEVES MacDONALD
6. VIOLAMAC
7. SUNSHINE LARDEAU
8. YALE LEAD & ZINC
9. GIANT MASCOT
10. MINERAL KING (SHEEP CREEK)

Scale 0 10 20 30 40 50 60 Miles

In this section the principal mines contributing to Canada's zinc production are briefly described. The order of arrangement is by provinces from west to east, followed by the Yukon Territory.

Information on the British Columbia mines was for the most part extracted from annual reports of the B. C. Department of Mines. In the case of mines in other provinces, the information came from companies' annual reports or from published papers describing the properties.

## British Columbia

### Southeastern Sector

#### The Sullivan (1, Map 2, page 22)*

The Sullivan mine is located on the south slope of Sullivan hill, about 1 1/2 miles northwest of Kimberley. It was acquired by The Consolidated Mining and Smelting Company of Canada Limited (Cominco) in 1910.

The original discovery of silver-lead-zinc ore was made in 1892. Development through the following 25 years proved the deposit to be very extensive, but early attempts to treat the ore failed owing to its complex nature and while there was some recovery of silver-lead ore by handpicking and selective mining, production on a commercial scale was not possible until 1919, when a process to recover high-grade lead and zinc concentrates by differential flotation was developed.

The ore occurs as a replacement in a sedimentary formation of quartzites and argillites that were deposited in late Precambrian age. The mineralized beds lie in an easterly plunging fold of the east limb of an open anticline, the axis of which strikes roughly north. Mineralization is thought to have occurred in the mid-Mesozoic era and to have been associated with the intrusion of granodiorite and syenite stocks and dikes. The over-all known dimensions of the orebody are roughly 5,000 feet north and south, and 3,000 feet east and west. It has an irregular dip varying from 20° to 45° to the east, and the thickness varies from about 30 feet in the lower horizons to over 300 feet near surface. The principal minerals are galena, sphalerite (usually the iron-rich variety, marmatite), pyrite, and pyrrhotite. The ore mined in recent years averaged about 4.5 per cent lead, 5.5 per cent zinc, 20 per cent iron, and 18 per cent sulphur.

The deposit outcrops near the top of Sullivan hill at an elevation of about 4,700 feet above sea level and from this horizon the mine has been developed for some 3,000 feet along the easterly dipping slope. Workings extend laterally for a distance of about one mile and over a vertical range of approximately 1,900 feet. The main entrance to the mine is the 3,900-foot level adit, which is over a mile in length from the portal to the orebody.

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* For location of Map 2 area, see frontispiece.

There are five haulage levels above the 3,900-foot level and seven below it, the deepest being the 2,850-foot level. In addition, the 3,700-foot adit level, completed in 1949, is used for haulage of ore to the mill and return of fill to the mine.

Primary and secondary crushing is all done underground in crushing stations at the 3,800 and 2,850 levels. The crushed ore from below the 3,900 level is raised to a loading pocket above the 3,700 by means of a series of inclined 17° conveyor belts. The system comprises 8 belts; it has a total length of 4,363 feet and a lift of 1,153 feet.

The main shaft is located near the south side of the orebody. It is inclined 39° and has a slope distance of 2,400 feet from its collar at an elevation of 4,380 feet to the 2,750-foot horizon. There is a second shaft near the centre of the orebody, also inclined at 39°, which extends from the 3,900-foot to the 3,300-foot level. Both shafts are used to move men and materials. Waste from below the 3,900-foot level is hoisted through No. 1 shaft.

The mine is operated five days a week at a rate of 11,000 tons of ore a day. About one-third of the ore is mined by open-pit methods at the top of the orebody. Stopes below the 3,900-foot level supply about half of the ore. Very little stoping has been carried out below the 3,350-foot level, but development is well advanced to the 2,900-foot horizon and plans to extend the workings below the present 2,750-foot depth have been announced.

The 3,700-foot haulage adit is about 2 miles in length. From its portal the haulage way is extended on surface about 2 miles to the concentrator, which is located at Chapman camp. All ore passes through a sink-float plant at the head of the concentrator. Here the coarse waste material, amounting to about 4,000 tons a day, is removed as a "float" product and returned to the mine for use as fill in worked-out stopes. About 7 per cent iron sulphide concentrate is added to the "float" as a binder. An average of 7,000 tons a day of "sink" material is fed to the concentrator.

The Sullivan concentrator was built in 1923 with a capacity of 2,500 tons; it has been increased from time to time to its present capacity of about 8,000 tons. The output per operating day amounts to about 600 tons of lead concentrate averaging 63 per cent lead, and 900 tons of zinc concentrate averaging 46 per cent zinc. In addition, about 2,200 tons a day of iron sulphides are produced and approximately one ton of tin concentrate averaging 60 per cent tin which is exported. The lead and zinc concentrates are shipped by rail to the lead smelter and zinc plant at Trail, B. C.

The annual production was relatively small prior to 1916. From that year until the Sullivan concentrator was built in 1923, the ore was milled in a concentrator at Trail. The following table gives some of the production details.

| Year | Tons of Ore Produced | Tonnage of Concentrates Produced | |
|---|---|---|---|
| | | Lead | Zinc |
| 1900-1950 | 55,315,110 | (a) | (a) |
| 1951 | 2,533,212 | 162,314 | 248,677 |
| 1952 | 2,699,533 | 139,337 | 246,099 |
| 1953 | 2,643,252 | 144,573 | 226,772 |
| 1954 | 2,681,635 | 173,008 | 281,425 |
| 1955 | 2,836,577 | 143,940 | 273,908 |

Gross Metal Content of Combined Concentrates[(b)]

| | Silver | Lead | Zinc |
|---|---|---|---|
| | oz. | tons | tons |
| 1951 | 3,197,829 | 124,269 | 137,916 |
| 1952 | 2,846,304 | 107,500 | 129,069 |
| 1953 | 2,950,234 | 103,893 | 114,905 |
| 1954 | 3,794,927 | 134,217 | 138,464 |
| 1955 | 2,907,749 | 112,763 | 132,682 |

(a) Not published.
(b) The metal content of the lead and zinc concentrates is not reported separately.

Ore reserves of the Sullivan mine have not been published in recent years. In 1940, they were reported to be sufficient for 20 years operation at the current rate of production, which would mean about 50 million tons. In 1947 the reserves were unofficially estimated at 60 million tons, averaging 7 per cent lead, 6 per cent zinc, and 2 ounces of silver per ton. It is regarded as probable that in view of new lower workings developed since 1947 the reserve position has been maintained, but that the average grade may be somewhat lower and the zinc content now greater than the lead content.

The H. B. mine (2, Map 2)

Cominco's H. B. property, consisting of 53 claims 7 miles southeast of Salmo, contains a large deposit of zinc-lead ore. The original discovery was staked in 1907 by Messrs. Horton and Benson, hence the name by which the property became known. Considerable development was carried out by a number of companies during the 20-year period prior to the purchase of the property by Cominco in 1927, but no ore suitable for production was found.

The host rock is limestone, of early Palaeozoic or late Precambrian age, which has been subjected to considerable folding and shearing. The deposit strikes north and south and plunges to the south at about 20°. It has been developed over a length of 700 feet, with the southerly limits not defined. Oxidation of the zinc-lead sulphides has taken place where the zone is exposed or near the surface at the north end, and has penetrated to a depth of about 300 feet. The sulphide bodies lie south of the oxide section and are protected from oxidation by overlying rocks. They extend southerly along the strike and are roughly parallel to each other about 150 feet apart. No. 1, or east orebody, is about 60 feet wide and 300 feet high. No. 2, or west orebody, is about 70 feet wide and 200 feet high.

Cominco reopened the mine in 1947 and for a few years shipped small amounts of zinc oxide ore to its Trail plant on a trial basis. About 1950 it was decided to develop the sulphide zones by driving the 2,800-foot level 700 feet below the 3,500-foot level, which gives access to the oxide zone; the elevations are based on sea-level. These levels have been interconnected by a vertical internal shaft, from which three intervening levels were established. When stoping began in 1955 it was concentrated on No. 1 zone, which has been developed over a length of 540 feet.

A 1,000-ton concentrator was built at the H.B. in 1952 and 1953, but production was deferred until May 1955, owing to the decline in zinc and lead prices.

Production in 1955 from 247,303 tons milled was 12,925 tons of zinc concentrate and 1,901 tons of lead concentrate. The contained metals were 6,842 tons of zinc and 1,262 tons of lead. In 1956 the ore milled was 435,305 tons.

The tonnage and grade of the ore reserves of the property have not been made public.

Bluebell mine (3, Map 2)

The property consists of 41 claims situated on Bluebell peninsula on the east side of Kootenay Lake six miles north of the ferry landing at Kootenay Bay and 10 miles from Proctor station on the Kootenay branch of the Canadian Pacific Railway. There is a motor road from the ferry landing to the mine community of Riondell on Galena Bay at the south end of the peninsula.

The presence of galena was noted early in the last century and the first claims were staked in 1882. There was intermittent production, amounting to about 550,000 tons of ore, between 1895 and 1927. Cominco acquired the Bluebell mine in 1929 and also purchased the Comfort property adjoining it to the north and the Kootenay Chief property adjoining on the south. The combined groups are now known as the Bluebell property.

The ore occurs as a lead-zinc sulphide replacement in a limestone bed of early Palaeozoic age. The bed strikes roughly north and south and dips 35° to the west. The ore mineralization is most extensive near the top of the limestone bed and varies in thickness from 0 to 120 feet. There are 3 individual ore zones in the Bluebell limestone separated from each other by about 1,500 feet. The Comfort zone lies to the north of the Bluebell and the Kootenay Chief zone to the south.

The main shaft, sunk in 1951, is situated between the Bluebell and Kootenay Chief ore zones. It is driven in the limestone bed which contains the ore and is inclined to the west at 35°. Levels have been established at vertical depths of 75, 225, 375, and 525 feet. Since production was resumed in April 1952, most of the ore has been derived from the Kootenay Chief zone. The Comfort zone has been developed for underground production and open-pit mining was started there in 1953.

The Bluebell concentrator, built in 1952, has a capacity of 750 tons a day and produces zinc and lead concentrates which are shipped by barge and rail to Cominco's plants at Trail. Appreciable amounts of silver and cadmium are recovered from the ore in addition to zinc and lead.

Production in Tons Since April 1952

| | Ore Milled | Concentrates | | Metal Content | |
|---|---|---|---|---|---|
| | | Zinc | Lead | Zinc | Lead |
| 1952 | 136,212 | 15,540 | 10,669 | 7,920 | 7,836 |
| 1953 | 216,401 | 25,447 | 17,286 | 13,030 | 12,505 |
| 1954(a) | 163,134 | 20,642 | 12,565 | 10,538 | 9,123 |
| 1955 | 241,788 | 27,777 | 17,085 | 14,177 | 12,486 |
| 1956 | 252,523 | | | | |

(a) The mine was closed by a strike from June 16 to September 14.

The ore reserves are not reported but it is considered that 4 or 5 years' ore supply at the property is a conservative estimate.

Canadian Exploration (4, Map 2)

Canadian Exploration Limited, a wholly owned subsidiary of Placer Development Limited of Vancouver, operates several mines on its property, comprising 41 claims about 5 miles southeast of Salmo. Trail is about 20 miles west of the property and Nelson 25 miles north.

The presence of zinc-lead ore was known for many years and there was a small production in the period 1917-1926. During World War II the Emerald tungsten deposit, located near former zinc-lead workings, was developed and brought into production by the Federal Government. This operation was closed in 1943, but in 1947 Canadian Exploration bought the property and resumed production of tungsten ore. During 1948 and 1949 it explored the Jersey zinc-lead deposit lying to the southeast of the Emerald mine and at a higher elevation on Iron Mountain. Owing to the low price of tungsten in 1948, the former tungsten mill was converted to a zinc-lead concentrator and the production of zinc and lead concentrates from the Jersey ore began in 1949. In 1951, when tungsten was in short supply, the Government reacquired the portion of the property containing the Emerald tungsten mine and built a new tungsten mill. In 1952, the company began development of the Dodger tungsten orebody lying more or less under the Jersey zinc-lead deposits and prepared this deposit for production in 1953. It reacquired the Emerald tungsten mine from the Government, together with the new tungsten mill.

The Jersey zinc-lead deposits are replacements in a bed of late Precambrian dolomitic limestone. The bedding has a general strike of about N20°E and plunges about 15° to the south. Intense folding has taken place in the area along a north-south axis and most of the ore occurs as lenses in the troughs of the folds. Exploratory drilling indicates that the lenses extend as a series for 7,000 feet along the strike of the formation and 2,000 feet in cross-section to it. The maximum thickness of the ore is 60 feet and the average about 12 feet.

Mining was carried out originally by standard methods using track haulage from two adit levels driven from outcrops at the south end of the deposit. This is known as the track section and it extends for 2,000 feet following the strike of the formation. In 1952 trackless mining was introduced by driving an 850-foot adit 14 feet by 14 feet in cross-section from the west side of the mountain to reach the main ore zones south of the track section. Heavy diesel equipment is used for loading into standard diesel dump trucks of 8- or 10-ton capacity. The ore is transported from the mine to the mill, a distance of 7,000 feet down the mountainside by tunnel and surface conveyor belts.

The company's zinc-lead mill has a capacity of 1,800 tons a day and it treated this amount of ore during part of 1953. Owing to difficulty in selling zinc concentrates, the tonnage rate was reduced to about 1,000 tons in the last quarter of 1953.

Production 1951-55

| Year | Tons milled | Contents - tons(a) | |
|---|---|---|---|
| | | Zinc | Lead |
| 1951 | 197,064 | 10,601 | 3,703 |
| 1952 | 369,335 | 17,157 | 7,722 |
| 1953 | 513,621 | 20,771 | 9,330 |
| 1954 | 369,484 | 10,876 | 8,611 |
| 1955 | 357,099 | 17,567 | 5,382 |

(a) Plus some silver and cadmium.

Ore reserves in the Jersey mine at the end of August 1956, were 2,208,647 tons, averaging 4.7 per cent zinc and 1.6 per cent lead.

Reeves MacDonald (5, Map 2)

The property of Reeves MacDonald Mines Limited consists of 2,278 acres of Crown-granted claims extending from the Pend d'Oreille River about 3 miles easterly. The mine is about 4 miles west of Nelway, a settlement on the International Boundary 33 miles south of Nelson.

The original zinc-lead discoveries were made in 1918. Extensive underground and surface drilling exploration was carried out in the period 1925 to 1929. The property then became idle until 1947, when steps were taken to resume production. A 500-ton a day concentrator was constructed and milling began in 1949. Production was continuous until July 1953, when operations were suspended owing to low metal prices.

The Reeves orebody is the most important of seven known deposits on the property and all the company's production has come from it. The ore occurs as a sphalerite and galena replacement in late Precambrian or early Palaeozoic dolomitized limestone. It strikes north 80° east and dips at 55° to the south. The width of the ore varies from 20 to 80 feet and it has a length of about 350 feet.

Access to the underground workings is by two adit levels at 1,900- and 2,650-foot elevations. These levels are connected by twin raises driven in the footwall, from which sublevels are established at 50-foot intervals. The apex of the ore is at about the 2,800-foot elevation and mining has been carried out over a vertical range of 800 feet above the 2,000-foot sublevel. All ore was removed from the mine through the 1,900-foot level. In 1953, a winze was sunk 562 feet below the 1,900-foot level.

Milling commenced in October 1949 at a rate of 500 tons a day. The mill capacity was increased to about 1,200 tons a day by mid-1952 but production was reduced to about 800 tons a day in 1953 and was suspended in July of that year. During the production years 898,000 tons were milled to produce zinc and lead concentrates containing 34,484 tons of zinc, 8,553 tons of lead, 218 tons of cadmium and 79,000 ounces of silver. In October 1955, operations were resumed at 1,000 tons per day when marketing conditions for zinc concentrates improved, and production has been continuous since.

The ore reserves in 1955 were reported to be between 2 1/2 and 3 million tons; the grade was not disclosed, but the ore mined has averaged about 5 per cent zinc and 1.0 per cent lead.

Violamac (6, Map 2)

Violamac Mines Limited of Toronto owns six claims, including the former Victor mine, on the west side of Carpenter Creek in the Slocan mining area, midway between Three Forks and Sandon.

The original silver-lead-zinc discovery was made in 1921. Small amounts of ore were shipped by lessees almost each year starting in 1922 until the property was acquired by Violamac Mines in 1947.

The ore occurs in a vein or lode of almost vertical dip that strikes northeasterly across inter-bedded argillite and quartzite rocks that dip southwesterly at about 40° into the mountain on the west side of Carpenter Creek valley. The vein varies in width from a crack up to 6 feet and it has been traced over a length of 700 feet on the lower levels.

The mine has been developed by nine adit levels, one below the other, over a vertical range of 650 feet. Little ore now remains above the fourth level. A 50-ton mill was built on the property in 1950, but it has been idle since 1952. Since 1953, the ore has been treated on a custom basis at Western Exploration Company's mill, Silverton, at a rate of about 70 tons a day. A small amount of hand-sorted ore has been shipped directly to the smelter each year. Lead and zinc concentrates are exported or shipped to the Trail plants for treatment.

The production of contained metals in the 1922-47 period from 1,424 tons of ore was 649 tons of lead, 154 tons of zinc, and 254,419 ounces of silver.

The ore milled or shipped by Violamac and its metal content since 1948 was:

| Year | Ore | Silver | Lead | Zinc | Cadmium |
|---|---|---|---|---|---|
| | tons | oz. | tons | tons | tons |
| 1948 | 220 | 25,562 | 118 | 28 | - |
| 1949 | 1,717 | 165,897 | 758 | 276 | - |
| 1950 | 2,497 | 182,189 | 1,137 | 455 | - |
| 1951 | 6,089 | 125,871 | 853 | 402 | 1 |
| 1952 | 12,182 | 282,851 | 1,986 | 1,142 | 6 |
| 1953 | 27,247 | 546,648 | 3,900 | 2,176 | 12 |
| 1954 | 22,628 | 542,049 | 3,498 | 2,338 | 15 |
| 1955 | 22,253 | 450,351 | 3,250 | 1,899 | 12 |
| 1956 | 21,640 | - | - | - | - |

Ore reserves in 1953 were reported as 210,000 tons, with 30,000 tons blocked out. The grade was not available.

Sunshine Lardeau (7, Map 2)

Sunshine Lardeau Mines Limited operates the Spider mine, located on 18 claims and fractions on Pool Creek, about 2 miles east of Camborne, which may be reached by boat and car from Arrowhead, 25 miles south of Revelstoke. There is also an access road to the mine from Kaslo. The company's camp and 80-ton a day mill are located at Camborne.

The ore occurs in two parallel veins striking northerly and dipping to the east at about 60°. The veins fill fractures cutting across a band of green chlorite schist. The eastern vein was worked by 4 adits and supplied most of the ore produced prior to 1949. The present operators have developed the western vein through several old adits and a new adit at a lower horizon driven in 1953.

The mine was operated intermittently from 1911 until 1949, when it was acquired by Sunshine Lardeau, with a total output of silver, lead, and zinc amounting to 323 tons. Sunshine Lardeau installed a 50-ton flotation mill in an old mill building and began production of concentrates in May 1952. Milling has been on an intermittent basis since, with production as follows:

| Year | Milled or Shipped | Silver | Lead | Zinc |
|---|---|---|---|---|
| | tons | oz. | tons | tons |
| 1952 | 7,119 | 147,710 | 649 | 418 |
| 1953 | 16,503 | 154,658 | 1,110 | 1,239 |
| 1954 | 17,904 | 299,252 | 1,955 | 1,640 |
| 1955 | 28,345 | 326,828 | 2,572 | 2,804 |

The ore reserves in October 1955 were 42,500 tons, averaging 13.2 ounces per ton silver, 9.6 per cent lead, and 9.9 per cent zinc.

Yale (8, Map 2)

Yale Lead and Zinc Mines Limited was formed in 1948 to consolidate and develop a number of old mines located in a group of about 80 claims between Coffee and Cedar Creeks on the west side of Kootenay lake, 25 miles northeast of Nelson. The village of Ainsworth adjoins the company's property near the mill site and plant.

Mining in the area began about 1892 and has been carried on intermittently since. Some of the more important of the old mines now included in the company's property were the Highlander, Banker, Albion, Eden, Crescent, Townsite, and Krao. Since 1951, most of the ore has come from the Highlander mine.

The ore occurs in large quartz-carbonate veins striking north and dipping about 60° to the west. Silver-lead-zinc mineralization is associated with shearing within the veins. The Highlander-Banker vein has been traced for some 5,000 feet. The ore sections in the vein are tabular and appear to rake to the north. Mining has been carried out through adits to the veins at various elevations above the level of Kootenay lake.

Milling commenced in April 1951 at about 150 tons of ore a day. Mill capacity has since been increased to about 350 tons.

The tonnage milled and metal content of the concentrates are as follows:

| Year | Ore Milled | Silver | Lead | Zinc |
|---|---|---|---|---|
| | tons | oz. | tons | tons |
| 1951 | 36,355 | 56,946 | 1,556 | 245 |
| 1952 | 56,095 | 131,107 | 975 | 502 |
| 1953 | 52,375 | 123,574 | 2,531 | 1,112 |
| 1954 | 53,760 | 113,171 | 3,103 | 792 |
| 1955 | 56,530 | 94,834 | 2,475 | 639 |
| 1956 | 53,120 | 95,619 | 3,023 | 551 |

Ore reserves at the end of 1956 were estimated at 132,000 tons, averaging 2.00 ounces per ton silver, 5.7 per cent lead, and 1.5 per cent zinc.

Silver Giant (Giant Mascot) (9, Map 2)

Giant Mascot Mines Limited operates the Silver Giant mine. The property consists of three groups comprising 240 claims (2,500 acres) on the west side of Jubilee Mountain, 7 miles west of Spillimacheen, on the Lake Windermere branch of the Canadian Pacific Railway. The original discovery was made before 1890 but there was little development or production until the property was acquired by the present owners.

The ore consists of galena, sphalerite, and barite as a replacement in Cambrian limestone beds or along a contact of the limestone with overlying slate formation. There has been considerable folding and deformation, so that the orebody has no definite strike or dip.

The mine has been developed by adits on Nos. 1, 2, 3, 5 and 6 levels. Nos. 7, 8 and 9 levels are serviced from the main haulage (No. 6 level) by a 49° incline winze. Most of the ore now comes from the deeper levels.

A 200-ton mill was completed and put into production in February 1951 to produce lead concentrates. The capacity has since been increased to 650 tons a day and a zinc circuit has been added.

Production has been as follows:

| Year | Ore Milled | Content | |
|---|---|---|---|
| | | Lead | Zinc |
| | tons | tons | tons |
| 1951 | 18,262 | 1,605 | 147 |
| 1952 | 112,705 | 4,287 | 327 |
| 1953 | 176,289 | 5,792 | 514 |
| 1954 | 187,653 | 6,603 | 767 |
| 1955 | 169,269 | 6,279 | 756 |

The ore reserves at the end of September 1956 were reported as 107,700 tons, averaging 3 per cent lead, and 0.5 per cent zinc. Owing to exhaustion of commercial ore, the mine and mill were closed in June 1957.

Mineral King (10, Map 2)

This property, owned by Sheep Creek Gold Mines Limited, comprises 2 lots (29 mineral claims) located on a ridge between Toby and Jumbo Creeks, about 25 miles southwest of Athalmer, a station on the Lake Windermere branch of the Canadian Pacific Railway.

There are three main orebodies occurring in magnesium limestone which has been partly brecciated. Insufficient development has been done to describe the zones except that they appear to be irregular replacements of zinc and lead sulphides containing considerable barite, as is common in Windermere Valley deposits.

The company acquired the property in 1951 and after outlining over 300,000 tons of ore by exploratory drilling it installed a concentrator of 500 tons capacity and began production in April 1954.

Production in 1955 was 161,962 tons milled, containing 5,689 tons of zinc, 2,467 tons of lead, and 126,709 ounces of silver.

Ore reserves as of May 1956, were reported as 347,105 tons, averaging 1.88 per cent lead, and 4.6 per cent zinc.

Western and Northern Sectors

Britannia (11, Map 1, frontispiece)

The Britannia mine, comprising some 550 claims on the east side of Howe Sound, is owned by Britannia Mining and Smelting Company Limited, a wholly owned subsidiary of Howe Sound Company of New York. The concentrator is located on tidewater at Britannia Beach, 28 miles north of Vancouver, and is connected by a gravel road with the company's main townsite, 3 miles to the east, at an altitude of 2,000 feet, from which point the upper levels of the mine are served by an adit. The original discovery was made in 1888 and the principal claims staked 10 years later. The company acquired the property in 1908. The production of copper concentrate has been almost continuous since 1905. Zinc concentrate production was sporadic prior to 1945 but has been continuous since that year.

The ore occurs in 10 or more separate deposits formed in sedimentary rocks of early Palaeozoic age. The intrusion of the Coast Range batholith in the Jura-Triassic period upheaved the formations and was accompanied by intense shearing and metamorphism. The copper and copper-zinc sulphide orebodies are within or closely related to a major shear that follows the east-west trend of the formations for several miles and extends over a vertical range of 5,400 feet as developed from surface exposures at an altitude of 4,500 feet to workings some 1,000 feet below sea level. The deposits are lenticular or egg-shaped, some being replacements and others made up of a series of veins or stringers. Pyrite is prominent and a by-product concentrate of this material has been made for some years.

The mine has been developed by many miles of adit workings interconnected by internal shafts. The portal of the main haulage level is near the head of the concentrator, about 200 feet above sea level.

The concentrator has a capacity of 6,500 tons of ore a day but in recent years has been operated at about half this amount. Details of ore milled and output of concentrates from 1951 to 1954 are tabulated below:

| Year | Ore Milled tons | Copper Concentrates tons | Zinc Concentrates tons |
|---|---|---|---|
| 1951 | 796,566 | 30,149 | 34,418 |
| 1952 | 829,652 | 24,528 | 26,511 |
| 1953 | 839,389 | 28,355 | 14,016 |
| 1954 | 916,419 | 30,022 | 17,455 |
| 1955 | 878,661 | 27,708 | 16,372 |

A small quantity of lead concentrate was produced in 1952 but its production ceased early in 1953. Greater emphasis was placed on mining copper ore rather than copper-zinc ore after 1952. The copper concentrate is all shipped to the Tacoma smelter of American Smelting and Refining Company. Zinc concentrate was treated chiefly at Trail until 1953 but has latterly been exported to foreign zinc plants.

The metal content of the above concentrates was:

| Year | Gold oz. | Silver oz. | Copper tons | Zinc tons | Cadmium tons |
|---|---|---|---|---|---|
| 1951 | 14,619 | 188,036 | 7,974 | 16,690 | 79 |
| 1952 | 10,669 | 97,017 | 7,172 | 14,295 | 65 |
| 1953 | 15,185 | 101,557 | 8,581 | 8,223 | 1 |
| 1954 | 11,569 | 98,990 | 9,026 | 10,224 | - |
| 1955 | 10,969 | 89,872 | 8,312 | 9,696 | 38 |

The ore reserves at the end of 1952 were estimated to be 3,500,000 tons averaging 1.2 per cent copper, 2.5 per cent zinc, and 0.03 ounces per ton gold. In addition there were zinc ore reserves of 2,000,000 tons, averaging 1.03 per cent copper, and 4.04 per cent zinc.

Tulsequah Mines (12, Map 1)

Tulsequah Mines Limited, an almost wholly owned Cominco subsidiary, operates two mines about 35 miles east of Juneau in the Alaska panhandle. The Tulsequah Chief mine comprises 18 claims on the east side of the Tulsequah River, about 10 miles from its junction with the Taku. The Big Bull mine comprises 19 claims and is located on the same side of the Tulsequah, about 9 miles south of the Tulsequah Chief. The ore from both mines is transported to a mill, situated on the west side of the river between the two mines, which was leased from the Polaris-Taku Mining Company.

Discovery and early development took place in the period 1923-1929. In 1946 Cominco acquired the properties and resumed exploration. The Polaris-Taku gold mine, which had been in production intermittently since 1937, was closed in 1950 and Cominco re-equipped its mill to provide for the treatment of 250 tons of base metal ore a day. This capacity was increased in 1953 to 500 tons a day.

The ore deposits at both mines occur in Mesozoic volcanic rocks mostly made up of rhyolite and tuff. The sulphide mineralization seems to be associated with regional north-south faulting and shearing.

At the Tulsequah Chief the ore occurs in lenticular sulphide replacement bodies measuring about 70 feet by 150 feet and plunging northwesterly. The mine is developed from adits over a vertical range of some 1,300 feet. There is an internal vertical shaft servicing seven levels spaced at 165-foot intervals.

At the Big Bull the ore occurs in steeply dipping stringer lodes or shoots of variable lengths and widths over a vertical range of some 300 feet. Mining is carried out from a 365-foot vertical shaft and two levels. Some ore is also mined in an open pit and loaded directly into trucks for shipment to the mill.

About 250 tons of ore a day are trucked to the mill from each mine. Coarse and fine crushing and grinding is followed by differential flotation to produce zinc, copper, and lead concentrates.

Production since 1952 is summarized as follows:

| Year | Ore Milled | Concentrates Produced | | |
|---|---|---|---|---|
| | | Zinc | Lead | Copper |
| | tons | tons | tons | tons |
| 1952 | 96,059 | 8,798 | 2,220 | 5,448 |
| 1953 | 173,115 | 16,086 | 4,081 | 10,210 |
| 1954 | 193,225 | 16,876 | 3,958 | 14,621 |
| 1955 | 196,700 | 18,062 | 4,276 | 13,912 |
| 1956 | 203,688 | | | |

Gross Metal Content of Concentrates

| Year | Gold | Silver | Copper | Lead | Zinc | Cadmium |
|---|---|---|---|---|---|---|
| | oz. | oz. | tons | tons | tons | tons |
| 1952 | 6,757 | 285,240 | 1,135 | 1,287 | 5,422 | 20 |
| 1953 | 16,073 | 519,265 | 2,071 | 2,303 | 10,533 | 39 |
| 1954 | 20,665 | 619,192 | 2,610 | 2,447 | 11,410 | 41 |
| 1955 | 20,867 | 670,916 | 2,675 | 2,673 | 12,205 | 43 |

The concentrates are stockpiled separately and shipped by barge from the head of navigation on the Taku river during the summer season. The lead and zinc concentrates are treated at Trail and the copper concentrates at Tacoma, Washington.

Owing to low base metal prices, operations were suspended in August 1957.

Silver Standard (13, Map 1)

The property, consisting of 46 claims, was acquired by Silver Standard Mines Limited in 1947. The mine is located about 5 1/2 miles north of New Hazelton on the Prince Rupert branch of the Canadian National Railways, to which it is connected by a gravel road.

Silver-lead-zinc ore has been found in a series of veins striking roughly northeast on the side of Glen mountain. They are contained in fractures that have cut a series of fairly flat-lying sandstone or greywacke beds forming the west link of an anticline and dipping to the west. The veins have an average dip of 60° to the southeast.

Mine development has been by 2 main adits that open up the 1,300-foot and 1,500-foot levels and a vertical winze to a depth of 500 feet below the 1,300-foot level, from which 3 levels have been established.

Ore was first found on the property about 1910, and in the period 1913-1922 shipments of ore and gravity concentrates amounted to 14,338 tons. The company installed a flotation mill on the property that began production in 1948. Its present capacity is 80 tons a day. Since 1951 the ore milled and metal content of concentrates were:

| Year | Ore Milled | Lead Concentrates | Zinc Concentrates |
|---|---|---|---|
| | tons | tons | tons |
| 1951 | 20,858 | 4,592* | |
| 1952 | 20,893 | 1,629 | 2,681 |
| 1953 | 21,559 | 1,631 | 2,770 |
| 1954 | 21,723 | 2,457 | 2,751 |
| 1955 | 10,048 | 935 | 1,286 |

Content

| Year | Gold | Silver | Lead | Zinc | Cadmium |
|---|---|---|---|---|---|
| | oz. | oz. | tons | tons | tons |
| 1951 | 1,516 | 889,849 | 922 | 1,488 | 20 |
| 1952 | 1,750 | 907,646 | 819 | 1,675 | 23 |
| 1953 | 1,801 | 871,165 | 867 | 1,593 | 20 |
| 1954 | 2,095 | 956,972 | 1,058 | 1,832 | 23 |
| 1955 | 642 | 362,196 | 451 | 769 | 10 |

* Combined lead and zinc.

Ore reserves in March 1956 were 8,333 tons, averaging 44.3 ounces per ton silver, 5.86 per cent lead, 5.95 per cent zinc.

## Saskatchewan and Manitoba

Flin Flon (14, Map 3, page 38)*

Hudson Bay Mining and Smelting Company Limited owns and operates the mine, copper smelter, and electrolytic zinc plant at Flin Flon, Manitoba. The property consists of about 9,400 acres on the Manitoba-Saskatchewan boundary.

The ore occurs as a replacement of massive or disseminated sulphides in quartz porphyry intrusive rocks that have been subjected to intense north-south shearing. The over-all dimensions of the ore are about 4,500 feet in length and 100 to 180 feet in width. The deposit is made up of six or more elliptical or egg-shaped masses of sulphides, within the shear, adjoining each other or separated by relatively narrow bands of waste; they have an average height of 500 feet. The strike of the ore is approximately north and south and the dip about 85° to the east. There is a definite plunge of about 30° to the south.

The interprovincial boundary line runs east and west at Flin Flon owing to a two-mile correction offset at latitude 54° 46'. The orebody is so located that the northerly part of the mine is in Manitoba while the southerly part is in Saskatchewan. Owing to the southerly plunge of the ore, the portion of the deposit lying in Saskatchewan becomes more extensive with depth.

The mine has been developed by (a) North Main shaft to a depth of 2,250 feet with 8 levels, the deepest at 2,210 feet; (b) South Main shaft to a depth of 4,073 feet with 11 main levels and (c) No. 3 shaft which is 3,250 feet deep. North Main and South Main shafts are 3,800 feet apart and No. 3 shaft is located between them. A winze sunk from the 4,000-foot level of South Main shaft to the 5,000-foot horizon gives access to the deepest mine workings. In recent years about 2/3 of the ore has been hoisted through the South Main shaft and 1/3 through the North Main shaft.

The original discovery was made in 1915. During the following 12 years, extensive diamond drilling was carried out and a satisfactory ore treatment process for the recovery of blister copper and electrolytic zinc was worked out. Production started in mid-1930 and has been continuous since. The tonnage milled to 1956 is shown in the table on page 39.

The plant consists of a concentrator for the production of copper and zinc concentrates with a capacity of 6,300 tons of ore a day, a cyanide plant to treat tailings from the zinc flotation for the recovery of gold, a copper smelter, a zinc roasting plant, a zinc electrolytic refinery, and a slag fuming plant for the recovery of zinc oxide from copper smelter slags.

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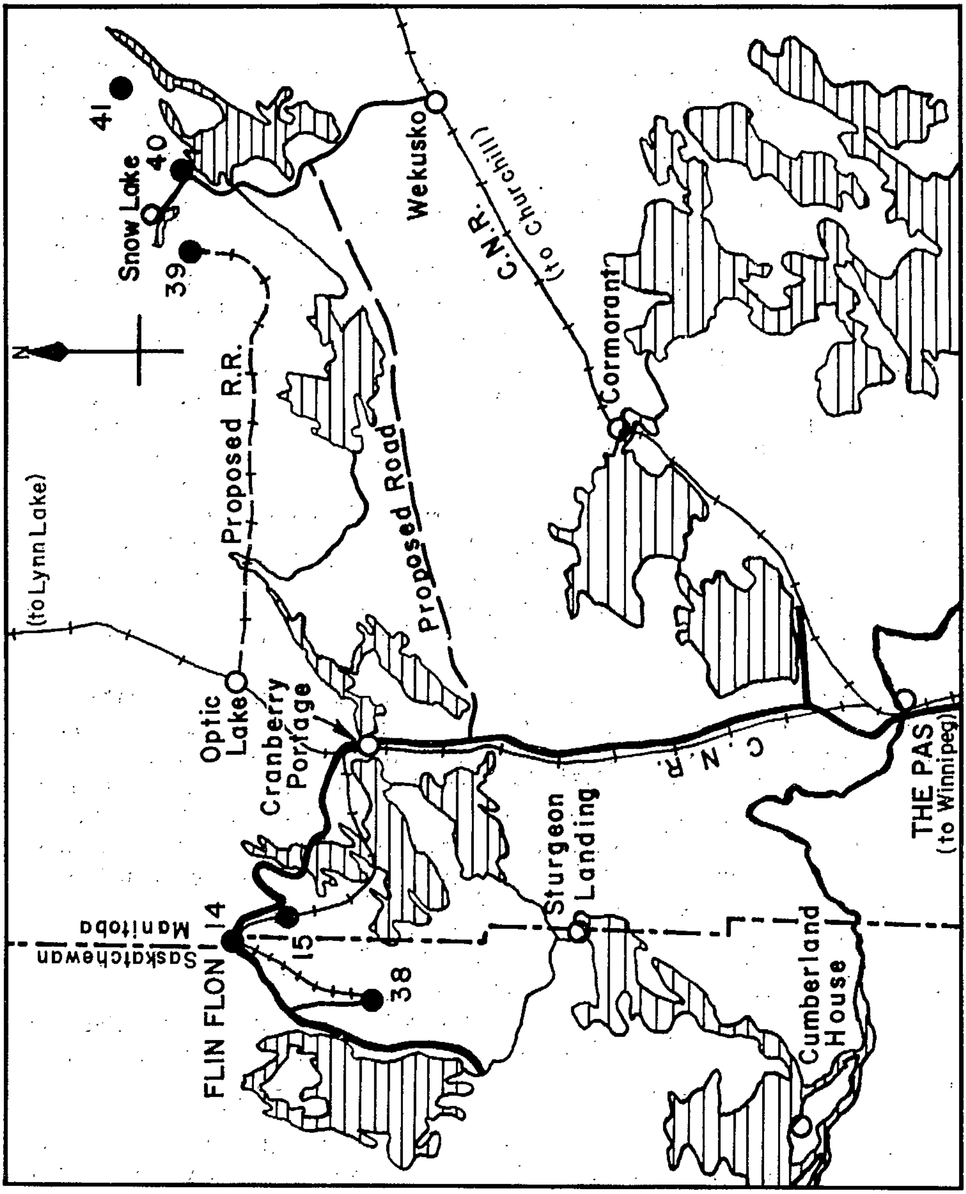
* For location of Map 3 area, see frontispiece.

# MAP No. 3

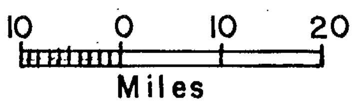



Producing Mines

14. Flin Flon
15. Schist Lake

Prospective Mines

38 Coronation
39. Chisel Lake
Ghost Lake
40. Stall Lake
41. Osborne Lake



| Year | Ore Milled | Year | Ore Milled |
|---|---|---|---|
| 1930 | 275,062 | 1943 | 2,241,142 |
| 1931 | 1,090,596 | 1944 | 2,027,926 |
| 1932 | 1,439,691 | 1945 | 1,822,628 |
| 1933 | 1,604,869 | 1946 | 1,837,472 |
| 1934 | 1,463,716 | 1947 | 1,855,035 |
| 1935 | 1,617,438 | 1948 | 1,865,835 |
| 1936 | 1,637,060 | 1949 | 1,853,476 |
| 1937 | 1,643,452 | 1950 | 1,852,394 |
| 1938 | 1,653,123 | 1951 | 1,820,805 |
| 1939 | 1,721,783 | 1952 | 1,527,577 |
| 1940 | 1,848,430 | 1953 | 1,478,095 |
| 1941 | 2,020,232 | 1954 | 1,553,821 |
| 1942 | 2,189,767 | 1955 | 1,642,943 |
| | | 1956 | 1,653,752 |

In the concentrator, talc is first removed from the feed by flotation and discarded. The flotation of copper concentrate with a copper content of about 14 per cent is followed by flotation of zinc concentrate having an average content of 45 per cent zinc. The tailings from the zinc flotation are treated in an adjoining cyanide plant, where about 10 per cent of the gold in the ore is recovered as a precipitate, which is added to the blister copper output.

The copper concentrates are roasted in 5 Nichols-Herreshoff roasters together with zinc plant residues. The resulting calcine is fed to a reverberatory furnace, the principal products from which are copper matte and slag. The matte is reduced to blister copper in 3 Pierce-Smith converters.

The reverberatory slag is fed to two 2,000 K.V.A. electromelt furnaces, followed by two fuming furnaces where zinc oxide fume is produced. The furnace gases and fume are drawn through waste heat boilers, then through a series of U tubes and finally a bag house where zinc oxide is collected for treatment at the zinc plant.

At the zinc plant zinc concentrate is roasted to eliminate most of the sulphur. The roasted concentrate or calcine is then leached with weak sulphuric acid to produce a solution having a high zinc content and a very low percentage of impurities. The solution is separated from the solids and treated to remove copper, cadmium, and cobalt. The solution is then pumped to the tank house. The solids after further leaching with stronger acid are sent either to a stockpile or to the copper smelter where the zinc passes off with the slag and is ultimately recovered by fuming.

There are 680 electrolytic cells in the tank house. High-purity lead-silver sheets are used for anodes. The cathode sheets on which the zinc is deposited are aluminum. The zinc is stripped off the starting sheets at 24-hour intervals, and is then melted and cast into standard slabs weighing 57 pounds.

The zinc oxide from the fuming plant is treated in the oxide treatment section of the zinc plant, where it is roasted to eliminate fluorine, then leached with spent electrolyte to dissolve the zinc. After precipitation of impurities the solution of zinc sulphate is combined with solutions from the sulphide leaching plant and treated in the electrolytic refinery. The residue from the fume leaching, which contains about 19 per cent zinc and 12 per cent lead, is stockpiled.

Production, 1952 to 1956 Inclusive

| | 1956 | 1955 | 1954 | 1953 | 1952 |
|---|---|---|---|---|---|
| Mine Production (a) (tons) | 1,396,292 | 1,467,347 | 1,524,441 | 1,497,093 | 1,559,081 |
| Containing- | | | | | |
| copper (%) | 2.63 | 2.62 | 3.10 | 2.90 | 2.74 |
| " zinc (%) | 4.4 | 4.3 | 5.0 | 4.8 | 4.8 |
| " gold (oz/ton) | 0.069 | 0.07 | 0.09 | 0.08 | 0.08 |
| " silver (oz/ton) | 0.95 | 1.03 | 1.23 | 1.17 | 1.12 |
| Zinc concentrate (tons) | 116,812 | 111,361 | 127,873 | 115,397 | 118,610 |
| Containing-zinc (%) | 45.2 | 45.2 | 45.3 | 45.4 | 45.1 |
| Zinc plant residue (b) (tons) | 703,854 | 757,635 | 808,926 | 857,386 | 906,386 |
| Containing-zinc (%) | 26.57 | 26.6 | 26.6 | 26.6 | 26.5 |
| Metals produced | | | | | |
| Copper (tons) | 46,340 | 46,889 | 45,223 | 39,950 | 39,717 |
| Zinc (tons) | 63,284 | 67,356 | 66,922 | 65,730 | 61,783 |
| Gold (ounces) | 104,851 | 109,281 | 126,302 | 111,253 | 117,316 |
| Silver (ounces) | 1,586,939 | 1,673,398 | 1,879,573 | 1,676,295 | 1,578,040 |
| Cadmium (pounds) | 156,986 | 191,691 | 154,596 | 157,997 | 114,352 |
| Selenium (pounds) | 107,800 | 130,582 | 115,268 | 94,622 | 100,053 |

(a) Flin Flon mine only.

(b) Amount stored for future treatment.

Ore reserves at the Flin Flon mine, including five properties either wholly owned or controlled in the Flin Flon area, were reported at the end of 1956 to be 20,541,000 tons averaging 2.72 per cent copper, 4.8 per cent zinc, 0.063 ounce per ton gold and 1.09 ounces per ton silver.

Schist Lake Mine (15, Map 3)

The Schist Lake mine, 3 1/2 miles southeast of Flin Flon, was acquired by Hudson Bay Mining and Smelting Company in 1942. Underground development was started in 1948 and was continued until August 1954, when the mine was brought into production. The ore occurs in a vertical shear in lava flows, striking north-south and dipping from vertical to 80° east. The orebody is relatively small. It has a maximum width of 40 feet and a length of 100 feet.

A shaft has been sunk to a depth of 1,172 feet and 9 levels established, the deepest being at 1,100 feet. On this level from a point 1,300 feet south of the shaft a winze was sunk to the 2,094-foot horizon and levels established at the 1,250-, 1,400-, 1,550-, 1,700-, 1,850- and 2,000-foot horizons.

Prior to coming into production, ore from development work was shipped to Flin Flon by truck or stockpiled. Production began August 1954, and to the end of 1956 was as follows:

| | Tons of ore | Contents | | | |
|---|---|---|---|---|---|
| | | Copper % | Zinc % | Gold oz./ton | Silver oz./ton |
| 1954 | 53,618 | 5.23 | 7.0 | 0.035 | 1.08 |
| 1955 | 118,206 | 5.34 | 8.6 | 0.042 | 1.25 |
| 1956 | 154,968 | 3.59 | 8.0 | 0.049 | 1.23 |

The ore reserves at the Schist Lake mine are not reported separately but the average grade is 8.0% zinc and 3.6% copper.

## Ontario

Jardun (16, Map 1, frontispiece)

Jardun Mines Limited, formed in 1951, acquired a property comprising 12 claims in Jarvis and Duncan townships, 18 miles northeast of Sault Ste. Marie and 10 miles north of Garden River on the Canadian Pacific Railway, to which it is connected by road. There are several old mines on the property, including the Victoria mine, which had been developed by two old shafts, the deepest being 410 feet, and the Cascade mine, situated half a mile north of the Victoria, on which a shallow prospect shaft had been sunk. Silver-lead-zinc ore was discovered on the property in 1875 and former development and some small production took place intermittently until 1904.

Ore occurs in four separate zones. At No. 1 zone (the Victoria mine) it occurs in schist and quartz veins in a shear zone that strikes approximately north and south. No. 2 zone (the Cascade mine) is probably a northerly continuation of No. 1. No. 3 zone, 1,600 feet northwest of the Victoria mine, is a vein type of deposit. The No. 4 zone was located by the company about a mile north of the Victoria mine, and consists of a basic dike mineralized over a length of 400 feet.

Jardun Mines has rehabilitated the Victoria mine and sunk a new shaft to a depth of 400 feet on the No. 4 zone from which three levels have been established. A new shaft on the Victoria mine was completed in 1956 to 400 feet with levels at 130, 255 and 375 feet. Production of zinc and lead concentrates began in May 1954 in a new 300-ton daily capacity mill built on the property, and the output of lead and zinc contained in concentrates is estimated to have been as follows:

| | Lead | Zinc |
|---|---|---|
| | tons | tons |
| 1954 | 1,408 | 710 |
| 1955 | 1,927 | 1,548 |
| 1956 | 1,707 | 1,500 |

The lead concentrates are shipped to St. Joseph Lead Company, Herculaneum, Missouri, and the zinc concentrates to Matthiessen and Hegeler Zinc Company, LaSalle, Illinois.

Ore reserves were reported in 1954 to be:

In No. 1 zone, 238,000 tons averaging 5.28 per cent combined lead and zinc and 1.73 ounces of silver per ton.

In No. 2 zone, 20,000 tons averaging 7.52 per cent combined lead and zinc and 1.52 ounces of silver per ton.

In No. 3 zone, 19,367 tons averaging 9.56 per cent combined lead and zinc and 1.10 ounces per ton silver, and in No. 4 zone, 58,877 tons averaging 13.14 per cent combined lead and zinc and 1.53 ounces per ton silver.

Mine ceased operations in April 1957.

## Quebec

### Abitibi East County

#### Barvue Mine (17, Map 4, page 43)*

Barvue Mines Limited was formed in 1950 to develop the Barvue zinc deposit, a property of approximately 700 acres in Barraute township about 6 miles north of Barraute village on the Canadian National Railways between Amos and Senneterre.

The deposit consists of fine-grained pyrite and sphalerite with minor amounts of galena and chalcopyrite occurring as a replacement in a belt of sheared and altered rhyolite breccia. The mineralized zone has a length of about 3,000 feet on the Barvue property. It strikes N60°W and dips about 75° to the north. The width of minable ore averages about 105 feet and the grade is 3.3 per cent zinc and one ounce of silver per ton. Pyrite, lead, and copper are not present in sufficient amounts for economic recovery.

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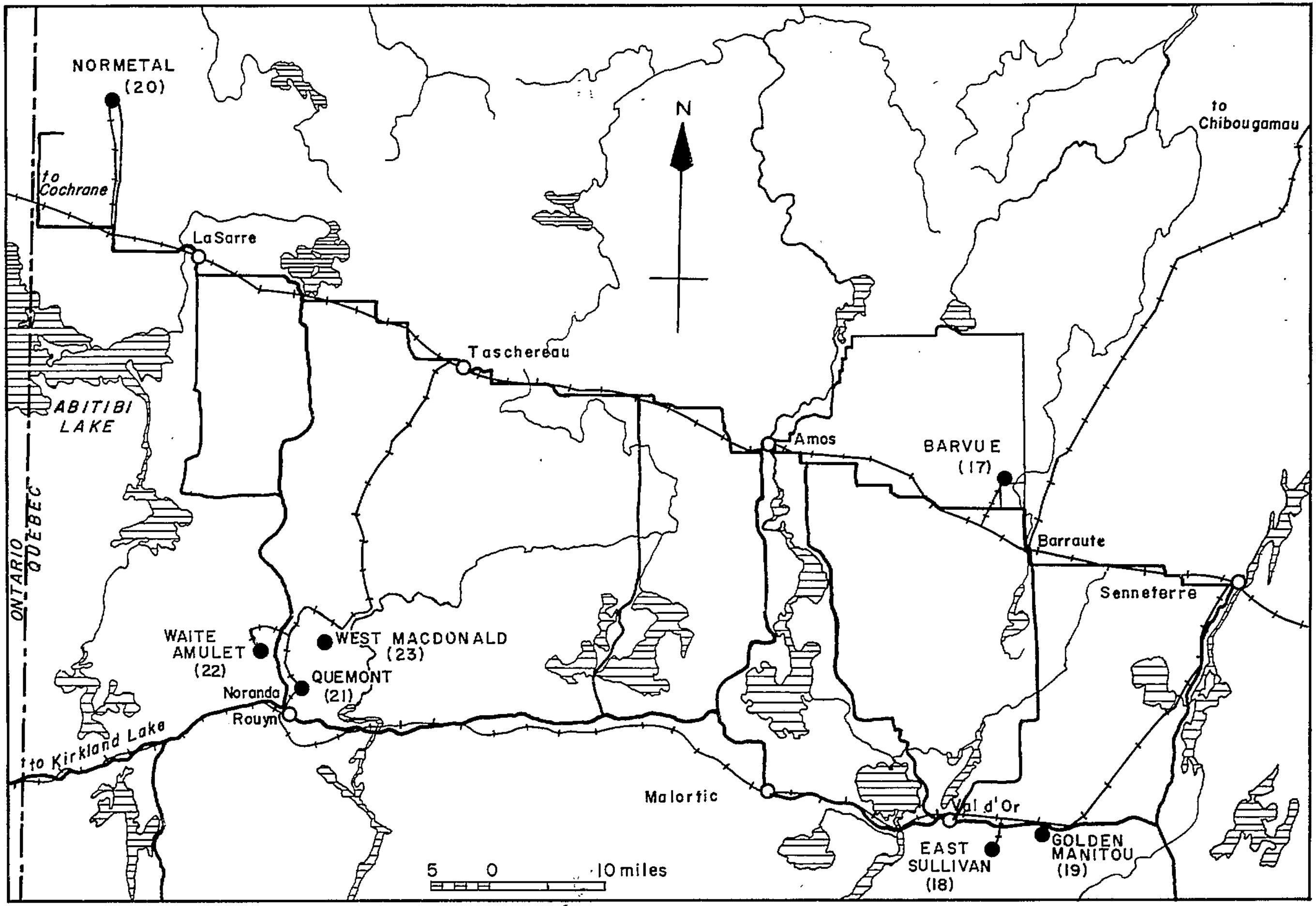
* For location of Map 4 area see frontispiece.




MAP NO. 4 – Noranda – Val D'Or Area

After removal of about 15 feet of overburden, open-pit mining began late in 1952 and ended September 1956 when the pit had been excavated to a depth of 250 feet. Preparations to carry out trackless underground mining, using diesel trucks and loaders, were commenced in September 1955 by driving a 16' x 16' down-grade adit to give access to 3 levels below the pit bottom, the deepest being at 500 feet. After September 1956 all ore was mined by underground operations.

The concentrator of 5,300 tons a day capacity is located near the pit and the ore is transported from the mine to the mill crushing plant by trucks. Production has been as follows:

| | Ore Milled | Contained in Concentrates | |
|---|---|---|---|
| | | Zinc | Silver |
| | tons | tons | oz. |
| 1953 | 1,376,249 | 33,184 | 943,065 |
| 1954 | 1,525,284 | 38,895 | 989,610 |
| 1955 | 1,332,043 | 35,713 | 897,163 |
| 1956 | 902,223 | 24,301 | 705,632 |

The concentrate, containing about 60 per cent zinc, is shipped to Arvida, Quebec, where most of the sulphur is removed by flash roasting in a plant operated by the Aluminum Company of Canada. The resulting calcine is then sent to a smelter in East St. Louis, Illinois.

The ore reserves to a depth of 650 feet were estimated at the end of 1956 to be 4,443,000 tons averaging 3.5 per cent zinc and 1.3 ounces of silver per ton. To a depth of 700 feet, diamond drilling originally indicated a reserve of 15,000,000 tons averaging 3.2 per cent zinc and 1.12 ounces per ton silver.

Owing to market conditions operations were suspended in September 1957.

East Sullivan (18, Map 4)

This property, comprising 17 claims in Bourlamaque township, about 3 miles east of Val d' Or, is owned by East Sullivan Mines Limited. The mine is connected to the Canadian National Railways by a 2-mile spur line.

The mine is developed by a five-compartment shaft to a depth of 1,050 feet and 3 compartments below this horizon with 19 levels established at 150-foot intervals, the lowest being at a depth of 2,850 feet. The shaft was deepened from 2,950 to 4,000 feet in 1955 and 1956. In the upper part of the mine, between surface and the 900-foot level, there are three main orebodies called A, B, and C, and three smaller orebodies designated D, E, and F. The G orebody occurs on the 1,800-foot level and also the top of H orebody. Both G and H orebodies are essentially zinc ore. Several new copper-ore zones have been partly outlined by drilling below the 2,850-foot level. All the orebodies are replacement deposits in siliceous fragmental tuff and agglomerate in an area bounded by fragmental flows to the north and diorite porphyry and andesite on the south. The ore is bounded on the east by a large syenite porphyry plug and diorite porphyry and andesite cut off ore extensions to the west. The orebodies strike generally east-west over a length of several thousand feet.

The concentrator has a capacity of 2,500 tons a day and is equipped to produce copper, zinc, and pyrite concentrates. The copper concentrates are shipped to the Noranda smelter. The production of zinc concentrate was discontinued early in 1954 but was resumed in March 1955.

Production to date is as follows:

| | Tons Milled | Percentage Content | |
|---|---|---|---|
| | | Copper | Zinc |
| 1952 | 898,338 | 1.74 | 1.45 |
| 1953 | 909,140 | 1.37 | 0.45 |
| 1954 | 916,119 | 1.13 | 0.95 |
| 1955 | 958,225 | 0.92 | 0.88 |
| 1956 | 895,188 | 0.99 | 0.69 |

Metals Recovered

| | 1952 | 1953 | 1954 | 1955 | 1956 |
|---|---|---|---|---|---|
| Copper (tons) | 14,243 | 11,392 | 9,554 | 8,122 | 8,256 |
| Zinc (tons) | 9,532 | 2,532 | - | 6,885 | 4,919 |
| Gold (ounces) | 11,816 | 5,876 | 4,294 | 7,115 | 5,527 |
| Silver (ounces) | 280,239 | 182,078 | 125,381 | 180,813 | 207,554 |
| Pyrite (long tons) | 50,778 | 28,631 | 5,302 | 6,301 | 11,460 |

Ore reserves at December 31, 1956, were reported to be 3,435,000 tons averaging 1.16 per cent copper, 0.69 per cent zinc, 0.009 ounces per ton gold and 0.34 ounces per ton silver.

Golden Manitou (19, Map 4)

The Golden Manitou property takes in 45 claims totalling 1,850 acres in Bourlamaque township, about 9 miles east of Val d'Or. It was acquired by Golden Manitou Mines Limited in 1941.

Zinc-lead ore occurs in lenticular sulphide bodies in a strong east-west shear zone over a length of 4,000 feet and width up to 60 feet, dipping about 80° north. Greenstone rocks lie south of the shear and rhyolite to the north. The mineralization includes pyrite, sphalerite, chalcopyrite, and galena. The galena is argentiferous and small amounts of gold occur in the ore.

A copper zone strikes parallel and adjacent to the zinc-lead zone near surface but owing to a flatter dip of about 60° to the north it becomes progressively more separated from the zinc-lead zone with depth. The width of this ore varies to a maximum of 120 feet above the 800-foot horizon and appears to average about 15 feet below this elevation. The only mineral of economic importance in the copper zone is chalcopyrite.

Access to underground workings is by a four-compartment shaft sunk south of the ore zones to a depth of 3,000 feet. There are 19 levels spaced at 150-foot intervals the deepest being at 2,960 feet. Cross-cuts to the copper zone have been driven on the 360-, 510-, 660-, and 810-foot levels.

Production of zinc-lead ore began in 1942 at a rate of 600 tons a day, but in 1943 the capacity of the mill was increased to 1,000 tons. The flowsheet includes cyanidation of a primary flotation concentrate for the recovery of precious metals. Zinc-lead concentrate is recovered by flotation of the tailings from cyanidation and primary flotation. This bulk concentrate is passed through a flotation de-leading circuit for the recovery of lead concentrate, which also contains some copper. In October 1955 the milling of zinc-lead ore was reduced to 500 tons a day and the treatment of 500 tons a day of copper ore was begun in a separate circuit. During 1956, the milling rate of copper ore was increased to 800 tons per day.

The tonnage milled and the metal content of concentrates and precipitates produced in the years 1946 to 1956 were as follows:

| | | Metal Content in Concentrates | | | | |
|---|---|---|---|---|---|---|
| Year | Ore Milled | Zinc | Lead | Copper | Silver | Gold |
| | tons | tons | tons | tons | oz. | oz. |
| 1946 | 224,550 | 10,633 | 855 | 27 | 570,035 | 8,080 |
| 1947 | 254,810 | 9,349 | 846 | 6 | 646,144 | 4,867 |
| 1948 | 344,200 | 14,441 | 937 | 31 | 561,203 | 7,964 |
| 1949 | 358,980 | 11,406 | 1,081 | 11 | 759,962 | 10,455 |
| 1950 | 333,180 | 10,071 | 1,197 | 85 | 1,140,637 | 10,791 |
| 1951 | 337,990 | 16,521 | 1,197 | 107 | 977,312 | 9,443 |
| 1952 | 341,655 | 15,490 | 1,178 | 78 | 774,164 | 8,132 |
| 1953 | 389,380 | 17,293 | 1,480 | 108 | 1,092,654 | 11,254 |
| 1954 | 401,750 | 18,728 | 1,431 | 191 | 1,078,498 | 15,334 |
| 1955 | 364,660 | 13,896 | 1,335 | 536 | 892,085 | 12,566 |
| 1956 | 420,645 | 10,330 | 766 | 1,877 | 496,350 | 10,653 |

Zinc concentrate averaging about 60 per cent zinc is shipped to the American Zinc Company of Illinois in East St. Louis and the lead-copper concentrate to the Montana smelter of the American Smelting and Refining Company. The gold-silver precipitate is exported to the American Metal Company at Carteret, New Jersey. Starting late in 1955, copper concentrate from the new copper circuit was shipped to the Noranda smelter.

Ore reserves at December 31, 1956, were reported as 645,000 tons averaging 6.12 per cent zinc, 4.86 ounces per ton silver and 0.04 ounces per ton gold. The lead content is not reported but is estimated at 0.5 per cent. In addition the company estimated the reserve of copper ore in the copper-bearing zone to be 800,000 tons averaging 0.9 per cent copper, 0.43 ounces silver, and 0.03 ounces gold per ton, to a depth of 800 feet, and 549,000 tons averaging 1.76 per cent copper from 800 feet to 2,330 feet.

## Abitibi West County

### Normetal (20, Map 4)

Normetal Mining Corporation Limited owns and operates the Normetal copper-zinc-pyrite mine comprising 19 claims in Desmeloizes township, 12 miles north of Dupuy, a station on the Canadian National Railways, seven miles east of the Ontario boundary. The company through a subsidiary operates a railway from Dupuy to the mine.

The ore occurs in the form of almost vertical veins or lenses in a shear zone that strikes roughly north 60° west and is mineralized over a length of about 1,000 feet. There are five orebodies within the zone near surface, but the three westerly ones merge at a depth of about 500 feet into one main body that persists to depths so far explored. Considerable variation exists in respect to the ratio of copper to zinc. Some veins or sections of veins are largely copper ore while others are predominantly zinc. The mine has been developed by three shafts, the deepest being 3,265 feet, and by a winze sunk from the 2,900-foot level to a depth of 5,400 feet.

Production of copper and zinc concentrates began in 1937 at a milling rate of 250 tons of ore a day. Subsequent additions to the mill increased its capacity to 1,000 tons a day and a pyrite recovery unit was added in 1952. The tonnage milled and the copper and zinc content of concentrates shipped since 1945 was as follows:

| Year | Ore Milled | Metal Content | |
|---|---|---|---|
| | | Copper | Zinc |
| | tons | tons | tons |
| 1945 | 204,067 | 6,934 | 10,429 |
| 1946 | 186,634 | 5,664 | 10,844 |
| 1947 | 209,310 | 6,438 | 11,257 |
| 1948 | 238,844 | 5,901 | 15,791 |
| 1949 | 292,235 | 7,585 | 17,696 |
| 1950 | 363,297 | 7,853 | 24,027 |
| 1951 | 359,266 | 7,031 | 21,354 |
| 1952 | 360,448 | 6,320 | 21,833 |
| 1953 | 290,849 | 5,878 | 15,230 |
| 1954 | 328,450 | 6,958 | 16,562 |
| 1955 | 362,173 | 8,068 | 16,221 |
| 1956 | 382,860 | 7,396 | 17,306 |

The copper concentrate is shipped to the Noranda smelter and the zinc to zinc plants in the United States. The production of pyrite has been intermittent for several years.

Considerable exploration has been carried out by the company both on its own property and in the surrounding area but no discoveries of interest have been reported.

Ore reserves at the end of 1956 were reported to be 3,731,900 tons averaging 2.47 per cent copper and 7.71 per cent zinc.

Quemont (21, Map 4)

This copper-zinc-gold property is owned and operated by Quemont Mining Corporation Limited. It comprises 640 acres in Rouyn township adjoining the property of Noranda Mines Limited, which lies immediately to the south.

There are two main orebodies, lying for the most part beneath Osisko Lake. The east zone extends from the lake bottom to a depth of 560 feet in the form of lenses dipping slightly to the north. The west zone is dome-shaped, with its apex about 175 feet below surface level. A number of limbs or shoots extend downward from the dome for several thousand feet. The deposits were discovered by drilling in 1944 and 1945; production began in 1949.

The main production shaft (No. 2) has five compartments and a depth of 3,520 feet. There are 19 levels, the deepest being at 3,270 feet.

The concentrator has a rated capacity of 2,000 tons a day and ore is transported to it by conveyor belt from No. 2 shaft. Copper, zinc, and flotation concentrates are produced, also base bullion from a cyanide circuit that treats the pyrite concentrate. The copper concentrate and base bullion are shipped to the Noranda smelter and zinc concentrate to New Jersey Zinc Company's plant in Pennsylvania.

Production since milling started in 1949 was as follows:

| Year | Ore Milled* | Content | | | |
|---|---|---|---|---|---|
| | | Copper* | Zinc* | Gold | Pyrite* |
| | tons | tons | tons | oz. | tons |
| 1949 | 346,014 | 5,643 | 198 | 42,081 | 6,451 |
| 1950 | 759,663 | 11,633 | 9,210 | 109,274 | 99,630 |
| 1951 | 772,781 | 11,468 | 12,362 | 98,249 | 100,176 |
| 1952 | 775,218 | 9,440 | 16,543 | 96,882 | 130,361 |
| 1953 | 631,578 | 9,468 | 11,357 | 88,513 | 92,767 |
| 1954 | 718,695 | 11,424 | 14,825 | 87,433 | 163,549 |
| 1955 | 842,807 | 11,336 | 20,226 | 108,222 | 183,182 |
| 1956 | 840,942 | 10,172 | 19,840 | 102,788 | 189,348 |

* Short tons.

Ore reserves, which have remained substantially the same since 1949, were reported at the end of 1956 as 7,980,000 tons averaging 1.30 per cent copper, 2.69 per cent zinc and 0.156 ounces per ton gold.

Waite Amulet (22, Map 4)

Waite Amulet Mines Limited operates several copper-zinc mines located in a relatively large property comprising about 2,250 acres in Duprat and Dufresnoy townships, some 5 miles north of Noranda.

Production began in the southerly or Amulet section in 1928 and in the Waite section in 1930; owing to low metal prices the mines were closed from 1930 to 1937.

The original Waite orebody was worked out in 1948, but in 1949 a new deep-seated deposit, the East Waite, was discovered about 3,000 feet east of the Waite mine. The East Waite mine is developed by a 2,080-foot shaft, and supplies about one-half of the ore milled.

In the Amulet section the B, C, D, E, and F orebodies have been exhausted. The lower A orebody was discovered in 1938 about 700 feet below the upper A. It is operated by Amulet Dufault Mines Limited, a subsidiary of Waite Amulet, and is the chief source of the balance of the mill feed. A small amount of ore found below the lower A orebody in Waite Amulet ground has been developed by a 600-foot winze.

The Waite Amulet mill of 2,000-ton capacity is located in the Amulet section about 2,500 feet northwest of the A orebodies. Ore is transported to it by underground haulage on the 1,000-foot level from the lower A to Central Shaft near the mill and from the East Waite mine by a 3-mile truck haul. In September 1955 the tonnage of Waite Amulet ore treated was reduced to 1,000 tons a day to provide for the milling of 1,000 tons of West Macdonald ore. Production for the years 1945 to 1956 was as follows:

| | | Content | | |
|---|---|---|---|---|
| Year | Ore Milled | Copper | Zinc | Pyrite |
| | tons | tons | tons | tons* |
| 1945 | 517,213 | 17,992 | 24,242 | 49,846 |
| 1946 | 427,400 | 18,243 | 18,733 | 50,017 |
| 1947 | 393,950 | 21,300 | 9,547 | 51,023 |
| 1948 | 422,785 | 22,256 | 14,521 | 50,218 |
| 1949 | 453,174 | 16,749 | 21,321 | 47,149 |
| 1950 | 524,365 | 12,935 | 22,688 | 49,414 |
| 1951 | 387,754 | 12,775 | 14,292 | 45,603 |
| 1952 | 427,672 | 14,530 | 16,033 | 72,164 |
| 1953 | 372,781 | 15,332 | 11,328 | 72,898 |
| 1954 | 430,412 | 20,773 | 11,526 | 83,811 |
| 1955 | 402,265 | 19,908 | 9,054 | 67,414 |
| 1956 | 310,081 | 11,357 | 8,438 | 55,466 |

* Long tons.

The zinc concentrate is usually exported to a zinc plant in Pennsylvania and the copper concentrate, which contains substantial amounts of gold and silver, is shipped to the Noranda smelter.

Ore reserves in December 1956 were:

| | Tonnage | Copper | Zinc |
|---|---|---|---|
| | | % | % |
| East Waite | 411,000 | 3.3 | 4.4 |
| Below Amulet Dufault block | 111,000 | 4.0 | 0.5 |
| Amulet Dufault | 464,000 | 6.0 | 3.6 |
| Total | 986,000 | 4.6 | 3.6 |

Exploration on the company's extensive property has been intensified in recent years, and while nothing of importance other than the East Waite orebody has been found, substantial areas remain to be tested, especially in the north and west sections of the property.

West Macdonald (23, Map 4)

West Macdonald Mines Limited was formed in 1952 to develop the west portion of Macdonald Mines property (940 acres) in Dufresnoy township, about 5 1/2 miles northeast of Noranda and 5 miles east of the Waite Amulet mine. Noranda Mines Limited, which owns a 46 per cent interest in West Macdonald, financed the bringing of the property into production which began in September 1955.

The ore consists of several massive replacement bodies in granodiorite. The largest (No. 1) orebody extends from surface to a depth of about 700 feet. It has a length of about 1,400 feet roughly east and west and a width of about 400 feet. Within this body a block containing some 9,000,000 tons grading 78 per cent pyrite and 3 per cent zinc has been outlined and another 9,000,000 tons containing the same percentage of pyrite but less zinc.

The mine has been developed by a shaft to a depth of 950 feet and there has been considerable lateral work done on the 325- and 925-foot levels. Several other levels have been established. An aerial tramway to the Waite Amulet mill was completed in 1955, and modifications to that mill were effected to provide for the treatment of 1,000 tons a day of West Macdonald ore. Production began September 1 at an initial rate of 600 tons a day, and in December was increased to 1,000 tons a day. During the first 10 months of 1956, 291,766 tons were milled, containing 6,020 tons of zinc and 190,078 long tons of pyrite concentrate.

Southern Quebec

New Calumet (24, Map 1, frontispiece)

The zinc-lead mine of New Calumet Mines Limited is located on 370 acres of Grand Calumet Island in the Ottawa River, Pontiac county. It is about 50 miles west of Ottawa, or 70 miles by road. The nearest railway station is Campbell's Bay on the Canadian Pacific Railway.

Between 1893, when ore was first discovered on the property, and 1937, intermittent development was carried out and there was a small production in 1912. Between 1937 and 1942 the predecessor of the present company carried out intensive diamond drilling and began underground work through a new shaft. The present operators acquired the property in 1942, and after continuing the mine development and constructing a 240-ton a day mill began production of zinc and lead concentrates in 1943. The mill capacity was increased to 600 tons daily in 1949.

The ore occurs as a series of lenticular sulphide deposits adjacent to a contact of gneissic rocks with an overlying amphibolite intrusive. The deposits strike roughly N30°W over a total length of 2,500 feet and plunge easterly with a dip varying from 25° to 50°. The thickness of the ore ranges from 50 feet near surface to 5 to 10 feet at depth. The economic minerals are sphalerite or marmatite, galena, silver-bearing minerals associated with the galena, and gold.

The Bowie-Longstreet deposit, which is the southerly and most important ore zone, has been developed by No. 1 shaft to a depth of 745 feet and seven levels, No. 4 shaft, 2,100 feet northeast of No. 1 to a depth of 2,200 feet, and No. 3 shaft, which is a winze sunk 940 feet from the 600-foot level, 600 feet northeast of No. 1, to a depth of 1,540 feet. The winze has six production levels and is connected with No. 4 shaft on the 1,350-foot level.

The Macdonald orebody has been developed by No. 2 shaft 1,100 feet northwest of No. 1 to a depth of 687 feet with six levels. There are several other outlying ore zones.

The zinc concentrate is usually shipped to a smelter in Pennsylvania and the lead to Leadville, Colorado, or to East Helena, Montana.

Ore reserves as of September 30, 1956, were reported as 383,396 tons grading, 7.49 per cent zinc, 1.64 per cent lead, 3.26 ounces per ton silver and 0.013 ounces per ton gold.

The ore milled and metals contained in the concentrates produced in the years 1947-1956 inclusive were as follows:

| | | Contained Metals | | | |
|---|---|---|---|---|---|
| Year* | Ore Milled | Zinc | Lead | Silver | Gold |
| | tons | tons | tons | oz. | oz. |
| 1947 | 182,020 | 10,147 | 3,273 | 504,615 | 1,994 |
| 1948 | 193,648 | 11,612 | 3,438 | 571,832 | 2,095 |
| 1949 | 212,441 | 12,269 | 3,476 | 555,451 | 2,686 |
| 1950 | 254,977 | 14,167 | 4,180 | 729,946 | 4,446 |
| 1951 | 259,214 | 11,567 | 3,320 | 593,135 | 4,553 |
| 1952 | 267,510 | 9,878 | 2,866 | 485,533 | 4,350 |
| 1953 | 192,233 | 9,541 | 2,291 | 387,569 | 2,971 |
| 1954 | 120,667 | 6,431 | 1,806 | 319,218 | 1,834 |
| 1955 | 150,000 | 8,258 | 2,292 | 431,675 | 3,407 |
| 1956 | 161,388 | 7,998 | 2,171 | 362,701 | 3,373 |

* Refers to company's fiscal year ending September 30th.

Weedon (25, Map 1)

The Weedon mine, operated by Weedon Pyrite and Copper Corporation Limited, comprises 10 claims (546 acres) in Weedon township, Wolfe county, about 40 miles northeast of Sherbrooke.

The main ore zone is a lenticular body of cupriferous pyrite striking north 37° east with a dip of 45° to the southeast. It lies on a contact between chlorite and sericite schists over a length of 550 feet and a width up to 45 feet. There is a parallel footwall vein about eight feet wide 50 to 80 feet from the main vein. The main vein averages 2 per cent copper, 28 per cent sulphur and 2 1/2 per cent zinc; the footwall vein averages 3.5 per cent copper and 8 per cent zinc with a little pyrite.

Previous owners in the years between 1910 and 1921 developed the mine by a 40° incline shaft to a vertical depth of 910 feet. Fourteen levels were established and considerable stoping carried out. Production prior to 1921 amounted to 584,697 tons of ore averaging 3.5 per cent copper and 40 per cent sulphur. The property was abandoned from 1921 until re-opened by the present operators in 1951.

The company has erected a new 250-ton a day flotation mill which began production in November 1952. A new shaft was sunk in the footwall in 1956 and two new levels established.

In 1955, 82,074 tons of ore were milled, from which 1,317 tons of copper, 722 tons of zinc, and 15,497 tons of sulphur were recovered. Copper, zinc, and pyrite concentrates are produced.

Ore reserves at the end of 1956 were 379,687 tons averaging 2.18 per cent copper, 1.31 per cent zinc and 31.11 per cent sulphur.

## Newfoundland

### Buchans (26, Map 1)

The Buchans zinc-lead-copper mine is operated under a long-term lease agreement by Buchans Mining Company Limited, a wholly owned subsidiary of American Smelting and Refining Company. The mineral rights on the Buchans property and an extensive area surrounding it in central Newfoundland are held by Terra Nova Properties Limited, a wholly owned subsidiary of Anglo-Newfoundland Development Company. Profits from the Buchans mining operations are divided equally between American Smelting and Refining Company and Anglo-Newfoundland Development Company.

The mine is five miles north of Red Indian Lake. It is 274 miles by rail from Port-aux-Basques, 347 miles from St. John's and 90 miles from the shipping port of Botwood.

The three original orebodies, Old Buchans, Oriental, and Lucky Strike have now been largely worked out. They consisted of fairly flat-lying, lenticular, replacement deposits and were mined by both open-cut and underground methods. In 1948, the Rothermere deposit was discovered some 3,000 feet northwest of the Lucky Strike, the most westerly of the older workings, and it is now the chief source of ore. The Rothermere orebodies have been developed by a 2,513-foot shaft and extensive underground workings. The Oriental No. 2 orebody was partly outlined in 1954.

Production began in 1928 at a rate of 500 tons a day. In 1931 the mill capacity was increased to 1,200 tons; copper, lead, zinc, and gravity concentrates are each produced.

The tonnage milled and metals contained in the concentrates shipped in the years 1949-1956 were as follows:

| | | Metal Content of Shipments | | |
|---|---|---|---|---|
| Year | Ore Milled | Copper | Lead | Zinc |
| | tons | tons | tons | tons |
| 1949 | 334,000 | 3,617 | 18,608 | 31,909 |
| 1950 | 328,000 | 3,221 | 17,918 | 30,539 |
| 1951 | 324,000 | 2,899 | 16,444 | 28,469 |
| 1952 | 334,000 | 2,959 | 18,059 | 30,517 |
| 1953 | 346,000 | 2,813 | 17,701 | 28,002 |
| 1954 | 340,000 | 3,481 | 18,526 | 30,003 |
| 1955 | 291,000 | 3,052 | 17,855 | 28,636 |
| 1956 | 366,000 | 3,402 | 23,297 | 37,140 |

The concentrates are shipped over the company's 37-mile branch railway to Millertown Junction on the Canadian National Railways and thence to Botwood. The lead and zinc concentrates are sold partly to European smelters and partly to United States plants. The copper concentrates are treated by American Smelting and Refining Company at Tacoma, Washington.

Ore reserves at the end of 1955 were estimated to contain 6,000,000 tons, most of which occurs in the Rothermere section of the property. The grade of the reserves is not available.

## Yukon

United Keno Hill (27, Map 1)

The properties of United Keno Hill Mines Limited comprise 459 claims on Galena and Keno hills in the Mayo district. The holdings include some 20 different ore occurrences where mines in various stages of development have been opened up over a length of about 14 miles east and west and a width of some 3 1/2 miles. The company's mill and principal community is at Elsa on Galena hill. The Hector mine, 3 1/2 miles east of Elsa, is the chief producer and there is another small community at Keno City, at the westerly base of Keno hill some 6 miles east of Elsa. The area is serviced by a 290-mile road from the main Yukon distributing centre of Whitehorse, which is located at the north end of the railway from Skagway, Alaska, and on the Alaska highway.

The presence of rich silver-lead ore in the area became known about 1906, but owing to its remoteness there was little production until about 1921, when the Treadwell-Yukon Company acquired many claims and thereafter produced silver-lead ore and concentrate for about 20 years. The company suspended operations in 1942. In 1946 the present operators acquired the Treadwell-Yukon holdings and subsequently purchased other property in the area. Production of bulk silver-lead-zinc concentrates was resumed in the former Treadwell-Yukon mill in April 1947. This plant of 150 tons capacity burned in 1949 and was replaced the same year by a larger mill which now has a capacity of 600 tons a day.

Rocks in the Mayo area are mainly interbedded quartzites and schists of late Precambrian age having a general east-west strike and southerly dip. They have been subjected to considerable folding and faulting and in places have been penetrated by sills and other intrusives. The veins are of two main types, longitudinal or transverse. The longitudinal veins strike northeasterly and dip at about 70° to the southeast. The transverse veins have a northerly strike and they are usually almost vertical. The richer silver-lead-zinc mineralization is most abundant at or near vein intersections. Ore in widths of up to 30 feet has been mined.

While considerable exploration has been carried out at a number of the more promising locations the company's effort has been chiefly concentrated on the Hector mine and more latterly the Calumet mine, which adjoins the Hector on the east; both mines are serviced by a common adit. The Hector mine is developed by an internal shaft to a depth of 914 feet and seven levels at 125-foot intervals. At the Calumet mine, an internal shaft extends to 500 feet below the adit level. A number of veins have been developed in both of these mines. In 1956 the Hector mine supplied 58 per cent of the production and the Calumet 40 per cent.

The ore is transported from the portal of the Hector-Calumet main adit to the mill at Elsa, a distance of 3 miles. Lead and zinc concentrates are produced by standard flotation practice and these are shipped via Whitehorse, Skagway, and Vancouver to the Cominco smelter at Trail, British Columbia.

Production from the time the company began operations in 1947 until September 30, 1956, was as follows:

| Period* | Ore Milled | Metal Content | | |
|---|---|---|---|---|
| | | Silver | Lead | Zinc |
| | tons | oz. | tons | tons |
| 1947-1952 | 356,100 | 14,286,600 | 26,983 | 13,384 |
| 1953 | 156,684 | 6,252,483 | 13,656 | 10,622 |
| 1954 | 180,249 | 6,191,599 | 15,331 | 13,067 |
| 1955 | 162,307 | 5,670,137 | 13,175 | 12,018 |
| 1956 | 155,702 | 5,582,979 | 12,541 | 12,053 |

* Fiscal year periods end on September 30.

The ore reserves in September 1956 were reported as 598,020 tons averaging 36.9 ounces silver per ton, 7.8 per cent lead, and 7.0 per cent zinc.

Galkeno (27, Map 1)

Galkeno Mines Limited operates 20 claims adjoining the east side of the Hector-Calumet mine. The geology and nature of the vein occurrences are similar to those of United Keno Hill. The mine has been developed by several adits and a 120-foot incline shaft with levels established at 100-, 200-, 300-, 400- and 500-foot depths. Two vein systems, the McLeod and the Sime, have provided most of the ore since the mine came into production. In 1954, underground exploration of the 2,000 feet of favourable ground lying between the Galkeno mine and the Calumet mine was started.

The company owns a 350-ton mill situated on the property of Yukeno Mines Limited on the north side of Mayo lake, 3 miles from the Galkeno mine. Production began in April 1953 and was continuous until January 1955, when it was suspended in order to place more emphasis on mine development. Milling was resumed in July 1956.

Very little zinc was produced in 1953. In 1954, from 32,836 tons of ore, concentrates containing 1,092,887 ounces of silver, 2,736 tons of lead, and 431 tons of zinc were produced. In 1956, from July 1 to October 31 production amounted to 378,287 ounces of silver, 761 tons of lead, and 703 tons of zinc.

Ore reserves in February 1957 were estimated to be 61,399 tons averaging 36.1 oz. per ton silver, and 8 per cent each of lead and zinc.

# CHAPTER VI

## SOME MAJOR OCCURRENCES AND NON-PRODUCING ZINC PROPERTIES

In the previous section the principal mines producing zinc ore were reviewed. This section deals with non-producing properties, which include the more important properties currently under exploration or development and also some former producers at which operations have been suspended owing to low metal prices. The description of the properties is arranged by provinces from west to east, followed by the territories. The estimates of ore reserves were obtained from government reports, published articles, or statements issued by the companies.

### British Columbia

There are a great many potential zinc producing properties in this province. Most of the known silver-lead-zinc deposits have been worked at one time or another during the past 60 or 70 years and considerable zinc has been produced from these ores. While no deposits of significant proportions have been recorded, occurrences exist in the following areas: Atlin, Spencer, Omineca, Nelson, Slocan, Ainsworth, and East Kootenay.

### Saskatchewan

During the past several years Hudson Bay Mining and Smelting Company has discovered and partly explored a number of deposits in Saskatchewan near Flin Flon and in Manitoba near the town of Snow Lake, 70 miles east of Flin Flon. It is reported that of these deposits the company will proceed first with production plans for the Birch Lake Mine (ore contains no zinc) the Coronation mine, and the Chisel Lake mine.

#### Coronation Mine (38, Map 3, page 38)*

The Coronation deposit of Hudson Bay Mining & Smelting Company Limited, 13 miles south of Flin Flon, was discovered by an electromagnetic survey during the winter of 1952-53. It is a copper sulphide replacement deposit in altered andesite, with minor zinc mineralization, occurring in two parallel lenses striking NE-SW. The dip is 70° SW under a lake and the plunge steeply southwest. The maximum width is 60 feet and the average 20 feet. The length is from 300 to 700 feet and the vertical depth 1,200 feet.

A shaft has been sunk to 1,350 feet and 9 stations established at 150-foot intervals. Cross-cuts have been driven on the 750- and 1,350-foot levels. A 15-mile standard gauge railway has been built from the mine to Flin Flon, where the ore will be shipped for treatment.

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* For location of Map 3 area, see frontispiece.

Production is planned for the summer of 1959 at 1,000 tons a day. Ore reserves are 800,000 tons averaging 5 per cent copper and 0.4 per cent zinc.

## Manitoba

### Chisel Lake (39, Map 3)

The Chisel Lake orebody of Hudson Bay Mining and Smelting Company Limited, 70 miles east of Flin Flon, was discovered by an electromagnetic survey early in 1956. By diamond drilling, an orebody of 3,800,000 tons was outlined by July 1956, the grade of which was 11.0 per cent zinc, 0.91 per cent lead, and 0.42 per cent copper, with some gold and silver.

The orebody is covered by 10 feet of lake water and 140 feet of lake bottom overburden. It consists of several shallow-dipping parallel lenses replacing quartz-hornblende gneisses and sericite schists. Striking northwest, the lenses dip 45° northeast towards the shoreline, gradually flattening at depth to about 10°. The width of the orebodies varies from 7 to 100 feet and they have been drilled to a depth of 800 feet below the lake level.

A three-compartment shaft will be sunk in 1957 and production is planned for 1960. A 50-mile railway from Optic Lake on the Lynn Lake branch of the Canadian National Railways is under consideration.

### Ghost Lake (39, Map 3)

This deposit of the Hudson Bay Mining and Smelting Company Limited lies 3,000 feet due east of Chisel Lake. Reserves are estimated at 260,700 tons averaging 1.42 per cent copper and 11.6 per cent zinc, with gold and silver in small amounts.

### Stall Lake (40, Map 3)

The Stall Lake deposit of the Hudson Bay Mining and Smelting Company Limited is located 8 miles east of Chisel Lake. The ore occurs as several levels in shear zone. Reserves are estimated at 783,000 tons averaging 4.5 per cent copper and 0.4 per cent zinc, with some gold and silver.

### Osborne Lake (41, Map 3)

This property of the Hudson Bay Mining and Smelting Company Limited is 13 miles northeast of the town of Snow Lake and 86 miles east of Flin Flon.

The estimated ore reserves are 443,000 tons averaging 4.01 per cent copper and 1.7 per cent zinc.

## Ontario

### Geco (28, Map 1, frontispiece)

The property of Geco Mines Limited, comprising 46 claims covering over 1,700 acres, lies on the north side of Manitouwadge Lake, 40 miles north-east of Marathon on the north shore of Lake Superior. Branch railways to the town of Manitouwadge were completed in 1955 by both the Canadian National and Canadian Pacific Railways from their respective main transcontinental lines.

The orebody strikes roughly east-west and is made up of three zones. Sulphides of copper and zinc with silver and pyrite occur in massive to disseminated form in biotite-sericite schist bounded to the north by granite and to the south by gneiss and quartzite. The westerly, or "A", zone has a length of 1,200 feet and is bounded on the east by a fault. The central, or "B", zone extends easterly from the fault for 900 feet to a diabase dike which separates it from the "C" zone, the latter continuing easterly from the diabase for another 600 feet. The width of the ore varies up to a maximum of 220 feet, the average width being about 75 feet. The rake or plunge of the zones is about 40° to the east.

Ore reserves at the end of 1955 were estimated as follows:

| Orebody | Tonnage | Copper | Zinc | Pyrite | Silver |
|---|---|---|---|---|---|
| | | % | % | % | oz. per ton |
| "A" | 5,611,251 | 2.19 | 1.79 | 7.44 | 1.33 |
| "B" | 7,140,000 | 1.38 | 3.91 | 15.00 | 1.55 |
| "C" | 2,476,000 | 1.89 | 6.06 | 15.00 | 3.38 |
| | 15,227,251 | 1.76 | 3.48 | 12.21 | 1.77 |

The mine has been developed by a main production shaft to a depth of 1,500 feet located near the east end of the "B" zone. It has seven levels at 200-foot intervals, the deepest being at 1,450 feet. The "A" zone was prepared for initial production by means of a development shaft (No. 2) to a depth of 500 feet with levels at 250 feet and 450 feet. It is located near the center of "A" zone. There are also two adit levels in the "A" zone. The ore will be drawn by gravity to a crusher station on the 1,250-foot level and transported from this point by conveyor belt system, a distance of 1,200 feet, to a loading pocket at No. 1 shaft.

The construction of a 3,300-ton capacity concentrator was begun in 1956, and production of copper and zinc concentrates commenced in September 1957.

### Willroy (28, Map 1)

The property of Willroy Mines Limited adjoins the Geco property, Manitouwadge area, on the west. It consists of 28 claims or approximately 1,120 acres.

There are three zones, No. 1 extends westerly from the Geco boundary for 1,650 feet and is divided by a pegmatite dike into an east and a west orebody. No. 2 lies 1,700 feet west of No. 1 zone and has an approximate length of 800 feet. No. 3 is 800 feet south of No. 2 and is probably the western extension of the Geco west orebody. It has a length of 1,600 feet and an average width of 21 feet. The dip is about vertical and the rake of the ore about 40° to the west.

Ore reserves in March 1956 were reported by the company as follows:

| Zone | Tonnage | Copper % | Zinc % | Silver oz./ton |
|---|---|---|---|---|
| No. 1 | 740,000 | 1.48 | 0.36 | 0.42 |
| No. 2 | 420,000 | 0.03 | 7.24 | 3.80 |
| No. 3 | 1,000,000 | 1.24 | 10.27 | 1.80 |
| | 2,160,000 | 1.09 | 6.29 | 1.72 |

The mine is being developed by two shafts. No. 1, the production shaft, located between No. 2 and No. 3 zones has a depth of 850 feet with levels at 200, 350, 500, and 650 feet. No. 2 shaft is bottomed at 650 feet in the No. 3 zone 700 feet south of No. 1 shaft; it will be used for ventilation purposes when production begins. It was planned to mine ore from No. 3 zone first and later to extend developments into No. 2 and No. 1 zones.

The construction of a 1,000-ton mill was started in 1956 and production of copper, zinc and lead concentrates began in August 1957.

Errington and Vermilion Lake (29, Map 1)

These properties are controlled and operated by Consolidated Sudbury Basin Mines Limited. The Errington comprises 4,000 acres in Balfour and Creighton townships, and the Vermilion Lake, totalling about 2,350 acres, covers the south shore and most of the bed of Vermilion Lake in Fairbanks township, some 2 miles west of the Errington mine. The city of Sudbury is about 15 miles southeast of the properties.

The properties are situated on the south limb and near the western end of the Sudbury basin. A contact between slate and tuff, adjacent to which copper, lead, and zinc mineralization occurs, passes through both properties over a length of about 9 miles. The ore is associated with faults and folds in the slate tuff contact zone, and occurs as lenticular replacement deposits containing sulphides of copper, lead, zinc, and iron.

There are three shafts at the Errington mine, the deepest to 1,572 feet, and considerable lateral work has been done on three levels. A new 1,800-foot production shaft was planned for 1957. At Vermilion Lake a shaft has been sunk to a depth of 1,300 feet, and five development levels established.

Ore reserves at the two properties were estimated in January 1957 to be 16. 5 million tons averaging 1. 2 per cent copper, 1. 0 per cent lead, and 4. 0 per cent zinc.

In 1953, a small pilot mill was built at the Errington mine, in which ore dressing tests were carried out to investigate concentration methods. The construction of a 3,000-ton per day concentrator was begun at the Errington mine in 1956 and production was planned for 1957. The Vermilion Lake ore will be transported 6 1/2 miles to the concentrator by aerial tramway. Owing to market conditions, plans for production were suspended in September 1957.

## Quebec

### Bachelor Lake (30, Map 1)

The Coniagas Mines Limited purchased the Bachelor Lake silver-zinc-lead property from Dome Mines Limited in August 1955. It consists of 25 claims (800 acres) in Lesueur township, Abitibi-East county, about 100 miles northeast of Senneterre. A new branch of the Canadian National Railways from Barraute to Chibougamau will pass through the property.

In the period 1947-1950, Dome Exploration Limited outlined by drilling several adjacent ore zones occurring within a band of rhyolite breccia that forms part of a southwesterly plunging anticlinal dragfold. The ore zones are irregular over a total length of 400 feet and an average width of 21 feet, and are known to persist to a depth of 700 feet.

Ore reserves are reported to be 365,000 tons averaging 23.8 ounces per ton silver, 13.55 per cent zinc and 0.88 per cent lead to a depth of 600 feet.

### Montauban (31, Map 1)

United Montauban Mines Limited owns 756 acres in Montauban township, Portneuf county, about 60 miles west of Quebec City. It adjoins Anacon Lead Mines to the north.

The rocks in the area are Grenville gneiss, quartzite, and limestone that have been intensely folded and metamorphosed. Lead and zinc mineralization occurs as a replacement following a north-south zone of weakness. Two ore zones, roughly parallel, have a combined length of 2,800 feet and vary in width from 60 to 300 feet. They are ribbon-like in attitude but have a general north-south strike and variable easterly dip. A shaft has been sunk to a depth of 540 feet and four levels established, the deepest at 416 feet. A 500-ton a day mill was installed on the property in 1953 and production was carried on from August of that year till January 1954, when operations were suspended owing to low metal prices. Concentrates produced in the operating period contained 5,249 tons of zinc and 1,102 tons of lead.

Ore reserves are estimated 370,000 tons averaging 3.5 per cent combined zinc and lead.

## New Brunswick

The large base metal deposits under development in the Bathurst area since 1952 occur in a belt of early Palaeozoic sediments and volcanic rocks that strikes southwesterly across the province. In Devonian times this structure was intruded by large granite batholiths accompanied by widespread mineralization. The narrow vein-type and the larger type sulphide bodies in the area are found in or around the margins of these intrusions. The normal northeasterly strike of the formations has in places been distorted by the intrusions of the batholiths, as at the Anacon and Austin Brook deposits, where the strike of the structure is north-south.

The sulphide replacements, particularly those of Brunswick Mining and Smelting Company, are the most important deposits in the area. They are predominantly made up of fine-grained pyrite containing fine-grained sulphides of zinc, lead, and copper in amounts totalling up to 10 per cent. Iron formation, largely maguelite, is often present in the wall rock or in tongues within the sulphides. To the north and west of Bathurst, a number of vein-type occurrences containing zinc, lead, and copper sulphides have been found. The Keymet mine is developed on one of these.

Outcrops of rock are uncommon, since most of the area is covered with 10 to 15 feet of overburden. Many of the deposits have been located by geophysical exploration methods in recent years and later outlined by diamond drilling.

### Austin Brook (32, Map 1)

Owned by Brunswick Mining and Smelting Corporation Limited, this property of 3,840 acres is situated 16 miles south of Bathurst, to which it is connected by rail and by gravel road.

The property was originally worked for iron ore prior to 1913 and again during World War II, but these operations proved uneconomic. In 1952, the presence of sphalerite was noted in the wall rock of one of the iron ore pits and this discovery led to general exploration of the area, which resulted in locating the Austin Brook zinc-lead deposit (No. 6 orebody) about 3,000 feet north of the iron ore workings. It strikes roughly north and south over a length of 1,200 feet with average width of 150 feet, and dips about 60° to the west with a plunge of 55° to the south, conforming with the volcanic and sedimentary rocks in the area. The deposit has a length of 1,100 feet and an average width of 140 feet.

About half the overburden has been stripped, and it is estimated that about 6 million tons can be mined by open-pit methods to a depth of 200 feet. A 150-ton pilot mill was built on the property in 1954 and began treating ore from the company's Anacon deposit, which is of a similar type, in February 1955.

Ore reserves indicated by drilling to a depth 1,000 feet are as follows:

| | Ore tons | Metal Content Zinc % | Lead % | Copper % |
|---|---|---|---|---|
| Main zone | 22,278,000 | 5.0 | 1.9 | 0.4 |
| Pyrite zone | 4,350,000 | 1.0 | 0.4 | 0.5 |
| Copper zone | 1,684,000 | 0.5 | 0.5 | 0.8 |
| Total | 28,312,000 | 4.1 | 1.6 | 0.4 |

The deposit also contains about 1.5 ounces of silver per ton.

Anacon (32, Map 1)

The Anacon, or No. 12, orebody lies in a group of 78 claims about 4 1/2 miles north of the Austin Brook deposit and is also owned by Brunswick Mining and Smelting Company. It is connected by road to the Austin Brook property and directly to Bathurst by a road partly owned by the Bathurst Pulp and Paper Company. The deposit was found early in 1953 near a marked magnetic anomaly, and was acquired by the present owners during that year.

The rocks in the immediate area, consisting of quartz porphyry, quartz sericite schist, and iron formation, strike roughly north-south and dip 50° to 70° to the west. The orebody conforms in strike and dip to the enclosing rocks. It has a length of 1,200 feet and its width varies from 80 to 200 feet. To a depth of 1,000 feet the ore reserve is estimated to be 27,440,000 tons averaging 5.3 per cent zinc, 1.9 per cent lead, 0.6 per cent copper, and 1.8 ounces per ton silver.

A shaft to a depth of 412 feet has been sunk in the footwall to the east of the ore and levels established at 200 and 350 feet. Development work within the orebody is proceeding on these levels and the ore so mined is transported to the company's pilot mill at the Austin Brook property for bulk ore-dressing tests. Plans have been reported to bring the two deposits into production jointly at a rate of 4,000 tons a day and to produce zinc, lead, and pyrite concentrates. The design of the concentrator and the flow sheet will be dependant on the pilot plant tests.

Middle Landing Property (32, Map 1)

New Larder "U" Island Mines Limited, a subsidiary of Anacon Lead Mines Limited, acquired the Middle Landing property of 2,320 acres in 1952. It is roughly 14 miles south of Bathurst and 6 miles east of the Austin Brook property.

The rock formations consist of steeply dipping interbedded quartizite, argillite, and volcanic rocks striking slightly west of north. A mineralized zone containing chalcopyrite near the Nepisiguithe River was discovered many years ago and was diamond-drilled in 1946 with inconclusive results. In 1952, a sulphide anomaly striking north and south was discovered by electromagnetic survey a little south of the copper showing; subsequent drilling of the anomaly disclosed three replacement bodies of pyrite, sphalerite, and galena resembling the Austin Brook and Anacon deposits, but narrower. A 1,500-foot shaft was begun in September 1954, and levels were to be established at 150-foot intervals to confirm the results of diamond drilling, which indicated reserves of 1,173,000 tons averaging 8.2 per cent combined zinc and lead to a depth of 1,200 feet. Development was suspended in February 1957.

Little River Property (32, Map 1)

American Metal Company is developing a zinc-lead-copper sulphide deposit on the above property, which is located 30 miles northwest of Newcastle and 12 miles southwest of the Brunswick Mining and Smelting Company's Austin Brook property. The discovery resulted from the indication of a sulphide body by an aeromagnetic survey carried out in 1953 by The International Nickel Company of Canada Limited, as a result of which it acquired a 25 per cent interest in the property. Heath Steele Mines Limited, a subsidiary of American Metal and International Nickel, was formed in 1955 to develop the property to production.

The ore is reported to occur as large lenses within an east-west striking shear zone. One orebody is estimated to contain 4,200,000 tons averaging 7.1 per cent zinc, 2.9 per cent lead, and 1.1 per cent copper, and another 3,000,000 tons averaging 3.5 per cent zinc, 1.2 per cent lead, and 1.3 per cent copper. Both estimates are based on drilling to a depth of 600 feet. In February 1957, regular production began from two open pits and a 1,500-ton mill produced copper, zinc and lead concentrates.

## Nova Scotia

Numerous zinc-lead occurrences have been found in Nova Scotia, but with the exception of the Stirling mine in southern Cape Breton Island no deposits of economic importance have been located. Since 1953, Cape Breton Metals Limited has carried out an exploration program on a number of mineralized belts containing zinc, lead, and copper sulphides occurring on the peninsula forming the north portion of Cape Breton Island. Some encouraging results have been obtained, particularly near Meat Cove.

## Newfoundland

Numerous deposits and occurrences of copper ore occur in the Notre Dame Bay area on the east coast of the Island but only at the York Harbour and Rambler properties has zinc mineralization been found in appreciable amounts.

York Harbour

This mine is on the west coast 20 miles west of Corner Brook. Mining operations were carried on intermittently between 1897 and 1913. The ore occurs as chalcopyrite and sphalerite in lenses or veinlets in breccia lavas. The main shaft is 485 feet deep with six levels, and there are several shallower shafts. About 30,000 tons of ore was produced during the above period. In 1951, Independent Mining Corporation Limited acquired the property. It drove a new adit for a distance of 2,400 feet and carried out considerable diamond drilling which was reported to have disclosed 102,000 tons averaging 2.38 per cent copper and 6.8 per cent zinc. In 1955 the property was sold to Nama Creek Mines Limited.

Rambler

This property is about 15 miles southwest of Mings Bight and 6 miles south of South Brook, Baie Verte, from which it is reached by a rough trail.

The deposit is composed of an irregular lens of silicified chlorite schist containing pyrite and a little chalcopyrite and sphalerite. It was discovered in 1905, and in 1907 a 65-foot shaft was sunk and short cross-cuts driven. The property was drilled in 1946 and 1947 by Siscoe Gold Mines Limited, which reported an indicated 330,000 tons of ore averaging 0.43 ounces per ton gold, 1.5 per cent copper, and 1.57 per cent zinc.

## Northwest Territories

Pine Point Mines Limited (33, Map 1)

The property is located near Pine Point on the south shore of Great Slave Lake, between the outlets of the Slave and Hay rivers. It comprises over 1,000 claims extending about 36 miles northeasterly along a mineralized belt roughly 3 miles in width. The company is a subsidiary of Cominco with Ventures Limited holding a minority interest.

The rock formations in the area are fairly flat-lying Devonian sediments. The ore occurs as a replacement in a bed of coarse dolomitic limestone. There is considerable variation in thickness of the overlying strata, but a number of locations have been found where open-pit mining appears practical. The ore zones vary in thickness from 40 to 150 feet. The property has been explored by the drilling of holes at 1,000-foot intervals along north-south sections spaced one mile apart and more closely spaced drilling has been carried out in areas of greater than average mineralization. Two shafts have been sunk, one on the N-42 orebody to a depth of 98 feet, the other on the N-40 orebody (about 3,000 feet east of N-42) to a depth of 160 feet; from the latter, 660 feet of lateral development has been done.

The grade of the ore varies considerably throughout the mineralized belt; the ratio of zinc to lead is generally 4 to 1, but in some sections lead predominates. No statement regarding ore reserves has been published by the company, but unofficial reports indicate an ore potential of 120,000,000 tons (about 5,000,000 tons being available for open-pit mining) with an average grade of 7.4 per cent zinc and 4.0 per cent lead. The N-42 orebody is estimated to be 1,000 feet long, several hundred feet wide and 50 feet thick and to contain over two million tons averaging more than 10 per cent combined zinc and lead. Preliminary ore dressing tests have shown that high-grade zinc and lead concentrates can be produced.

Tentative plans to bring the property into production include a concentrator to treat 10,000 tons of ore a day. Production, however, is predicated on the building of 430 miles of railway from Grimshaw, Alberta, to the property, over which concentrates would be transported for treatment at Trail.

Indian Mountain Metal Mines Limited (34, Map 1)

A number of zinc occurrences have been located in the Indian Mountain Lake area 6 to 8 miles north of McLeod Bay, Great Slave Lake. The ore occurs in folded sedimentary beds striking northeasterly. Diamond drilling on the company's property has indicated 923,850 tons averaging 10.3 per cent zinc, 0.85 per cent lead, and 3.45 ounces per ton silver to a depth of 650 feet. There has been little activity in the area since 1952.

## Yukon

Mayo Area (27, Map 1)

This area has been the most thoroughly prospected base-metal district in the Yukon and probably contains more potential mines than all other known areas in the Territory. It extends over a length of 14 miles and averages 3 1/2 miles in width. Most of the deposits are on property owned by United Keno Hill Mines Limited, the principal producer, but there are many silver-lead-zinc occurrences on claims held by other interests.

Pelly River Area (35, Map 1)

Vangorda Mines Limited, a subsidiary of Prospectors Airways Limited, has partly developed a zinc-lead deposit on Vangorda Creek, a tributary of the Pelly River about 110 miles northeasterly from Whitehorse. The deposit consists of a flat-lying zone of sulphides 4,100 feet in length and averaging 800 feet in width, with a thickness of about 50 feet. The mineralization is reported to resemble the fine-grained iron sulphides of the Bathurst area of New Brunswick. Diamond drilling in 1954 and 1955 disclosed an ore zone of 9,400,000 tons averaging 5 per cent zinc, 3 per cent lead, and 1.76 ounces per ton silver.

Jeff Lake Deposit (36, Map 1)

The deposit is located 230 miles northeast of Whitehorse on the Canol Road. Hudson Bay Mining and Smelting Company Limited, through its wholly owned exploration subsidiary, has outlined a fine-grained sphalerite and galena replacement body in bedded limestone containing about 9,000,000 tons of low-grade silver-lead-zinc ore.

Hyland River Area (37, Map 1)

The McMillan property, located at the west end of Quartz Lake, 240 miles east of Whitehorse and 40 miles northeast of Watson Lake, has been explored extensively by the American Smelting and Refining Company. About one million tons containing 10 per cent zinc, 5 per cent lead, and 1.8 ounces per ton of silver have been outlined by drilling. The orebody is a flat-lying replacement zone in limestone bedding.

## CHAPTER VII

## ORE RESERVES - CANADA AND THE WORLD

The zinc ore reserves of Canada cannot be completely reported by deposits since some companies do not reveal the tonnage and grade of their reserves. The total measured and indicated reserves, including the Pine Point deposit and the deposits in New Brunswick, amount to 240,416,900 tons. The contained metals in this ore include 16,691,300 tons of zinc, 8,033,800 tons of lead, 1,917,200 tons of copper and 401,118,600 ounces of silver. In addition there is a significant amount of inferred ore, especially in Yukon, British Columbia, Manitoba, and New Brunswick, the total of which is in excess of 20 million tons containing 1,400,000 tons of zinc and 300,000 tons of lead.

Zinc ore reserves are widespread and important deposits occur in the United States, Mexico, Peru, Chile, Australia, Belgian Congo, Northern Rhodesia, Southwest Africa, Algeria, Morocco, and many European countries. In North America the reserve picture is perhaps more obscure than elsewhere, owing to the reluctance of certain companies to disclose their reserves; however, the U.S. Bureau of Mines, in its Bulletin 556, published estimates in 1955 from which Table 4 has been prepared. The Department of Mines and Technical Surveys estimate for 1956 is used for Canada instead of the U.S. Bureau of Mines figure.

TABLE 4

World Reserves of Zinc Ore

| | Zinc Content-Tons | % of World Reserves |
|---|---|---|
| North America | | |
| United States | 8,480,000 | 11.4 |
| Canada | 16,691,000 | 22.4 |
| Mexico | 1,120,000 | 1.5 |
| Europe | | |
| Eastern Europe | 11,000,000 | 15.0 |
| Western Europe | 11,000,000 | 15.0 |
| South America | | |
| Peru, Argentina, Bolivia & Chile | 6,000,000 | 8.2 |
| Africa | | |
| Belgian Congo, Algeria, Morocco, Northern Rhodesia, Southwest Africa & Tunisia | 4,000,000 | 5.4 |
| Asia | | |
| Burma, Japan, China, Korea, Vietman | 4,500,000 | 6.1 |
| Australia | 11,000,000 | 15.0 |
| | 73,791,000 | 100.0 |

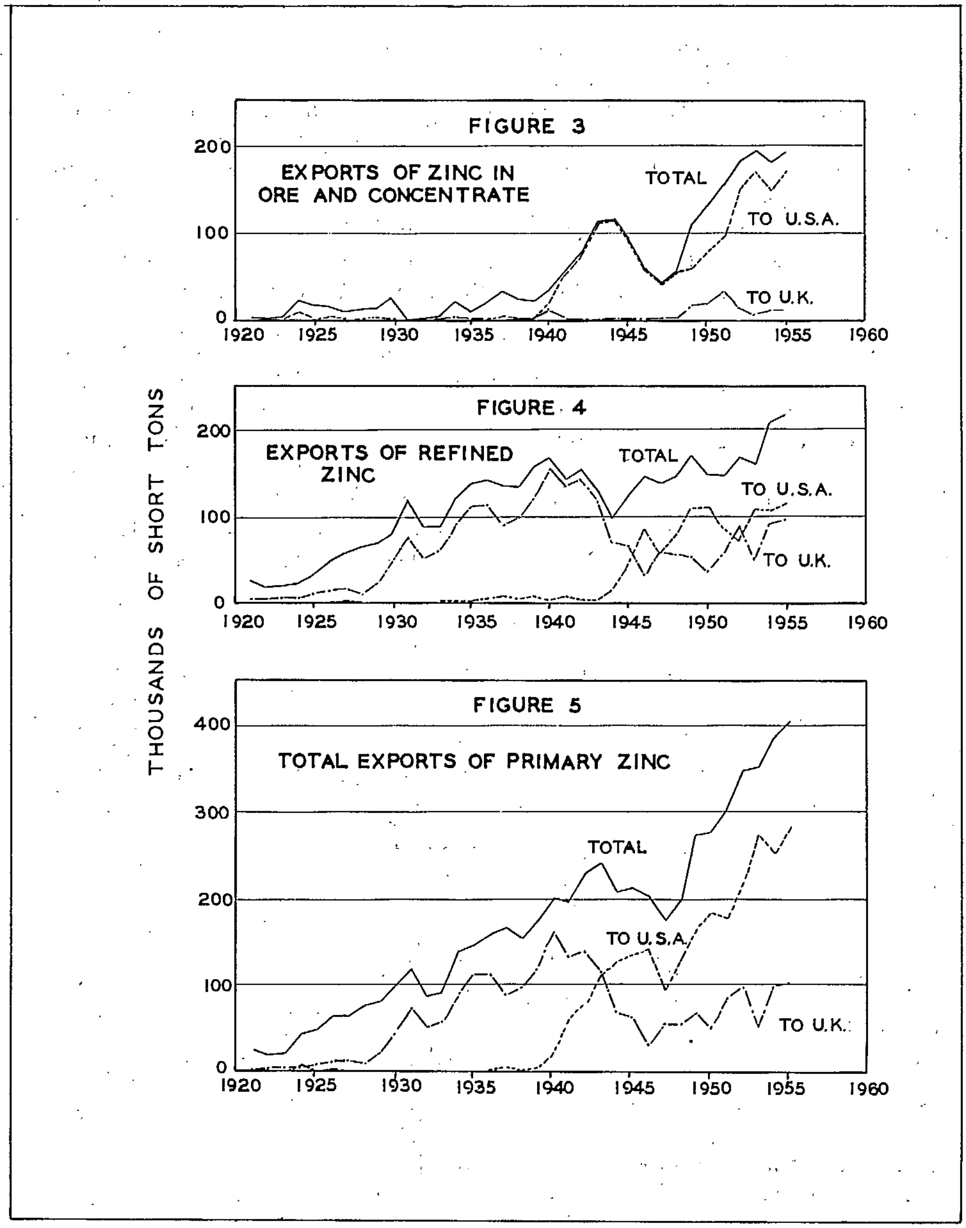
FIGURE 3
EXPORTS OF ZINC IN ORE AND CONCENTRATE
TOTAL
TO U.S.A.
TO U.K.
200
100
0
1920
1925
1930
1935
1940
1945
1950
1955
1960
FIGURE 4
EXPORTS OF REFINED ZINC
TOTAL
TO U.S.A.
TO U.K.
FIGURE 5
TOTAL EXPORTS OF PRIMARY ZINC
TOTAL
TO U.S.A.
TO U.K.
400
300
THOUSANDS OF SHORT TONS

# CHAPTER VIII

## WORLD PRODUCTION AND TRADE

Zinc is mined in many countries. As shown in Table 5*, about 40 per cent of the mine production in 1955 came from North America; about 17 per cent was produced in 10 or 11 European countries, exclusive of Poland. Algeria and other north African countries are moderately sizable producers and the output of Northern Rhodesia has been increasing in recent years. Australia also is an important producer.

In the communist sphere, Russian production is estimated to have increased substantially since the end of World War II. Polish output, mostly from the Silesia district of southern Poland, is reported to be greater than in any previous period.

The world production of zinc metal does not correspond with world mine production as closely as in the case of copper, lead, and other metals. As shown in Table 5 , the United States produced about 35 per cent of the world's slab zinc in 1955, about half of which was derived from imported ores. The total slab zinc production of North and South America was approximately equivalent to the mine production of these continents. In Europe, Belgium, which now has virtually no mine production, is the leading producer of zinc metal. Other important producing countries are Germany, France, and the United Kingdom, all of which import large amounts of zinc concentrates. Italy and Spain both produce slab zinc, but they also export sizable amounts of zinc concentrates. Norway, though a small zinc ore producer, has a fairly large treatment capacity for electrolytic zinc. In other parts of the non-communist world, Australia and Japan are important zinc metal producers. There is thought to be sufficient treatment capacity in Russia and Poland to take care of the total communist zinc ore production.

Because many of the world's zinc smelters and treatment plants are located in regions where there is little or no zinc mining and, conversely, in some important zinc mining regions no treatment facilities exist, there is considerable international trade in zinc concentrates. Large excess treatment capacity in the United States has been met by imports from Canada and Mexico, with smaller amounts from Peru and other Latin-American countries. The United Kingdom requirements are largely supplied by Australia. Belgian zinc plants are fed mostly from the Belgian Congo and also draw supplies from many other African and also from South American sources, with small amounts from Canada. The French plants draw some material from Morocco and Algeria also from Spain, Italy, and Greece. Holland and Germany receive concentrates from Latin-America, Italy, and Spain. In some cases world trade in zinc concentrates is influenced by part ownership of the mines by certain smelters or from long-standing arrangements; however, the present-day close competition in the world markets usually tends to channel the trade along economic lines.

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* Except for the year 1955, the figures in this table are taken from 'Zinc in its international setting'. Dept. Trade & Commerce, Canada, Feb. 1955.

International trade in zinc metal is less than that of concentrates, and the movement is naturally from countries that produce more zinc than they use to countries where consumption exceeds production. Canada and Belgium are the largest exporters of zinc metal, others include Australia, Norway, Mexico, Northern Rhodesia, and Italy. The United States and United Kingdom are the largest importers but sizable amounts are also imported by Japan, Brazil, and South Africa. The United States requirements are largely met by Canada and Mexico. The United Kingdom buys most of its zinc from Canada, but Australia and Belgium are also important sources. In Western Europe, the countries that are deficient in zinc metal obtain their needs from Belgium, Norway, and Italy.

The Canadian exports of zinc contained in ore or concentrates and of refined zinc to the United Kingdom, the United States, European countries, and other countries in the years 1926 to 1956 are shown in Tables 6 and 7 and Figures 3, 4 and 5 following immediately.

TABLE 5

World Production of Zinc Metal, 1913-1955

(Thousands of Short Tons)

| Country & Region | 1913 | 1917 | 1921 | 1929 | 1932 | 1942 | 1946 | 1950 | 1955 | % 1955 |
|---|---|---|---|---|---|---|---|---|---|---|
| Americas | | | | | | | | | | |
| United States | 373 | 686 | 218 | 673 | 222 | 945 | 773 | 910 | 1,031 | 34.8 |
| Canada[a] | - | 11 | 28 | 86 | 86 | 215 | 186 | 204 | 257 | 8.6 |
| Mexico | - | - | - | 17 | 33 | 54 | 53 | 54 | 62 | 2.1 |
| S. America | - | - | - | - | - | 2 | 3 | 10 | 34 | 1.1 |
| Total | 373 | 697 | 246 | 776 | 341 | 1,216 | 1,015 | 1,178 | 1,384 | 46.6 |
| W. Europe | | | | | | | | | | |
| Belgium | 225 | 11 | 73 | 218 | 106 | 32 | 87 | 195 | 233 | 7.8 |
| Germany[b] | 310 | 206 | 99 | 112 | 46 | 346 | 16 | 150 | 197 | 6.6 |
| France | 70 | 25 | 27 | 96 | 50 | 25 | 34 | 79 | 123 | 4.2 |
| United Kingdom | 65 | 42 | 66 | 65 | 30 | 80 | 73 | 78 | 91 | 3.1 |
| Italy | - | - | 1 | 17 | 19 | 37 | 17 | 42 | 78 | 2.6 |
| Norway[a] | 10 | 24 | 4 | 6 | 44 | 8 | 34 | 47 | 50 | 1.7 |
| Other[c] | 37 | 25 | 20 | 53 | 29 | 27 | 25 | 60 | 72 | 2.4 |
| Total | 717 | 333 | 230 | 567 | 324 | 555 | 286 | 651 | 844 | 28.4 |
| Africa, Asia, Etc. | | | | | | | | | | |
| Northern Rhodesia[a] | - | - | - | 14 | - | 14 | 19 | 25 | 31 | 1.0 |
| Belgian Congo | - | - | - | - | - | - | - | - | 37 | 1.2 |
| Japan | 2 | 60 | 8 | 27 | 33 | 70 | 12 | 54 | 123 | 4.2 |
| Australia[a] | 5 | 5 | 2 | 58 | 60 | 83 | 85 | 95 | 113 | 3.8 |
| Grand Total | 1,097 | 1,095 | 486 | 1,442 | 758 | 1,938 | 1,417 | 2,003 | 2,532 | 85.2 |
| Russia | 8 | 1 | - | 4 | 16 | 77 | 62 | 142 | 300 | 10.0 |
| Poland & Other[b] | 24 | 14 | 17 | 201 | 100 | - | 77 | 103 | 144 | 4.8 |
| Total | 32 | 15 | 17 | 205 | 116 | 77 | 139 | 245 | 444 | 14.8 |
| World Total | 1,129 | 1,110 | 503 | 1,647 | 874 | 2,015 | 1,556 | 2,248 | 2,976 | 100.0 |

Sources: 1913-1921: International Control in the Non-Ferrous Metals.
1929-1932: Materials Survey-Zinc.
1942-1955: Metallgesellschaft, Minerais et Metaux, A. B. M. S.

(a) All electrolytic production - U. S., France, Italy, Japan in part only.

(b) Germany-Poland - Boundary changes in Silesia became basis of new Polish industry after World War I; occupied by Germany in World War II; but now again in Polish territory.

(c) Other includes Netherlands, Spain, Yugoslavia.

TABLE 6

Exports of Zinc Contained in Ore or Concentrate
(Short Tons)

| Year | United Kingdom | United States | European Countries | Other Countries | Total | Total Value |
|---|---|---|---|---|---|---|
| | | | | | | $ |
| 1926 | - | 3,000(e) | 12,242(e) | - | 15,242(e) | 1,393,165 |
| 1927 | - | - | 9,540(e) | - | 9,540(e) | 862,498 |
| 1928 | - | - | 11,255 | - | 11,255 | 1,438,619 |
| 1929 | - | 5 | 12,864 | - | 12,869 | 1,415,725 |
| 1930 | - | - | 19,467 | 4,015 | 23,482 | 1,014,915 |
| 1931 | - | - | - | - | - | - |
| 1932 | - | - | - | - | - | - |
| 1933 | - | - | 3,036 | 1,127 | 4,163 | 135,249 |
| 1934 | 2,490 | 3 | 12,556 | 4,473 | 19,522 | 654,835 |
| 1935 | 1,468 | - | 7,245 | 1,087 | 9,800 | 337,732 |
| 1936 | - | - | 18,339 | 1,227 | 19,566 | 727,253 |
| 1937 | - | 85 | 32,646 | 117 | 32,848 | 2,618,641 |
| 1938 | - | - | 20,945 | 1,976 | 22,921 | 1,154,812 |
| 1939 | - | - | 20,630 | - | 20,630 | 526,905 |
| 1940 | 11,321 | 22,190 | - | - | 33,511 | 780,852 |
| 1941 | - | 55,279 | - | - | 55,279 | 2,326,109 |
| 1942 | - | 76,114 | - | - | 76,114 | 4,070,803 |
| 1943 | - | 111,275 | - | - | 111,275 | 6,097,117 |
| 1944 | - | 113,303 | - | - | 113,303 | 7,046,844 |
| 1945 | - | 91,780 | - | - | 91,780 | 5,540,384 |
| 1946 | - | 58,200 | - | - | 58,200 | 3,181,120 |
| 1947 | - | 40,575 | - | - | 40,575 | 2,916,649 |
| 1948 | - | 54,227 | - | - | 54,227 | 4,752,238 |
| 1949 | 15,445 | 59,298 | 31,941 | - | 106,684 | 12,562,931 |
| 1950 | 16,421 | 76,484 | 36,656 | - | 129,561 | 17,399,678 |
| 1951 | 31,978 | 94,530 | 24,532 | 3,553 | 154,593 | 27,153,095 |
| 1952 | 13,544 | 149,223 | 18,987 | - | 181,754 | 34,491,726 |
| 1953 | 4,178 | 168,856 | 19,622 | - | 192,656 | 22,923,232 |
| 1954 | 9,007 | 148,140 | 23,025 | - | 180,172 | 18,838,888 |
| 1955 | 8,245 | 168,069 | 14,271 | - | 190,585 | 22,988,483 |
| 1956 | 6,311 | 173,325 | 19,677 | - | 199,313 | 26,484,600 |

(e) Estimated zinc content. In years 1926 and 1927, Trade of Canada reported gross weight of ores exported. Zinc content as shown above has been estimated for these years. In all subsequent years zinc content of zinc ore shipments is shown.

TABLE 7

Exports of Slab Zinc
(Short Tons)

| Year | United Kingdom | United States | European Countries | Other Countries | Total | Total Value |
|---|---|---|---|---|---|---|
| | | | | | | $ |
| 1926 | 13,244 | - | 12,809 | 21,951 | 48,004 | 7,107,876 |
| 1927 | 14,648 | 4 | 25,688 | 15,870 | 56,210 | 6,826,808 |
| 1928 | 10,810 | - | 33,829 | 18,955 | 63,594 | 6,602,867 |
| 1929 | 23,251 | - | 22,069 | 22,223 | 67,543 | 7,031,645 |
| 1930 | 47,553 | - | 7,020 | 20,909 | 75,482 | 5,146,215 |
| 1931 | 74,376 | - | 24,596 | 20,037 | 119,009 | 5,554,511 |
| 1932 | 51,243 | - | 14,464 | 21,954 | 87,661 | 3,852,990 |
| 1933 | 58,910 | 28 | 9,789 | 18,000 | 86,727 | 4,990,705 |
| 1934 | 90,538 | 64 | 8,837 | 19,508 | 118,947 | 6,990,639 |
| 1935 | 111,107 | 623 | 6,848 | 16,881 | 135,459 | 7,809,691 |
| 1936 | 113,452 | 2,301 | 3,496 | 20,962 | 140,211 | 8,523,906 |
| 1937 | 89,028 | 7,248 | 18,207 | 19,706 | 134,189 | 12,739,242 |
| 1938 | 99,389 | 2,392 | 12,398 | 18,033 | 132,212 | 8,626,961 |
| 1939 | 121,676 | 6,437 | 3,343 | 24,539 | 155,995 | 9,343,586 |
| 1940 | 155,032 | 1,716 | 10,245 | 80 | 167,073 | 11,133,824 |
| 1941 | 132,738 | 6,765 | - | 1,583 | 141,086 | 9,876,787 |
| 1942 | 140,918 | 2,061 | 1,780 | 7,400 | 152,159 | 10,783,049 |
| 1943 | 117,416 | 1,405 | 9,323 | 1,171 | 129,315 | 10,260,030 |
| 1944 | 69,672 | 14,201 | 11,920 | 192 | 95,985 | 7,666,731 |
| 1945 | 64,731 | 43,267 | 11,297 | 2,665 | 121,960 | 14,122,706 |
| 1946 | 31,688 | 85,258 | 25,256 | 2,694 | 144,896 | 24,174,704 |
| 1947 | 56,175 | 55,152 | 25,088 | 813 | 137,228 | 26,661,360 |
| 1948 | 55,433 | 75,408 | 11,408 | 2,638 | 144,887 | 36,685,950 |
| 1949 | 52,692 | 108,068 | 4,211 | 3,336 | 168,307 | 42,482,982 |
| 1950 | 35,823 | 108,117 | 816 | 2,124 | 146,880 | 40,593,669 |
| 1951 | 55,415 | 84,281 | 3,712 | 2,724 | 146,132 | 55,423,769 |
| 1952 | 87,167 | 70,934 | 4,660 | 4,103 | 166,864 | 61,309,973 |
| 1953 | 48,894 | 107,841 | - | 1,653 | 158,388 | 34,292,884 |
| 1954 | 91,127 | 105,212 | 1,848 | 7,851 | 206,038 | 39,188,377 |
| 1955 | 95,598 | 113,306 | 112 | 4,821 | 213,837 | 47,107,303 |
| 1956 | 63,838 | 115,895 | - | 3,995 | 183,728 | 47,013,213 |

## CHAPTER IX

## PROPERTIES, USES, AND CONSUMPTION

Zinc is a soft, silvery-grey metal. It has a low melting-point (787° F) and a boiling point of 1661° F. Its specific gravity is 7.14. The metal may be cast, rolled, drawn, and extruded. It takes a high polish and may be readily plated on other metals or alloys.

Slab zinc is produced and sold in the United States by grades specifying a maximum content of certain undesirable impurities. These grades are recognized by the American Society for Testing Materials and by industry generally. The grades are shown in the following tabulation:

| Grade | Maximum Permissible Content | | | | Total Permissible Pb, Fe, Cd |
|---|---|---|---|---|---|
| | Lead | Iron | Cadmium | Aluminum | |
| | % | % | % | % | % |
| Special High Grade | 0.006 | 0.005 | 0.005 | none | 0.010 |
| High Grade | 0.07 | 0.02 | 0.02 | none | 0.10 |
| Intermediate | 0.2 | 0.03 | 0.50 | none | 0.50 |
| Brass Special | 0.6 | 0.03 | 0.50 | none | 1.0 |
| Selected | 0.8 | 0.04 | 0.75 | none | 1.0 |
| Prime Western | 1.6 | 0.08 | - | - | - |

In the United Kingdom, Europe, and certain other zinc-metal-producing regions, similar grades are in use. At the two Canadian zinc plants, High Grade and Special High Grade electrolytic zinc are produced. One Canadian producer turns out Prime Western by adding the requisite amount of lead to his High Grade product.

About 20 to 25 per cent of Canada's refined zinc production is sold and used in the domestic market. Owing to war requirements, the highest consumption was in 1942, when 84,000 tons was used; since 1946 the annual consumption has averaged 51,350 tons (Fig. 2, page 3 ). The outlook appears to indicate a general increase in consumption in keeping with the forecast for increased output of steel products and other manufactures. About 90 per cent of the zinc-consuming industry is in the Montreal and Toronto-Hamilton-Windsor areas.

Zinc has a wide range of industrial uses, the more important being in galvanizing, die-casting, brass products, rolled zinc products, and paints. Table 8 shows the industrial uses of primary zinc in Canada in the period 1951 to 1956. The general decrease in the quantities used for die-casting and brass manufacture from 1951 until 1954 may be accounted for by reduced requirements for national defense purposes.

TABLE 8

Consumption of Refined Zinc* in Canada by Industries
(Short Tons)

| Industry | 1951 | 1952 | 1953 | 1954 | 1955 | 1956 |
|---|---|---|---|---|---|---|
| Electrogalvanizing | 924 | 422 | 531 | 491 | 1,091 | 1,130 |
| Hot-dip galvanizing | 22,505 | 22,843 | 21,445 | 23,920 | 26,955 | 32,579 |
| Zinc die-casting alloys | 11,538 | 7,887 | 9,065 | 6,713 | 10,464 | 9,354 |
| Brass | 10,858 | 11,992 | 9,485 | 6,778 | 9,350 | 7,721 |
| Other alloys | 926 | 1,793 | 1,667 | 771 | 678 | 692 |
| Rolled and ribbon zinc | 2,975 | 1,257 | 1,205 | 1,265 | 1,395 | 1,648 |
| Zinc dust | 158 | - | - | - | - | - |
| Zinc oxide | 9,748 | 5,189 | 7,013 | 7,154 | 7,141 | 7,497 |
| Miscellaneous | 1,166 | 326 | 307 | 192 | 1,400 | 1,568 |
| Total | 60,798 | 51,709 | 50,718 | 47,284 | 58,474 | 62,189 |

* Does not include secondary zinc.

In Table 9, zinc consumption in Canada is compared to that in the United States and the remainder of the world for the period 1934-1955. It may be noted that Canada's consumption has about trebled during the period in comparison with approximately a double amount used by the United States.

## Galvanizing

In this process iron or steel is coated with a thin layer of zinc for the purpose of retarding corrosion. The zinc coating is usually applied by the hot-dipping method, which involves pickling or cleaning the steel and then passing it through a bath of molten zinc. Because zinc has a high affinity for iron, the coating is formed of an inner layer of iron-zinc alloy that merges into progressively purer zinc. Small articles such as water pails are galvanized by hand-dipping. In the case of sheets, strips, wire, etc., the operation is carried out mechanically. During the last decade the use of continuous strip galvanizing lines has progressed rapidly in the United States, Canada, and Europe. These lines provide not only an increased output at a lower cost, but an improved product having a thinner inner layer, and one that can be more readily fabricated. For many years Prime Western zinc has been preferred for hot-dip galvanizing, since the 1 to 1 1/2 per cent lead content is considered to promote bonding. The formation of the undesirable inter-metallic layer may be prevented by the addition of 0.15 to 0.17 per cent aluminum. Aluminum also reduces the formation of dross, a zinc-iron alloy that forms on the zinc bath.

TABLE 9

World Consumption of Zinc
(Thousands of Short Tons)

| Year | Canada | United States | Other Countries | Total |
|---|---|---|---|---|
| 1934 | 15.4 | 346.0 | 929.3 | 1,290.7 |
| 1935 | 14.5 | 457.7 | 1,044.4 | 1,516.6 |
| 1936 | 18.7 | 542.7 | 1,106.9 | 1,668.3 |
| 1937 | 23.1 | 573.7 | 1,161.8 | 1,758.6 |
| 1938 | 18.7 | 418.9 | 1,146.0 | 1,583.6 |
| 1939 | 23.0 | 628.3 | 1,186.9 | 1,838.2 |
| 1940 | 36.9 | 716.5 | 1,165.3 | 1,918.7 |
| 1941 | 56.7 | 832.2 | 1,057.2 | 1,946.1 |
| 1942 | 84.0 | 760.6 | 1,045.2 | 1,889.8 |
| 1943 | 80.6 | 848.8 | 881.7 | 1,811.1 |
| 1944 | 67.3 | 925.9 | 759.0 | 1,752.2 |
| 1945 | 55.7 | 887.4 | 485.4 | 1,428.5 |
| 1946 | 55.0 | 832.2 | 770.0 | 1,647.2 |
| 1947 | 51.1 | 786.4 | 1,003.5 | 1,841.0 |
| 1948 | 46.9 | 817.7 | 1,031.4 | 1,896.0 |
| 1949 | 45.7 | 711.8 | 1,077.2 | 1,834.7 |
| 1950 | 54.4 | 967.1 | 1,167.3 | 2,188.8 |
| 1951 | 61.0 | 934.0 | 1,270.4 | 2,265.4 |
| 1952 | 51.6 | 852.8 | 1,260.7 | 2,165.1 |
| 1953 | 50.7 | 985.9 | 1,316.9 | 2,353.5 |
| 1954 | 47.3 | 886.3 | 1,633.2 | 2,566.8 |
| 1955 | 58.5 | 1,114.0 | 1,745.2 | 2,917.7 |

Sources: Canada
Dominion Bureau of Statistics.
Other
1934-46; Metallgesellschaft Aktiengesellschaft.
1947-55; American Bureau of Metal Statistics.

Electrogalvanizing or zinc plating is used to coat wire and sometimes small articles such as nuts, bolts, and washers. The articles to be plated comprise the cathode, and the zinc is deposited from highly acid zinc sulphate solutions or from zinc anodes of high purity in an acid or cyanide bath.

In addition to forming a seal to prevent moisture from coming into contact with the iron base the zinc coating provides added protection through galvanic action, i.e. where pinholes or small exposed areas occur.

Galvanizing constitutes the largest industrial use for zinc, utilizing almost half of all zinc consumed. In Canada, there are about 40 plants engaged in hot-dip galvanizing and 9 using the electrogalvanizing process. In 1955, Steel Company of Canada Limited, the largest consumer in Canada, and Dominion Foundries and Steel Company Limited installed continuous-strip galvanizing lines in their plants at Hamilton, Ontario.

## Die-casting

Die-casting is a method of mass-producing small- to medium-sized castings by running molten metal into steel moulds or dies under pressure. The dies are made in two matching halves of polished steel with cavities shaped exactly like the required finished part cut into one or both faces. When the halves are together the molten metal is forced into the cavity at a temperature only slightly above its freezing point so that it solidifies almost immediately. The halves of the die are then automatically separated and the casting removed. In practice, the die may be operated 10 to 15 times a minute, and in the case of small parts it is possible by cutting multiple cavities in the die to make a number of castings simultaneously. Owing to its speed, and the uniformity of the castings, the die-casting process has become increasingly important in the manufacture of automobiles, aeroplanes, electrical components, washing machines, refrigerators, oil burners, air conditioners, and hundreds of other appliances.

Die-castings are made from non-ferrous metals that may be classified into low- and high-melting-point groups. The low-melting-point group includes alloys of zinc, lead, and tin, while the high-melting-point group comprises alloys of aluminum, magnesium, and copper. Zinc is the most widely used die-casting metal and accounts for about two-thirds by weight of all castings made. Aluminum ranks second in this respect, its lightness being of importance in aeroplane parts or other applications where weight is a factor. The reasons for the preference for zinc in die-casting may be summed up as follows:

1. The speed of die operation is higher.

2. The casting is made at a low temperature, which means longer life for the die.

3. The product may be easily machined, if necessary, after casting.

4. Castings are readily finished with an electroplated coating such as chromium.

5. Castings can be readily produced in complex shapes.

Special High Grade (99.99+ pure) zinc is used for zinc-base die-casting alloys. From 3.5 to 4.5 per cent aluminum is added to reduce the corrosive action of zinc on both the die and the pressure mechanism. Magnesium and copper are also added to ensure long-lasting stability to the casting.

The metal composition of the principal zinc-base die-casting alloy (Alloy 23) is:

| | Maximum Per Cent |
|---|---|
| Copper | 0.10 |
| Aluminum | 3.5 - 4.3 |
| Magnesium | 0.03 - 0.08 |
| Iron, max. | 0.100 |
| Lead, max. | 0.007 |
| Tin, max. | 0.005 |
| Cadmium, max. | 0.005 |
| Zinc | Remainder |

In Canada the following are the more important consumers of zinc for use in die-casting:

| | |
|---|---|
| Schultz Die Casting Co. of Canada Ltd. | - Wallaceburg, Ont. |
| Barber Die Casting Co. Ltd. | - Hamilton, Ont. |
| Pressure Castings of Canada Ltd. | - Toronto, Ont. |
| National Hardware Specialties Ltd. | - Dresden, Ont. |
| Dominion Die Casting Ltd. | - Wallaceburg, Ont. |
| Lakeshore Die Casting Ltd. | - Oakville, Ont. |

## Brass

There are many types of brass, with varying proportions of copper and zinc. The composition may range from 95 per cent copper and 5 per cent zinc to 50 per cent copper and 50 per cent zinc. The average brass contains 70 per cent copper and 30 per cent zinc. The zinc content imparts hardness, strength, and colour to the alloy. Brass pipe, tubing, and hardware are widely used in construction, and the automotive industry consumes large amounts for engine fittings and for parts of radiators. Other uses include telephone, radio, and television equipment. In war-time brass requirements are especially heavy for the manufacture of cartridge and shell cases.

The principal makers of brass mill products in Canada are Anaconda American Brass Limited, New Toronto; Noranda Copper and Brass Limited, Montreal, and Canadian Arsenals Limited, Quebec. There are some 30 brass fabricators in the country.

Rolled Zinc

Slab zinc, rolled into sheets or ribbons, is used principally in the making of dry cells for flashlights, etc. ; it is also used for photo-engraver's plates, lithographer's sheets, cathodic protection plate anodes, and weather-stripping.

Burgess Battery Company Limited, Niagara Falls, is the only producer of rolled zinc in Canada, almost all of its output being used to make dry-cell battery cups.

Zinc Oxide

In Canada zinc oxide is produced by the so-called "French" process by vaporizing metallic zinc in an oxidizing atmosphere. The resulting zinc oxide, a white powder, is cooled and collected. Its principal uses are in the manufacture of paints and rubber. A more recent and expanding use is in the making of rayon, which is produced from wood fibre by the viscose process in which zinc sulphate (made from the oxide) is an important precipitating reagent. Zinc oxide is also used in pharmaceuticals, cosmetics, ceramic manufactures, and linoleum.

The principal producers in Canada are Zinc Oxide Company of Canada Limited, and Durhams Chemicals (Canada) Limited, Montreal, and Canadian Felling Zinc Oxide Company Limited, Milton, Ontario.

Zinc Dust

Zinc dust has been made for quite a number of years by General Smelting Company of Canada Limited in Hamilton for use mainly by the mining industry for precipitation of gold and silver from cyanide solutions. A special grade of dust is prepared for this purpose. Regular grades of chemical dust, such as made by most foreign producers, is used by the chemical, paint, and oil industries. Since zinc dust produced in Hamilton is all made from galvanizers' zinc dross, it is not shown in the consumption by industries, (Table No. 8, page 78) which refers only to primary zinc. Canadian production of zinc dust is approximately 500 tons a year, about 90 per cent of which is "cyanide" grade dust. Part of Canada's zinc dust requirements is imported.

Scrap Zinc

The amount of secondary zinc recovered from scrap is relatively small as compared to recoveries of scrap lead or copper. In the United States, production of secondary slab zinc amounts to about 40,000 tons a year or about 5 per cent of the total production. In Canada the zinc content of metals and alloys recovered from scrap zinc material is not reported separately, but ingot makers' reports to the Dominion Bureau of Statistics show total receipts of scrap zinc amounting to 3,608 tons in 1954, of which galvanizers' dross amounted to 58 per cent and scrap die-cast alloy 25 per cent; in 1955 the indicated consumption was 5,250 tons, of which galvanizers' dross amounted to 64 per cent and scrap die-cast alloy 22 per cent.

Substantial quantities of zinc contained in brass are recovered in the form of secondary brass ingot.

# CHAPTER X

## PRICES, IMPORTS, TARIFFS, AND MARKETING

### Prices

The Canadian market for zinc is almost entirely supplied by the two Canadian producers, who sell at a price quoted in cents per pound based on deliveries at Toronto, Ontario. The Canadian price generally conforms to the United States price for Prime Western zinc f.o.b. East St. Louis, Illinois, subject to monetary exchange adjustment.

Over the years the price of zinc has been subject to wide fluctuations. The lowest price was 2.10 cents a pound in 1932 and the highest 20.6 cents in 1915. During the period from 1917 to 1940 it averaged about 6 cents and during and after World War II the price to Canadian consumers was controlled at 5.15 cents a pound. When the control was lifted early in 1947 the price in Canada increased sharply to 10.25 cents and in the years 1948 to 1952 it varied between 10 cents and 18 to 20 cents. During 1955, it increased slightly from 11.5 to 13 cents and early in 1956 to 13.5 cents a pound. For a number of years there was a premium of 1.35 cents a pound above the Prime Western price for Ordinary High Grade zinc and of 1.5 cents for Special High Grade. These premiums were reduced in Canada on January 14, 1957, to 0.6 cents and one cent a pound respectively.

Table 10 shows the prices of Canadian Ordinary High Grade and Prime Western and the United States Prime Western price at East St. Louis for the years 1946-56 inclusive.

TABLE 10

Zinc Prices

| Year | Canadian | | | | | | U.S. |
|---|---|---|---|---|---|---|---|
| | Ordinary High Grade | | | Prime Western | | | Prime Western |
| | High | Low | Average | High | Low | Average | Average |
| 1946 | 5.75 | 5.75 | 5.75 | 5.15 | 5.15 | 5.15 | 8.726 |
| 1947 | 11.00 | 5.75 | 10.32 | 10.75 | 5.15 | 9.94 | 10.500 |
| 1948 | 18.00 | 11.00 | 13.87 | 17.25 | 10.75 | 13.12 | 13.589 |
| 1949 | 18.00 | 10.00 | 13.207 | 17.25 | 9.25 | 12.457 | 12.144 |
| 1950 | 19.75 | 11.50 | 15.68 | 18.55 | 10.75 | 14.936 | 13.866 |
| 1951 | 21.35 | 19.23 | 19.90 | 20.00 | 18.35 | 18.830 | 18.000 |
| 1952 | 21.35 | 13.55 | 17.46 | 20.00 | 12.10 | 16.108 | 16.215 |
| 1953 | 14.05 | 11.10 | 11.981 | 12.70 | 9.75 | 10.618 | 10.855 |
| 1954 | 12.85 | 10.35 | 11.94 | 11.50 | 9.50 | 10.70 | 10.861 |
| 1955 | 14.35 | 12.85 | 13.65 | 13.00 | 11.50 | 12.30 | 12.299 |
| 1956 | 14.85 | 14.35 | 14.84 | 13.50 | 13.00 | 13.49 | 13.494 |

## Imports

Since Canadian requirements are largely supplied by Canadian producers, imports of zinc are relatively small and largely consist of zinc manufactures and chemical compounds. Table 11 shows the tonnage and value of imports for 1953 and 1954.

TABLE 11

Imports of Zinc and Zinc Products

| | 1953 | | 1954 | |
|---|---|---|---|---|
| Goods Imported | Tons | $ | Tons | $ |
| Zinc dust .................... | 335 | 104,831 | 298 | 82,708 |
| Zinc in blocks, pigs, bars, rods, and plates............ | 29 | 16,048 | 98 | 31,538 |
| Zinc in sheets, strips, & boiler plate anodes ......... | 1,297 | 587,732 | 1,257 | 526,408 |
| Zinc slugs for dry batteries ... | - | 388,991 | - | 386,829 |
| Zinc oxide .................. | 1,382 | 343,820 | 1,035 | 262,149 |
| Zinc sulphate ................ | 1,265 | 142,547 | 1,407 | 123,535 |
| Zinc chloride ................ | 136 | 29,457 | 148 | 27,722 |
| Zinc manufactures N.O.P. .... | - | 2,368,677 | - | 1,740,685 |
| Lithopone .................. | 3,348 | 474,638 | 2,541 | 350,149 |
| Total value ............. | | 4,456,741 | | 3,531,723 |

## Tariffs

The following tariff rates apply as of February 1957 to certain zinc products imported into Canada. Information regarding tariffs on items not listed may be obtained from the Customs and Excise Branch, Department of National Revenue, Ottawa.

The United States tariffs are of great significance to Canadian zinc producers, as the United States is Canada's principal customer for both refined zinc and zinc concentrates. In 1930, the duties were set at 1.75 cents and 1.50 cents per pound of metal and zinc content of ore respectively. There were some temporary suspensions during World War II, and in 1947 the rates were reduced to 7/10 of a cent and 3/5 of a cent for metal and ore content. Since 1954 there has been considerable agitation on the part of some United States producers to have the duties increased, and the United States Tariff Commission recommended certain increases in order to restrict or discourage imports. The President, however, has favoured increased government stockpiling as a means of assisting United States zinc producers.

| Tariff Item | Goods Subject to Duty and Free Goods | British Preferential Tariff | Most Favoured-Nation Tariff | General Tariff |
|---|---|---|---|---|
| 329 | Ores of metals, N.O.P. (includes zinc concentrate) | Free | Free | Free |
| 345 | Zinc dust, strip and sheets; zinc plates for marine boilers; sal ammoniac skimmings and seamless drawn tubing of zinc | Free | Free | Free |
| 345 a | Zinc spelter and zinc in blocks, pigs, bars, rods, or granular form; zinc plates, n.o.p. per pound | 3/4¢ | 1¢ | 1¢ |
| 345 b | Zinc dross and scrap for use in the recovery of the zinc content | Free | Free | 25% |
| 346 | Zinc, manufactures of, N.O.P. | 15% | 22 1/2% | 25% |
| 346 a | Zinc slugs or discs, when imported by manufacturers of electric dry batteries for use in the manufacture of seamless cups or shells for such batteries, in their own factories | Free | Free | 25% |
| 346 c | Zinc sheets, not planished, ground or polished, coated on one side with acid-resisting material, imported by planishers, grinders or polishers of zinc sheets to be used exclusively in the planishing, grinding, polishing or other processing of such sheets, ready for use by photo engravers | Free | Free | 25% |
| 358 | Anodes of nickel, zinc, copper, silver or gold | 5% | 7 1/2% | 10% |

The principal United States tariffs on zinc in 1956 were:

| | |
|---|---|
| Ores and concentrates, zinc content .......... | 3/5¢ per pound |
| Blocks, pigs, and slabs .................... | 7/10¢ " " |
| Sheets ................................ | 1 ¢ " " |
| Scrap ................................. | 3/4¢ " " |
| Dust .................................. | 7/10¢ " " |
| Zinc manufactures n. o. p. .................. | 22 1/2% ad valorem |
| Zinc die-casting alloys ..................... | 12 1/2% ad valorem |

Canadian zinc metal is marketed by the producers in Canada and by their agents in foreign countries. A wide range of sales contracts may be made to suit customers' requirements with respect to grades, shapes, and quantities for present and future delivery. Information regarding purchases may be obtained from the Consolidated Mining and Smelting Company of Canada Limited, 215 St. James St. W., Montreal, Quebec, and from Hudson Bay Mining and Smelting Company Limited, Royal Bank Building, Winnipeg, Manitoba. Both companies maintain sales research personnel who keep closely in touch with industrial consumers of zinc in order to advise and assist where possible in the best application of the metal or its alloys. This service has done much to promote the use of zinc and to demonstrate that zinc, when properly used, is both more economical and superior to competitive metals for many applications.

# CHAPTER XI

## BIBLIOGRAPHY

1. Zinc and Lead Deposits of Canada; Geological Survey of Canada; Series No. 8, 1930.

2. Handbook of Non-Ferrous Metallurgy; Liddell.

3. Zinc in its International Setting, Department of Trade and Commerce, Canada. Feb. 1955.

4. Canadian Mining Journal, Cominco Issue, May 1954.

5. American Bureau of Metal Statistics - Annual Issues.

6. United States Bureau of Mines Bulletin 556, 1956.

7. Ontario Department of Mines, Metal Resources Circular No. 2. 1957.

8. Annual Reports of the Minister of Mines for British Columbia.

9. The Zinc Industry; The American Zinc Institute Inc.

10. The Canadian Mines Handbook; The Northern Miner Press Ltd.

11. The Financial Post Corporation Service.