CANADA

PROSPECTORS' GUIDE

FOR

STRATEGIC MINERALS IN CANADA

Chromium
Manganese
Mercury
Molybdenum
Tin
Tungsten
Vanadium
Fluorspar
Graphite
Mica

MINES AND GEOLOGY BRANCH
DEPARTMENT OF MINES AND RESOURCES
OTTAWA, CANADA
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INTRODUCTION

CANADA is a leading world source of several of the most important of the essential war minerals. But there are some that she does not produce at all, and others of which her production falls far short of her own needs in the present emergency, let alone Britain's.

This booklet is designed to aid the prospector who is searching primarily for gold and the other commonly known Canadian minerals to search also for workable deposits of these deficiency or strategic minerals. The minerals to which the attention of prospectors is specially directed are the ores of chromium, manganese, mercury, molybdenum, tin, tungsten, and vanadium; also fluorspar, graphite, and mica. The assurance of ample future supplies of practically all of these minerals has been a matter of considerable concern to the Department of Munitions and Supply, whose duty it is to guard against shortages of essential minerals, a task in which there is the closest co-operation with the British and United States governmental agencies of mineral supply.

Most of the minerals described come mainly from distant countries over long ocean routes subject to high war risks. Tungsten, manganese, and tin are examples of such minerals. The discovery in Canada of economic deposits of these strategic minerals would be a real contribution to Dominion and Empire security.

Deposits of other minerals described have been found in Canada, and in many cases have been or are being worked; but, for one reason or another, the Dominion has drawn its requirements in large part from the more abundant resources of nearby friendly countries. In such cases, of which molybdenum is an example, the problem of future war supplies is not at present a critical one. Discoveries of these minerals to be of immediate worthwhile national advantage must be of large deposits of the higher grade ores.

Not all of the important strategic minerals are included, the striking omission being bauxite, the commercial ore of aluminium and the key mineral of aircraft production. Canada's aluminium-producing capacity, which is rapidly expanding to meet the growing demands of new domestic, British, and United States war-plane industries, is entirely dependent upon imported bauxite. However, the tropical or sub-tropical conditions with alternating wet and dry seasons generally considered an important essential for the formation and deposition of bauxite have not prevailed in Canada since the Ice Age; and any deposits which may have been formed prior to that era have almost certainly been removed by glacial erosion from those huge areas of the Dominion which were covered by the ice sheets of the period. The chance of discovering economic deposits of bauxite in most of the areas under examination by prospectors appeared therefore to be too remote to warrant its inclusion in this booklet. It should be mentioned here that the lack of bauxite in Canada is spurring on at the present time the investigation of certain domestic minerals as a possible source of aluminium.

The information presented herein has been prepared by engineers, geologists, and other members of the staff of the Mines and Geology Branch, and is based upon their own observations as well as upon authoritative reference works. Generally speaking, only the simple field identification tests are given, the less easily applied chemical and blow-pipe tests being inserted only when considered advisable to do so. Some minerals are very difficult to identify positively. In such circumstances prospectors working in provinces whose Departments of Mines provide mineral examination services should take advantage of them. The Bureau of Geology and Topography (Mineralogical Section), Ottawa, provides a similar service; and is also prepared to furnish specimens of many of the minerals described herein to the prospector to facilitate the identification of his finds. The charges made for these specimens, covering costs only, are listed on page 61. Arrangements can also be made for the testing of bulk samples in the ore-dressing laboratories of the Bureau of Mines, Ottawa.

The numbers used in the text to indicate the hardness of minerals are those of the Moh's scale, number 1 in which designates the hardness of the softest minerals, talc and graphite, 2 of gypsum, 3 calcite, 4 fluorite, 5 apatite, 6 feldspar, 7 quartz, 8 topaz, 9 corundum, and 10 of diamond. The finger nail has a hardness in this scale of about 2·5, and an average knife blade, which is usually softer than glass, a hardness of about 5·5.

Special attention has been given to marketable grades of ores, current prices, and buyers, and brief mention is made of world and Canadian positions. It should be noted that all tons referred to are short tons of 2,000 pounds unless otherwise stated.

Prospectors should bear in mind that exports from Canada of ores and concentrates of all of the minerals described are prohibited at the present time except under permit. Applications for such permits to export should be made to the Export Permit Branch, Department of Trade and Commerce, Ottawa.

It is hoped that the information presented in this booklet will aid the prospector to make discoveries which will be of material benefit not only to himself personally but to Canada in the present critical emergency when national freedom itself is at stake.

Prospectors are invited to forward suggestions for the practical improvement of the booklet from their standpoint to—

The Director,
Mines and Geology Branch,
Department of Mines and Resources,
OTTAWA.

CHROMIUM

Chromium is one of the principal alloying elements in a great variety of steels, chief of which, in amount of chromium used, are the highly important stainless and corrosion-resistant steels. The steel industry also consumes a large quantity of chromium ore in refractory bricks and furnace linings, and ore of chromium is also the source of the chromium chemicals used in the electroplating, dyeing, tanning, and paint industries.

Occurrence and Formation

The only economic ore of chromium is chromite (FeO, Cr_2O_3). Theoretically, it consists of 68 per cent chromic oxide (Cr_2O_3) and 32 per cent iron oxide (FeO), but it is never found in this state, because some of the iron and chromium is replaced by varying proportions of magnesium and aluminium. Commercial ores are relatively low in iron.

Chromite is invariably associated with ultrabasic igneous rocks, dunite, peridotites, and pyroxenites, and with the serpentines to which they alter. Scattered grains of the mineral occur everywhere throughout these rocks, the principal host rock being dunite, which is sometimes mistaken for chromite. It is a fine-grained, grey-black, iron-magnesian rock of a dull appearance and when scratched leaves a pale grey streak. The only other metallic mineral present is magnetite, which strongly resembles chromite but is easily distinguished by its magnetic quality and black streak.

Chromite ores fall into the following classes:

(a) Disseminated ores, in which individual grains of chromite are surrounded by serpentine. The size and concentration of the grains determine the richness of the ore. The disseminated ores may form long, narrow, parallel bands, separated from each other by similar bands of barren rock; or, less commonly, they may have lens-like shapes. In a few places, disseminated ores are accompanied by rounded nodules of practically solid chromite, ranging from about one-quarter inch to two inches in diameter. This is termed "grape ore," and constitutes a very small proportion of the orebodies.

(b) Massive ores—large nodules, plates, and short irregular vein-like masses of almost pure, solid chromite. These fill fault and joint fissures in zones of fracturing and faulting. The chief impurity is serpentine, which may be present in small quantity between the grains, or may traverse the massive ore in threads or veinlets.

Areas of interest to the prospector are the serpentine areas throughout the Dominion, especially those of the Eastern Townships, Quebec, and of south central British Columbia, in the latter of which chromite is sometimes associated with the platinum of the Tulameen district.

Identification

Chromite has the following physical characteristics:

Hardness—5·5
Specific gravity—4·3 to 4·6
Colour—Black and brownish black
Streak—Greyish brown to dark brown
Lustre—Submetallic to metallic, opaque
Tenacity—Brittle

Chromite may be distinguished in the field from other similar-looking heavy minerals by its comparative softness and the fact that when scratched with a knife or the edge of a hammer it leaves a pale chocolate-brown streak. The finely powdered mineral is also brown.

Chromite is not magnetic, which distinguishes it from the highly magnetic, hard, black magnetite which it resembles. It may be so intimately mixed with particles of magnetite, however, that a specimen of it is slightly

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magnetic, but when the specimen is pulverized the magnetite can be withdrawn with the aid of a hand magnet.

Marketable Grades and Specifications

For steel making, chromite must be converted to ferrochromium and the ore must contain not less than 48 per cent Cr_2O_3 and as little iron as possible. The amount of chromium, computed as metal, should be at least three times that of the iron though some users are accepting a slightly lower ratio (2·7 to 1) because of the present emergency. The maximum allowance for sulphur is 0·50 per cent and for phosphorus 0·20 per cent. Although, ordinarily, lump ore is preferred, fines or concentrates are now used in quantity. For some high carbon steels, ores with a Cr_2O_3 content as low as 42 to 45 per cent are employed provided that only a small amount of iron is present.

The specifications for chromite used in refractory bricks vary to some extent, depending in part upon the types of brick to be made. One Canadian manufacturer places a limit of 20 per cent on the iron oxide content, 18 per cent on the alumina (Al_2O_3), and 4 per cent on the silica (SiO_2). The silica should be as low as possible, since it usually occurs in the ore not as free silica but as serpentine, which has a comparatively low melting point.

It is very important that the chromite be present in an evenly and finely distributed form, not as coarse grains mixed with blobs of the silicate. The ore should also be hard and lumpy, none of it passing a 12-mesh screen. If the above specifications as regards impurities are fulfilled, the Cr_2O_3 content should be between 40 and 45 per cent.

Concentrates

Concentration, when required, can be effected by ordinary gravity methods, as most Canadian chromites are relatively free from heavy sulphides. High iron or magnetite chromites must undergo a preliminary roasting or straight magnetic separation. At present prices, it is doubtful whether an ore with less than 10 per cent Cr_2O_3 can be profitably treated.

Buyers

The principal Canadian buyers of chromite for metallurgical use are:

Chromium Mining and Smelting Corporation, Limited, 700 Bank of Commerce Building, Toronto, Ontario.

Electro Metallurgical Company of Canada, Limited, Welland, Ontario.

The leading steel companies buy much smaller amounts. They are:

Steel Company of Canada, Limited, Hamilton, Ontario.

Algoma Steel Corporation, Limited, Sault Ste. Marie, Ontario.

Dominion Steel and Coal Corporation, Limited, Canada Cement Building, Montreal, Quebec.

Occasional small buyers include: Canadian Car and Foundry Company, Limited, Montreal, and Manitoba Rolling Mills Company, Limited, Winnipeg.

The only important purchaser of refractory ore is:

Canadian Refractories Limited, Canada Cement Building, Montreal, Quebec.

Prices

In December, 1939, United States prices per long ton, laid down in North Atlantic ports, were $26 to $28 for chromite containing 48 per cent Cr_2O_3. Prices on June 11, 1941, according to Engineering and Mining Journal

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were \$43 to \$45 for Indian and African metallurgical ore (48 per cent Cr_2O_3); Turkish concentrates (48 per cent Cr_2O_3) were not quoted. Lower grade ore (ordinary ore) was quoted at \$37 to \$39, and refractory ore (43 per cent to 45 per cent Cr_2O_3) at \$25 to \$26.

World Production and Canada's Position

In 1939, world output of chromite was 1,300,000 tons, the four principal producing countries being, in order, Russia, Turkey, South Africa, and Southern Rhodesia. Production in Canada has come almost entirely from the Eastern Townships of Quebec. In recent years the output has been insignificant, and has been far short of the present requirements.

FLUORSPAR

Fluorspar, the more common name for the mineral fluorite, is a commodity of the highest industrial and defence importance. Its value lies in its fluxing properties, which make it an essential material for the melting of ferrous and non-ferrous metals, more especially for the manufacture of basic open-hearth steel. Close to 70 per cent of the fluorspar produced in the United States in 1940 went to the steel industry. It also finds important uses in the ceramic (glass and enamels) trade; in the manufacture of hydrofluoric acid, which is used chiefly for making synthetic cryolite for the production of aluminium; in refrigerants of the "Freon" type; and for minor industrial purposes.

As far as North American requirements are concerned, the United States is virtually self-sufficient, with probably adequate domestic reserves to draw on for considerably increased requirements. Imports in 1940 were drawn chiefly from France, Newfoundland, and Mexico. Improved methods of concentration have recently stepped-up recovery and grade at a number of mines in the United States, notably those in the important Illinois-Kentucky field.

Occurrence and Formation

Fluorspar is a simple compound of calcium and fluorine (CaF_2), with 51·1 per cent calcium and 48·9 per cent fluorine. It is common as a gangue mineral in metalliferous veins and also often occurs as a minor accessory constituent of igneous rocks, notably granite, syenites, and pegmatites, and in contact metamorphic deposits associated with such rocks. Such accessory fluorspar is rarely of economic interest, though small amounts have occasionally been recovered.

Fluorspar is usually deposited at moderate or shallow depths from circulating hydrothermal solutions, probably derived from a deep-seated igneous source. Many of the world's principal deposits are veins in limestones or other sedimentary rocks. Usually the sediments have been extensively fractured and jointed, providing a series of solution-channels in which the fluorspar was deposited as more or less closely-spaced veins. Fracturing with deposition of vein fluorspar may extend down into underlying igneous rock, as in the Madoc district, Ontario, where a number of the veins have been followed into granite.

Fluorspar may thus be found in rocks of very varied character, and there are no definite rules to guide the prospector. Where a strong vein of fluorspar is discovered, however, it is most likely that it will not be a single, isolated deposit, but will point to the existence of a fairly widespread occurrence of the mineral in the area.

Minerals commonly associated with fluorspar are calcite, barite, and quartz, and many deposits contain sulphides such as galena and sphalerite. Usually, veins exhibit a banded structure, with alternating crusts of fluorspar and the associated calcite, barite, or quartz.

Identification

Fluorspar has the following characteristics:

Hardness—4

Specific gravity—3·18

Cleavage—Perfect octahedral

Lustre—Glassy, transparent or translucent

Crystallization—Isometric, usually in well-formed cubes, or in cubes modified by the octahedron.

Colour—Ranges from clear and colourless through varying shades of yellow, green, and purple.

Other Distinguishing Properties—Decrepitates violently on application of even moderate heat, and at higher temperatures shows in the dark a strong fluorescent glow, usually of a purple colour. Shows no effervescence with hydrochloric acid; and when powdered and heated with sulphuric acid gives off fumes of hydrofluoric acid which etch glass.

Marketable Grades and Specifications

A large proportion of the fluorspar can often be recovered by hand-picking and cobbing, but there will always be considerable intergrown material that requires milling and concentration to bring it up to marketable grade. Where only one of the usual gangue minerals is present, beneficiation presents little difficulty, but where, as in the case of the Madoc ores, fluorspar-calcite-barite intergrowths are dominant, clean separation, combined with satisfactory recovery, has so far proved almost impossible of attainment by gravity methods. Flotation may yield better results on such mixtures, but has not proved particularly successful; and for metallurgical use the concentrate requires to be sintered or briquetted into lump form, since fine, powdery fluorspar is not acceptable to the trade.

Of the minerals commonly associated with fluorspar, barite and metallic sulphides are the most objectionable to practically all the consuming industries, and the content of these must be reduced to a minimum. Calcite and quartz are not directly detrimental in metallurgical grades, but for other uses they lower the percentage of fluorine and thus involve price penalties. Proper attention to picking and cobbing usually can ensure a certain tonnage that will meet market specifications for the three standard grades noted below, since most commercial deposits carry a considerable proportion of spar clean enough to ship with such preparation. Lower-grade fluorspar-calcite-quartz intergrowths, down perhaps to 65 to 75 per cent calcium fluoride content, may be marketable to certain branches of the steel industry at corresponding price reductions, or may be concentrated, depending on the current available supply and the individual economic factors involved. Usually, each productive field has its own individual and fairly uniform type of ore, which requires specific study of its ore-dressing and economic problems.

Although certain consumers have their own individual specifications, most of the production is marketed in three standard grades, these, in order of descending quality, being:

Acid grade—Minimum CaF_2 content 98 per cent, maximum silica content one per cent; sold in lump, gravel, and ground form. Used in making hydrofluoric acid.

Ceramic grade—Minimum CaF_2 content 95 per cent, maximum silica content 3 per cent, maximum iron (Fe_2O_3) content 0·12 per cent; sold in ground form only, coarse, fine, and extra fine. Used as a batch fluxing ingredient in glass and enamels.

Metallurgical grade—Minimum CaF_2 content 85 per cent, maximum silica content 5 per cent; sold as washed or screened gravel or crude lump, preferably under one inch in size and with not more than 15 per cent of fines. Used as a flux mainly in making basic open-hearth steel, but also in foundries and in the melting of various ferrous and non-ferrous metals and alloys.

Buyers

The following firms are the principal Canadian consumers of metallurgical grades of fluorspar:

Steel Company of Canada, Limited, Hamilton, Ontario.

Dominion Steel and Coal Corporation, Limited, Sydney, Nova Scotia.

Dominion Foundries and Steel, Limited, Hamilton, Ontario.

Canadian Car and Foundry Company, Limited, Montreal, Quebec.

Outlets for higher-quality, ceramic grade material exist with the undermentioned concerns:

Ferro Enamels (Canada), Limited, 629 Wellington Street, Ottawa, Ontario.

Dominion Glass Company, Limited, 1111 Beaver Hall Hill, Montreal, Quebec.

North American Cyanamid, Limited, Niagara Falls, Ontario.

Acid grade fluorspar is in demand chiefly by:

Aluminum Company of Canada, Limited, 1000 Dominion Square Building, Montreal, Quebec.

Prices

Prices in June, 1941, as quoted in American trade journals, are as below, all f.o.b. Kentucky-Illinois mines:

Acid grade	$27 per ton
Ceramic grade	32 " "
Metallurgical grade	20 " "

Colorado fluorspar, 82 per cent grade, is quoted at $13.50 per ton, f.o.b. mines.

World Production

The total world production of fluorspar of all grades in 1938 (the last year for which fairly complete figures are available) was 458,000 tons, and in 1937 was 569,000 tons. About twenty countries contributed to the total, but 90 per cent of the output has come from five sources: United States (32 per cent), Germany (29 per cent), Russia (13 per cent), United Kingdom (9 per cent), and France (7 per cent).

Canada's Position

Canadian requirements for the domestic steel trade and for use in other industries have been mostly imported in recent years, mainly from the United States, Newfoundland, France, and the United Kingdom. A small tonnage has been secured from the Madoc area, Ontario, the only producing field, and renewed activity there in 1940 resulted in considerably increased shipments. Most of this, however, ran considerably under standard market grade. At present, Newfoundland, the output from which has been steadily increasing and is capable of sustained expansion, is regarded as the principal future source of supply.

Aside from the Madoc area, no important occurrences of fluorspar are known in Eastern Canada. The only other deposit of major interest in Canada is the long-idle Rock Candy mine, near Grand Forks, British Columbia. High freight charges from this property to eastern consuming centres are a serious obstacle as long as Newfoundland material is available.

Prospecting attention in Eastern Canada should be given to any occurrence of the mineral in metalliferous deposits where it is present as a major gangue constituent, with the idea of recovering it as a by-product of milling operations.

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GRAPHITE

Graphite is used chiefly in the manufacture of crucibles used in the melting of steel and non-ferrous metals and alloys; in foundry facings; for lubricants and paints; and in commutator brushes, electrodes, dry batteries, and pencils. The poorer grades of amorphous graphite are used in paints, stove polishes, etc., while the richer grades are used extensively in dry batteries, commutator brushes, foundry faces, and in crucibles. For certain purposes, artificial graphite made in the electric furnace competes with the natural product.

Occurrence and Formation

Natural graphite occurs in crystalline (plumbago), flake, and amorphous forms. All three varieties are actually crystalline, but the term amorphous has come into use to describe graphite of very fine particle size.

Plumbago occurs as vein-like deposits of comparatively pure, dense, and very coarsely crystalline material. The crystals are usually thick wedge-shaped plates, and less frequently, long needles, or fibres, resembling coarse asbestos. Veins of plumbago are rather common in western Quebec, particularly in the Buckingham and Grenville districts, Papineau and Argenteuil Counties. They are seldom more than 2 to 4 inches wide and thus are of doubtful economic importance, though in the Grenville area considerable plumbago was obtained several years ago from localized shoots or pockets associated with flake material. Such veins or shoots are found mostly in crystalline limestones of the Grenville series, particularly where these have undergone intensive local metamorphism or are cut or intruded by igneous rocks.

Flake graphite occurs in the form of small disseminated flakes or plates, usually either in gneiss or crystalline limestone of the Grenville series. In limestones, the flakes are usually larger and thinner than those of the gneissic formations and often have a well-developed hexagonal crystal form. As a rule, graphite-rich zones in limestone tend to follow a somewhat definite banding in the rock, which may be related to structure or to some nearby intrusive. The graphite content is usually much lower than that of the graphite gneisses and seldom exceeds 8 per cent. There are exceptions, however, as in the case of some of the deposits in Argenteuil County, Quebec, where very rich vein-like flake bodies occur in limestone.

In the graphitic gneisses the flakes are commonly thicker and heavier than in limestone, are more densely intergrown, and show little if any crystal form. At times the flake has an elongated needle form. The graphite content varies, but is uniformly higher than that of the limestone area, usually ranging in the richer sections of the older worked deposits from 10 to 22 per cent. The bodies are seldom very wide or long, being usually localized short lenses or a series of overlapping lenses with individual widths of from 5 to 12 feet.

Amorphous graphite usually occurs as bedded deposits in formations younger than the Precambrian and has generally been formed by partial metamorphism of original carbonaceous shales or coal seams. The material is black, soft, and earthy and the graphite particles are of microscopic size. Amorphous ores vary widely in their carbon content, and commercial deposits range from low-grade material with 35 to 50 per cent carbon to the rich Mexican type which contains 80 to 90 per cent carbon.

Identification

Graphite has the following properties:

Hardness—1 to 2
Specific gravity—2·10
Colour—Iron black to dark steel grey.
Lustre—Metallic, sometimes dull, earthy.
Streak—Black.

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The mineral is readily distinguishable from almost all other minerals by its softness, colour, streak, and high greasy slip. The only other mineral with which it is likely to be confused is molybdenite, which often occurs in similar associations. Molybdenite, however, gives a characteristic olive-green streak when rubbed on glazed porcelain and it has a more bluish lead-grey colour and higher metallic lustre. Amorphous graphite is not so readily distinguishable from ordinary natural carbon such as often occurs in ancient sediments, and laboratory methods are required to definitely determine its nature.

Marketable Grades and Specifications

Coarsely crystalline plumbago is usually sufficiently pure to be sold in the crude mine-run state, or with a minimum of cobbing and hand-picking. Such material will generally grade well over 90 per cent carbon and finds a ready market with the foundry-facing mills equipped to grind it for blending into their several products.

Both the limestone and gneiss types of flake graphite require concentrating to at least a 65 per cent carbon content, and preferably higher. This requires the erection of a mill, the cost of which may be roughly estimated at $1,000 per ton of ore treated daily. Crushing, grinding, classification, and flotation, followed by drying, re-grinding, and screening of the finished product is the general method of treatment. Close laboratory control of products is essential since graphite is sold on the basis of its carbon content. Market specifications vary with the different consuming industries, but products containing 75 per cent and upwards of carbon are generally required. With the use of modern methods of concentration there appears to be a reasonably good chance for the successful development of flake deposits for use in the domestic foundry trade and, perhaps, in other industries.

Owing to the fine state of division of the graphite and associated clayey impurities, it is usually not practicable to beneficiate amorphous graphite ores, and the material is ground and used in the natural state.

Except for the crucible trade, where size of flake is an important consideration, prepared graphite is sold on the basis of carbon content and freedom from objectionable impurities. Certain trades, such as the paint, battery, and pencil manufacturers, prefer the amorphous type; crucible makers may use both flake and crystalline plumbago, while foundries also employ both of these forms. In an emergency, probably many consumers would waive their preference and utilize flake material provided it were of suitable grade, though this might involve some change in plant practice.

Buyers

No crucibles are manufactured in Canada and thus there are no important outlets in this country for the higher priced grades of large flake graphite The dry battery trade, which is one of the largest users of graphite, employs mainly Mexican high-grade amorphous material as well as some artificial graphite. The paint industry uses considerable lower-grade amorphous graphite and possibly also some fine flake and dust. Thus the foundry trade is the most important single domestic outlet for general flake and plumbago grades and it is this industry that will suffer most from any shortage of supplies.

The most logical channels for disposal of finished products are the established importer—supply and jobber houses whose names are available in trade directories. A direct market might be found, however, with the foundry-facing trade, the most important producers of which are:

Canadian Foundry Supplies and Equipment, Limited,
4295 Richelieu Street, Montreal.

Hamilton Facing Mill Company, Limited, Hess Street North, Hamilton, Ont.

F. B. Stevens of Canada, Windsor, Ontario.

Other larger individual buyers of graphite are:

General Dry Batteries of Canada, Limited, 228 St. Helen's Avenue, Toronto.

Canadian National Carbon Company, Canada Life Building, Toronto.

Burgess Battery Company, 399 Buttrey St., Niagara Falls, Ontario.

Canadian Talc and Steel Products, Limited, 5765 Hamilton Street, Montreal.

Standard Sanitary and Dominion Radiator, Limited, Royce and Lansdowne Avenue, Toronto.

Aluminum Company of Canada, Limited, 1700 Sun Life Building, Montreal.

Electric Reduction Company of Canada, Limited, Buckingham, Quebec.

Sultana Limited, 1000 Amherst Street, Montreal.

Sherwin-Williams Company, 2875 Centre Street, Montreal.

Brandram-Henderson Limited, 6684 St. Urbain Street, Montreal.

Canadian Raybestos Company, 280 Perry Street, Peterborough, Ontario.

Imperial Oil Limited, 56 Church Street, Toronto.

Canadian Industries Limited, Beaver Hall Hill, Montreal.

Prices

Prices vary with type and grade and those given below afford an idea of the range. They are taken from American trade journals of June, 1941, and are all f.o.b. New York, in American funds:

Ceylon plumbago, lump	8 to 10	cents per pound
" carbon, lump	7 to 8	" "
" chip	6 to 7	" "
" dust	3 to 4	" "

Madagascar,	No. 1 flake......	9 to 16 cents per pound
"	No. 2 flake......	7 " "
"	No. 3 flake (55 to 70 per cent carbon)	3 " "
Mexican amorphous, crude......		$12 to $23 per ton.

World Production

The annual world production of natural graphite in recent years has averaged about 140,000 tons. Germany, Austria, Czechoslovakia, and Madagascar are the leading sources of flake graphite; Ceylon, of crystalline; and Mexico and Korea, of the amorphous variety. Although the United States possesses large reserves of graphite, principally of flake type, the mineral ordinarily can be imported more cheaply than it can be mined and most of the American requirements have come chiefly from Madagascar, Ceylon, and Mexico.

Canada's Position

A part of Canada's requirements of foundry and lubricating grades is obtained from the Black Donald Graphite Company's mine near Calabogie, Renfrew County, Ontario, and the remainder is imported chiefly from the United States, Ceylon, Madagascar, and Mexico. Graphite is widely distributed in the Archæan rocks of western Quebec and eastern Ontario, but with the exception of the Black Donald mine, at present the only Canadian producer, the properties have long been idle.

Any substantial reduction of imports from Madagascar owing to cargo restriction would be of particular concern to the foundry trade, and accordingly it is desirable that new sources of supply be found in Canada.

MANGANESE

Of the world output of manganese ore about 90 per cent is consumed in the production of ferromanganese and spiegeleisen for use in the manufacture of steel and special manganese steels. On this continent about 14 pounds of manganese metal is required, on the average, for every ton of steel produced. The manganese ore consumed in this way is classed as metallurgical, and the remainder, which is used mostly for dry batteries, as chemical.

Occurrence and Formation

The most important, economically, of the numerous ores of manganese are the black oxides, chief of which from the Canadian standpoint is pyrolusite, then psilomelane and manganite.

Most commercial deposits are a mixture of all three minerals, together with varying amounts of sand or clay, iron oxide, and barite.

Wad or bog manganese is an amorphous, earthy substance formed by precipitation from surface waters passing through rocks containing manganese. It commonly occurs as basin-shaped deposits a few feet deep or as small benches on gently sloping hillsides. The consolidated lumps occurring in the loose bog manganese are termed wad. There are very many of these bog deposits in Canada, particularly in the Maritime Provinces and, to less extent, in British Columbia and Manitoba. The great majority, however, are low and very variable in grade.

Manganese minerals are found in Canada in limestone of Carboniferous age, in red shale, conglomerate, granite, and sandstone. The commonest occurrences are of the replacement type in limestone. They generally consist of irregular deposits of manganese oxide that follow the bedding of the limestone and often branch into pipes and veins. Overlying many of these deposits is a residual clay up to 20 feet in depth in which occur nodules and larger masses of the manganese ore. Illustrating this type are the Markhamville deposits in Kings County, New Brunswick.

Less common occurrences consist of lenticular veins in faults and fissures in biotite granite, such as occur at New Ross, Lunenburg County, Nova Scotia; veins and stringers in joints and shear zones in buff-coloured granite and felsite, as are now being worked at Gowland Mountain in Albert County, New Brunswick; and veins in joints and bedding planes of red brecciated sandstone as seen near Truro, Colchester County, Nova Scotia. In the Magdalen Islands, certain areas of limestone and grey sandstone, which underlie the recent covering of red sandstone, contain manganese minerals, the best ore occurring as nodules and bodies in the limestone, just below its contact with the red sandstone.

The most favourable areas for the prospector are the Maritime Provinces and the Magdalen Islands. A few scattered deposits occur in British Columbia and some bog deposits are known in Manitoba.

Identification

Pyrolusite

Pyrolusite (oxide of manganese) has when pure a content of 63·2 per cent of manganese. It is distinguished from the other black manganese minerals by its softness. An important feature is that it blackens the fingers very readily. It has the following physical characteristics:

Hardness—About 2
Specific gravity—4·8
Colour—Black to blackish grey.
Streak—Black.
Lustre—Metallic to dull, opaque.
Tenacity—Rather brittle.

It is frequently composed of short indistinct needle-shaped crystals, but is also found in massive, compact, or fibrous, columnar forms.

Psilomelane

Psilomelane (an impure hydrous oxide of manganese) has from 45 to 60 per cent of manganese. It is distinguished from both pyrolusite and manganite largely by its earthy form. It is smooth and massive with no crystalline structure, and not infrequently occurs in the form of a bunch of grapes or depending columns. It has the following physical characteristics:

Hardness—5 to 6

Specific gravity—3·7 to 4·7

Colour—Black to greyish black.

Streak—Brownish black.

Lustre—Earthy, submetallic to dull, opaque.

Tenacity—Brittle.

Manganite

Manganite (a hydrous oxide of manganese) has a theoretical content of 62·4 per cent of manganese. It is harder than pyrolusite but softer than psilomelane and occurs usually in long prismatic crystals, which are often grouped in bundles. It has the following physical characteristics:

Hardness—4·0

Specific gravity—4·3

Colour—Dark grey to iron black.

Streak—Dark reddish brown.

Lustre—Submetallic, opaque.

Tenacity—Brittle.

Bog Manganese

Bog manganese, when pure, is black, like powdered pyrolusite, but usually is a red-brown to reddish black, depending on the amount of iron present and the degree of contamination by soil or peaty matter. It is earthy, soft, and loose, but sometimes hard and compact. It commonly soils the fingers. Other physical characteristics are:

Hardness—0·5 to 6

Specific gravity—3 to 4·26

Streak—Brown.

Lustre—Dull, opaque.

Manganese Minerals Generally

As black heavy nodules and lumps in the surface soil are common above many known deposits of manganese minerals their presence in the overburden points to the possibility of orebodies below. Such lumps are often ploughed up by farmers, and should be sent for identification to the provincial Department of Mines or to the Bureau of Geology and Topography, Ottawa.

Grades and Specifications

The prime metallurgical grade of manganese ore is known as "ferrograde" since it is used for making ferromanganese, the form in which manganese is customarily added in steel manufacture. Specifications call for a minimum of 48 per cent metallic manganese and maxima of 7·0 per cent iron (the manganese content should be not less than seven times that of the iron), 8·0 per cent silica, 0·15 per cent phosphorus, 6·0 per cent alumina, and 1·0 per cent zinc. In addition, the content of copper, lead, and barium should each be quite low. The ore should be in hard lumps less than 4 inches across, and not more than 12 per cent should pass a 20-mesh screen. "Soft" ores like bog manganese are objectionable.

Ore of chemical grade must be an oxide ore containing not less than 80 per cent manganese dioxide and not more than 1·5 per cent iron, 1·0 per cent alumina, 6·0 per cent silica, 0·02 per cent copper, and 1·0 per cent moisture. Other metals should not be present in amounts exceeding 0·05 per cent. The ore should be finely ground (85 per cent to 90 per cent should pass a 200-mesh screen). Some users, however, purchase the unground ore as they are equipped to do their own grinding. Pyrolusite is the ore used because of its high content of oxygen, which is essential for many of the chemical purposes to which manganese compounds are applied.

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As regards treating low-grade manganese ores to obtain concentrates that will meet industry's requirements, a degree of economic success in this direction has only recently been achieved, and some plants in the United States are now concentrating such ores by chemical and by electrolytic methods. The application of ordinary wet gravity methods to certain types of ore has also met with success, as has been demonstrated by the work of the Ore Testing Laboratories of the Department of Mines and Resources, Ottawa.

Buyers

The Canadian market for metallurgical ore is mainly confined to two manufacturers of manganese ferro-alloys:

Electro Metallurgical Co. of Canada, Ltd., Welland, Ont.

Canadian Furnace Co., Ltd., Port Colborne, Ont.

About 3,000 tons of chemical grade ore is consumed annually in Canada, the bulk of it in dry batteries made by the following manufacturers:

General Dry Batteries of Canada, Limited, 228 St. Helen's Avenue, Toronto, Ont.

Burgess Battery Company, Niagara Falls, Ont.

Canadian National Carbon Company, Ltd., 805 Davenport Road, Toronto, Ont.

Prices and Other Economic Considerations

Prices of ferrograde ore depend on manganese content and the amount of harmful impurities. Imported ore is usually quoted in cents per long-ton unit, i.e. in cents per 22·4 pounds (= 1 per cent of a long ton) of contained manganese.

United States quotations on June 18, 1941, on imported manganese ore (ferrograde) ranged from 70 cents to 80 cents per long-ton unit (equivalent to $33.60 to

$38.40 per long ton of ore containing 48 per cent manganese), c.i.f.* Atlantic ports, exclusive of duty.

Prices of manganese ores of chemical grade (battery-grade ores) about that date were $55 per ton for Brazilian or Cuban ores (80 per cent minimum content of MnO_2) in carloads, f.o.b. New York, exclusive of duty. The delivered price in Canadian currency for finely ground chemical-grade ore imported into Canada was about $65 to $70 a ton, and for unground, in lumps, about $50 a ton.

Although the actual manganese content is about the same as that of the best ferrograde ore, the price of chemical-grade ore is much greater, largely because of the special packing its softness necessitates, its high available oxygen, very low iron content, and freedom from moisture.

Imports from Canada into the United States of manganese ores containing 10 per cent or more of manganese are subject to a duty of one-half of a cent per pound of contained manganese.

World Production and Canada's Position

In 1938, world output of manganese ore was not far short of 6,000,000 tons, U.S.S.R. being by far the largest producer, followed, in order of importance as major producers, by India, Union of South Africa, Gold Coast, Brazil, and Cuba.

The United States produced in 1940 about 45,000 tons, but this was only about 7 per cent of her consumption. Canada's production is negligible relative to her requirements, and as her imports normally are mainly from Gold Coast, the present need of searching for new Canadian deposits and reopening some of those previously worked cannot be over-emphasized.

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* *Cost, insurance, and freight.*

MERCURY

Mercury (quicksilver) and its salts are indispensable in both peace and war. Many peace-time uses fill also war needs, as in the case of medical supplies, electrical equipment (automatic devices, radio, etc.), and fulminate (for special types of detonators). A great amount is now being used in the United States in the form of mercuric oxide (HgO), in antifouling paints for ship bottoms.

The leading sources of the world's supply of mercury have always been Spain and Italy, from which England can no longer obtain the quantity required. Prior to 1940 Canada produced a negligible amount, but has since developed a deposit which is to-day yielding far in excess of her domestic consumption. But England's needs are great, and since she is now very largely dependent upon United States and Canada for her supplies the search for other Canadian deposits is of paramount importance both to obtain an adequate quantity and to save foreign exchange.

Occurrence and Formation

The principal ore of mercury is cinnabar, a scarlet mercuric sulphide (HgS), accompanied in places by native mercury. Other ores, which are secondary or oxidation products, are rare and of little economic importance. They sometimes occur with cinnabar in small amounts, especially the black secondary sulphide, metacinnabarite.

Cinnabar is found in a great variety of rocks. It is not of sedimentary origin, but always associated with some evidence of igneous activity and found near the surface that existed at the time of its deposition. The containing rocks are fractured or porous, the largest and best deposits of cinnabar being those in which the mineral solutions have been trapped and preserved under a capping of impervious rock, such as lava, shale, or clay.

In Canada all known deposits of cinnabar are in British Columbia. Besides the property at Pinchi Lake in the north-central part of the province where a substantial production is now being maintained, cinnabar is known to occur on both sides of Kamloops Lake, in the Yalakom and Bridge River areas due west of there, and at Sechart on the west coast of Vancouver Island.

Host rocks for the mineral include altered and carbonated limestone (ankerite), volcanic breccias, and green and purple andesitic lavas, especially if they have been subjected to shearing and fracturing. The ore occurs as discontinuous stringers, small grains, or scattered blobs, often in veins or stringers of dolomite or calcite. Orebodies are generally irregular and indefinite though usually confined to faulted or sheared zones.

Stibnite (antimony sulphide), a grey-black, shiny, very brittle mineral is found rather commonly with cinnabar; less common are pyrite and realgar, the orange-red sulphide of arsenic.

Identification

Cinnabar, when pure, has the composition HgS and contains 86·2 per cent mercury and 13·8 per cent sulphur. It has the following physical characteristics:

Hardness—2·0 to 2·5

Specific gravity—8 to 8·2

Colour—Scarlet, brownish-red, rarely blackish.

Streak—Scarlet or vermilion.

Lustre—Bright, somewhat "oily" appearance, dull when scattered through rock or in powdery masses.

Tenacity—Brittle to sectile (i.e. severable by knife with smooth cut, yet pulverizable).

When cinnabar occurs in white or buff-coloured rocks, the bright red colour and softness are means of identification, the solid mineral being often a blackish red and thin films of it sometimes assuming a fern-like appearance. Smears or stringers of red-brown hematite iron might be mistaken for cinnabar, but a comparison of the two minerals will quickly settle any doubt. A fairly reliable method of identification consists in pulverizing and panning a piece of rock containing the suspected mineral, when the cinnabar, if present, will appear as bright red specks at the point of the tail.

When it is carefully heated in an open tube, fumes of burning sulphur are given off and metallic mercury condenses in minute globules on the cold walls of the tube.

Marketable Grades and Treatment

In the United States the grade of ore of the principal producing deposits averages slightly under 0·5 per cent (a number with 0·35 per cent ore are being profitably operated), which is about the economic limit for any small producer in Canada at prevailing prices for mercury.

Hand-cobbing is profitable if the ore is concentrated in small veins and not distributed throughout the rock. Owing to its brittleness, with consequent loss of fines, and its usually erratic occurrence, accurate sampling is difficult except in evenly disseminated deposits. A close check can be obtained, however, by panning numerous samples from the rock faces. Minute globules of mercury should also be looked for in the tail of the pannings.

As cinnabar generally occurs close to the present surface of erosion, open-pit methods of mining are common. Provision should always be made to save the fines.

The extraction of mercury is generally effected by roasting the coarsely crushed ore in furnaces that are usually of the rotary-kiln type through which air is circulated. The sulphur escapes as sulphur dioxide and the mercury is driven off as vapour, which is condensed to the liquid metal in cooling-chambers.

A prospector who wishes to treat specially high-grade ore during the initial stages of developing his property might find it sufficiently remunerative to roast the ore in a circular or D-shaped horizontal cast-iron retort and collect the escaping mercury vapour in a water-cooled pipe whose end dips into a bucket of water. The interior of the retort must not come in contact with flame or air. A little lime should be added especially if any pyrite is present in the ore, in order to convert the sulphur into calcium sulphide.

Retorts made of fire-clay in place of cast iron may be used but if stibnite (antimony trisulphide) is present it may cause trouble owing to its tendency to fuse through the retort walls.

Buyers

The principal Canadian buyers of mercury are manufacturers of heavy chemicals, e.g.:

Shawinigan Chemicals, Ltd., P.O. Box 6072, Montreal, Que.

Canadian Industries, Ltd., 1135 Beaver Hall Hill, Montreal, Que.

Other buyers are drug and medicinal manufacturers, e.g.:

Merck & Co., Ltd., 560 Decourcelles St., Montreal, Que.

N. C. Polson & Co., Ltd., 649-651 Notre Dame St. W., Montreal, Que.

Mallinckrodt Chemical Works, Ltd., 378 St. Paul St. W., Montreal, Que.

A fair quantity of mercury, in the aggregate, is consumed by gold-mining companies that employ the amalgamation method of treating ore, and by the following manufacturers, among others, of electrical equipment:

Canadian General Electric Co., Ltd., 212 King St. W., Toronto, Ont.

Canadian Westinghouse Co., Ltd., Hamilton, Ont.

English Electric Co. of Canada, Ltd., St. Catharines, Ont.

Northern Electric Co., Ltd., 1261 Shearer St., Montreal, Que.

Prices and Other Economic Considerations

New York prices of mercury just prior to the war were about $75 per flask (76 lbs.); prices, June 11, 1941, were $184 to $186. The Canadian price is about $235, which is the same as the U.S. price with exchange and sales and war taxes added. Any Canadian imports into United States would be subject to a tariff of 25 cents per pound, or $19 per flask, in U.S. currency.

Speaking somewhat generally it should be possible under favourable conditions to make a profit mining, on a fair scale, a deposit grading even lower than 0·25 per cent mercury, whenever the United States price for the metal is $180 per flask of 76 pounds.

World Production and Canada's Position

Estimated world production of mercury in 1939 was 132,000 flasks of 76 pounds, equivalent to slightly over 5,000 tons. Spain, Italy, and United States are the chief producing countries. The output of United States in 1940 was 36,300 flasks, or nearly 1,400 tons, a record for many years and double that of 1939.

Canada's production, as has already been stated, was insignificant prior to 1940, but since June of that year, when the mine at Pinchi Lake in British Columbia came into production, it has reached a point where it is several times that of her consumption, permitting, therefore, of exports. In view, however, of the British Empire's growing requirements, the search for new deposits from which to increase the output of mercury from Canadian sources is a matter of both military and economic importance.

MICA

Mica is of essential importance as an electrical insulator. No satisfactory substitute has yet been found for it, and without it the electrical industry, including the generation of power, would be at a standstill.

Electrical mica is of two types, muscovite (often termed white mica) and phlogopite (amber mica). Muscovite is by far the more common, being practically world-wide in its distribution, and many countries produce it. Phlogopite is much rarer, and the world supply is derived mainly from Canada and Madagascar, in probably about equal proportions. No war shortage of muscovite is anticipated and Empire and American requirements can probably continue to be filled by supplies from India and Brazil, two of the leading producers. For this reason, Canada is not vitally concerned in attempting to step-up its small output. With phlogopite the situation is different, as Madagascar shipments have been seriously curtailed and the electrical trade is faced with an imminent shortage of supply. Accordingly, every effort is required to step-up Canadian production of phlogopite in order to make good the deficiency, particularly of grades suitable for airplane sparkplug parts for which muscovite is not suitable. Although practically all phlogopite can be employed for general electrical purposes, only the finer quality of hard, heat-resistant material can meet the requirements of sparkplug manufacturers, and such mica is produced at present from only a few properties. Laboratory tests are required to determine the suitability of phlogopite for sparkplug use; the Bureau of Mines, Ottawa, is prepared to receive samples for such testing and to advise on the quality.

Occurrence and Formation

Muscovite

Muscovite is always found in granite pegmatite dykes, which are widely distributed throughout the Archæan rocks of Canada, from coast to coast. Only rarely has it been found, however, that the quantity and quality of the muscovite of such dykes are such as to offer any possibility of commercial development. Small amounts have occasionally been recovered as a by-product of feldspar mining from pegmatites. A very superior quality of reddish-coloured muscovite (so-called ruby mica) has recently been found, and is now being produced on a small scale in the Saguenay district of Quebec, and this region seems worthy of prospecting.

Phlogopite

The occurrence of phlogopite mica in Canada is confined to certain areas of pyroxenite, a greyish-green and generally coarse-textured basic rock that is quite extensively developed in the Precambrian complex of adjacent portions of western Quebec and eastern Ontario along a line running from Kingston on Lake Ontario to Ottawa and thence northward through Papineau and Labelle Counties in Quebec. Phlogopite is also found in smaller areas of pyroxenite occurring as outliers beyond the main productive region, as far west as the Bancroft-Wilberforce section in Ontario and Pontiac, Argenteuil, and Joliette Counties in Quebec. An isolated occurrence is also known as far east as Quebec City.

The phlogopite is found usually in irregular shoots or erratic, veinlike bodies in the parent pyroxenite, which in turn forms irregular masses, sometimes approximating to dyke form, in the enclosing gneisses or crystalline limestones, the dominant rocks of the region. The mica may occur as scattered crystals or intergrown masses of crystals in bodies of calcite or apatite filling chimney-like cavities in the pyroxenite. In other deposits it tends to occur in more regular form, following more or less definite contacts between pyroxenite and the enclosing gneiss or limestone, and crystals are also often found scattered irregularly through the pyroxenite rock itself. Each occurrence has its own peculiarities.

Many mica bodies have suffered severely from local crushing caused by rock movement, with the result that a large proportion of the crystals may be so broken or creased as to yield only a small amount of sound, merchantable sheet, leaving the remainder as scrap salable only for grinding into mica powder for roofing and other purposes. Even the best deposit may carry sections that yield very little sound mica, and a proportion of 20 to 30 per cent of merchantable sheets out of the total rough mica mined may be considered a high average yield.

Marketable Grades and Specifications

Except in special circumstances, where mine-run mica is of unusually high quality and contains a minimum of waste, it requires to be given at least some preliminary preparation before it can be sold. Formerly, a considerable amount of phlogopite was marketed in the so-called "rough-cobbed" form, which means that the crystals, or "books," are simply rifted or split into thicknesses of about one-eighth of an inch and have adhering rock and rough edge-waste knocked off by a hammer. In recent years relatively little mica has been sold in this form and the primary producer now generally carries preparation to at least the "thumb-trimmed" stage where the crystals are split by hand-knife into sheets one-sixteenth of an inch or less in thickness and most of the broken and otherwise imperfect material removed by similar means. Thumb-trimmed mica, however, still usually contains 25 per cent or more of waste, which must be cut away before the material is acceptable. This final trimming is termed "knife-trimmed," and may be done either by hand-knife, using a bevel or bias cut (so-called "sickle trimming"), hand-operated guillotine knife, or a special type of power-driven knife. Only the smaller trade sizes, up to 2 by 3 inches, are usually trimmed by guillotine or power-knife.

When carried to the knife-trimmed stage, mica is usually termed "block," and a large proportion of the output is marketed in this form. Much of the smaller-sized material, however, and mainly the 1-inch by 1-inch and 1-inch by 2-inch sizes are converted into so-called "splittings," used in the manufacture of built-up mica plate, or "micanite." Splittings are thin films, only one-thousandth of an inch thick, that are made by hand. Considerable skill and practice are required in the work, which is usually performed by girls, and much of the production is done on a piece-work basis in the operators' own homes or in small local shops in the villages of the productive mica territory. Splitting is a slow, laborious operation, and it is difficult even for an expert worker to turn out more than one pound an hour of finished material.

The marketing of mica in the finished trimmed form is a highly specialized business and the small mine operator would be better advised to sell his output in the semi-finished, rough-trimmed, or even final knife-trimmed, form to a regular mica dealer, who knows the market situation, size requirements, and specifications. Sometimes he can find a small buyer in a village or small town in his district who purchases rough or semi-trimmed material, gives it further preparation, and then disposes of accumulated stock to one of the larger established dealers. Alternatively, the producer can sell direct to one of the latter concerns, and, provided that the mica is of satisfactory quality, he can usually be assured of a market.

Buyers

The following firms are purchasers of, and dealers in, both mine-run and semi-finished sheet mica of all kinds for the electrical insulation trade. Persons having small lots of rough or trimmed mica to sell are advised to submit representative samples to any or all of these firms, who will then advise on the quality of the material and quote the price they are prepared to offer for the various standard sizes of sheet:

Mica Company of Canada, Lois Street, Hull, Quebec.

W. C. Cross, 209 Bridge Street, Hull, Quebec.

Blackburn Brothers, Blackburn Building, Ottawa, Ontario.

Prices

Mica prices are difficult to determine owing to the lack of reliable market quotations and to the prevailing system of trade discounts. Quality has such a bearing on value that the only satisfactory method of getting information is to submit samples to an accredited dealer for a quotation. The mica market is subject to pronounced periodic fluctuations in demand owing to prevailing trade conditions and the practice by consumers of laying in stocks well ahead of current requirements. According to dealers' reports, general retail price averages for phlogopite in 1940 advanced slightly from those of 1939, quotations being approximately as given below. These prices, however, are not an index of what producers may expect to receive from dealers for small parcels, as they include the dealers' overhead, culling, grading, and marketing costs, profit, etc.:

Knife-trimmed Sheet

Size	Per Pound	Size	Per Pound
1 x 1 inch......	$0.30	2 x 4 inches.....	1.25
1 x 2 inches.....	0.40	3 x 5 "	2.00
1 x 3 "	0.60	4 x 6 "	2.50
2 x 3 "	0.85	5 x 8 "	3.50

Size	Splittings	Per Pound
1 x 1 inch		$0.55
1 x 2 inches		0.60
1 x 3 "		0.70

Canada's Position

Phlogopite mining in Canada in recent years has been on a very much restricted scale, and the greater part of the production has come from a few of the larger operators with established mines. The remainder is derived from numerous small and intermittent operations, augmented by material recovered from old waste dumps. The entire mica-bearing region is pitted with small surface prospect openings many of which have never been given a fair trial for want of capital. It is possible that a number of these could be reopened or further prospected to advantage, especially if the anticipated shortage of stocks should occasion any important increase in the market price of phlogopite.

MOLYBDENUM

Molybdenum is used chiefly in steel to intensify the effects of other alloying elements, particularly nickel, chromium, and vanadium. Molybdenum alloys are used extensively for hard-wearing and other important parts of aeroplanes, trucks, etc., and also in the manufacture of shell steels, and in armour plating and high-speed tool steels.

Occurrence and Formation

Molybdenite (MoS_2), the sulphide of molybdenum, is by far the most important ore, and contains 60 per cent molybdenum and 40 per cent sulphur. It occurs in many different types of rocks. In Eastern Canada the more common occurrences are in pegmatite dykes or in green pyroxenite, usually on or near the contact between gneisses and crystalline limestone. Pyrite and pyrrhotite are the metallic minerals commonly present. In northern and western Ontario and in British Columbia, molybdenite is usually associated with quartz veins, intruding granites, or diorites.

Most of the world's production comes, however, not from deposits of the "contact" type referred to above, but from those in which the molybdenite is evenly distributed throughout large bodies of rock. It is only discoveries of the latter type containing at least 0·75 per cent molybdenite that are of special interest to Canada at the present time.

Identification

Molybdenite has the following properties:

Hardness—1 to 1·5
Specific gravity—4·7
Colour—Lead grey; a bluish grey trace on paper.
Lustre—Metallic.

Molybdenite is a very soft, shiny, grey-blue mineral. It occurs as very pliable flakes or leaves and often as crystals which are hexagonal in shape and made up as "books" of leaves resembling fresh lead foil. Flakes vary in size from a pin's head to several inches. An infallible test is the dark olive-green smear it imparts when rubbed on glazed white porcelain or enamel (a piece of a China cup will serve), the smear of graphite which it closely resembles being grey.

Marketable Grades and Specifications

The ore must be in the form of a concentrate containing not less than 85 per cent molybdenum sulphide and very low in copper, arsenic, and bismuth. In deposits containing large, pure flakes or crystals a marketable grade might be obtained by hand-picking, but the amount would be small. Hand-cobbing to bring up the grade of the mill feed is often done on certain types of irregular large-flake deposits. Most molybdenite ores readily respond to ordinary flotation methods of concentration, though the amount and type of flotation reagents may vary considerably for different ores.

Molybdenite concentrate is not added direct to the steel, but must first be converted into a suitable addition agent.

Buyers

Several steel and alloy manufacturers use molybdenite concentrate in the form of addition agents. As these agents are not made in Canada, except at the Moss mine at Quyon, Quebec, where the company has a small plant for converting its own concentrates, there are at present no buyers of concentrates in Canada. Most, if not all, of the Dominion's requirements of addition agents are at present imported from the United States. In wartime, however, conditions might arise where the United States would not be in a position to meet Canada's full requirements along with those of Great Britain. Although this will probably not occur, it is well to guard against it by giving some attention to a search for the type of deposit referred to in the description of occurrences and formation. At present, the duty on concentrates is much too high to permit their entry into the United States, and as Great Britain, by agreement, is obtaining all of its requirements of molybdenum from that country it is not in a position to purchase concentrates from Canada.

Prices

Prices mean little under the circumstances, but those of the addition agents given below may be of interest in the event of a change in conditions.

Molybdic oxide and calcium molybdate, each 98 cents a pound of contained molybdenum f.o.b. Toronto; ferromolybdenum, $1.23.

World Production

Close to 95 per cent of the world production comes from the United States, where Climax Molybdenum Company alone contributes about three-quarters of the domestic output. Consumption of molybdenum in the United States in 1940 was 50 per cent greater than in 1939; and in Canada, though the consumption is still relatively small, it is far in excess of the peacetime consumption.

Canada's Position

More than 400 molybdenite occurrences and deposits are known throughout Canada, but they are all small. Under suitable market conditions, however, some of these, if developed as a group, could probably be operated successfully. During a part of the last war, Canada was the leading producer of molybdenite, but the output was insignificant as compared with the present output in the United States.

TIN

Tin is widely distributed, but in only a few countries are the deposits sufficiently large for commercial development. Although tin has few strictly military uses, its ordinary uses in industry are essential in character and it is thus necessary for countries without sufficient supplies of their own to have convenient access to supplies from other countries. The metal is used chiefly in the manufacture of tin plate, mainly for use in the making of tin cans and of containers of all kinds. It is a necessary ingredient of solder and is a component part of most babbit and other anti-friction metals, without which manufacturing and transportation would be impossible. Smaller quantities are used in foil, which in turn is used for wrapping food, tobacco, etc.; in terneplate; pipe and tubing; type metal; bronze; galvanizing; and in bar tin.

Occurrence and Formation

Cassiterite (SnO_2) is the only important ore of tin and in the pure state it contains 78·6 per cent of the metal. Some workable deposits of the mineral, however, contain less than one per cent of tin. Stannite, a sulphide of copper, iron, and tin, is of little significance as an ore mineral.

Although there is considerable difference in detail between the types of tin deposits of the principal tin-producing countries, they are similar in a broad way. The lode deposits are related in origin to granite or some closely allied intrusive rock and occur either in the intrusive rock itself or in adjacent rocks. The classic deposits of Cornwall in England are quartz veins in granite of latest Palaeozoic age and in adjacent sedimentary rocks of Palaeozoic age. The ore mineral is cassiterite and associated with it is tourmaline. The granite wall-rocks contain quartz, muscovite, tourmaline, cassiterite, stannite, and topaz. In Bolivia, the lodes are quartz veins in granite or allied types of intrusive rocks or in adjacent slates and contain cassiterite, tourmaline, pyrrhotite, and wolframite. Silver-tin deposits in Bolivia are somewhat similar, but contain considerable stannite and pyrite. In Malaya, the production is mainly from placer deposits and is called stream tin. The stream tin is cassiterite and was derived by erosion from cassiterite-bearing quartz veins, pegmatites and pipe-like deposits and also from cassiterite disseminations in granite. The lodes are associated with granite of Mesozoic age.

Attempts to mine lode deposits of tin in South Dakota, the Carolinas, California, Texas, and Virginia have been unsuccessful as the deposits were too small or too low in grade. Alaska, however, supplies a hundred tons or more of stream tin annually.

Stannite is present in the veins at the Snowflake property near Revelstoke, British Columbia, and cassiterite and stannite have been noted at several other places in the province. Cassiterite occurs also in many other places in Canada, but no commercial deposits have been found. In the unglaciated parts of Yukon, stream tin has been found in small quantity, but no serious attempt seems to have been made to thoroughly test the gravels for tin.

If commercial tin deposits do occur in Canada, the lode deposits will be found in the Cordilleran region, Canadian Shield, or Maritime Provinces and will be in granites or closely allied intrusives or in adjacent rocks. Commercial stream tin may occur in Yukon and in British Columbia.

Identification

Cassiterite

Hardness—6 to 7
Specific gravity—7
Streak—White, greyish, brownish.
Lustre—Diamond-like.
Colour—Sometimes white, or colourless, more often black or brown. Red and yellow varieties also occur. In powdered form, it is usually pale brown.
Other properties—Occurs with prismatic crystal forms as granular masses and disseminated grains; occasionally fibrous, with structure resembling wood; insoluble in acid; when treated with a few drops of hydrochloric acid on a zinc plate, small fragments of cassiterite will, within a few minutes, become coated with a film of metallic tin which in turn will become bright on being rubbed.

Stannite

Hardness—4
Specific gravity—4·3 to 4·5
Lustre—Metallic.
Streak—Blackish.
Colour—Steel grey to iron black; sometimes a bluish tarnish; often yellowish from the presence of chalcopyrite.
Other properties—Opaque; massive, granular, and disseminated.

Marketable Grades and Specifications

The impurities generally present in tin ores are copper, arsenic, antimony, lead, iron, bismuth, and traces of sulphur and silver; tungsten, manganese, and stannic oxide are sometimes also found. The tendency of the impurities is to increase the hardness and to diminish the malleability of the metal. As a rule, tin ore occurring in veins yields a less pure metal than does placer tin.

Because of changing conditions and the wide range in the market value of the metal, no definite statement can be made as to what constitutes payable ore. Under wartime conditions, however, provided the deposit is reasonably large, it is worthy of attention, even though the grade of the material is lower than would ordinarily be regarded as suitable for commercial development. Most tin ores are too low in grade to be treated directly and accordingly must be concentrated. As a rule also, they contain impurities which must be removed as far as possible before they can be smelted. The ore is prepared partly by hand-picking, but chiefly by gravity methods of concentration, in which advantage is taken of the high specific gravity of cassiterite.

Concentrates are in most cases purchased on a 60 per cent tin basis and for each unit or fraction above or below 60 per cent the returning charge is reduced or increased. They are subject to penalties if they contain more than 1 per cent sulphur and 5 per cent iron. Impurities such as lead, copper, arsenic, antimony, and bismuth are not penalized, but an increased charge is made to cover the costs arising from the treatment of such ores.

Buyers

There are no tin smelters on the North American Continent, but a smelter now under construction at Texas City, Texas, is expected to be in operation early in 1942. It is being built to treat Bolivian tin ore concentrates, but it is possible that the smelter will accept concentrates from other sources.

If available in sufficient quantities, the British enterprises listed below would likely be interested in the purchase of tin concentrates produced in Canada. In any event, under present conditions, little difficulty would be experienced in the disposal of concentrates.

Victor G. Stevens, Limited, Felling-on-Tyne, England.

Copper Pass and Son, Limited, Bedminster Smelting Works, Bristol, England.

Philipp and Leon, 28 Finsbury Square, London, E.C. 2.

Metal Traders, Limited, 7 Gracechurch Street, London, E.C. 3.

Hewey Gardner and Company, Limited, 2 Metal Exchange Building, London.

Anglo Metal Company, Limited, 2 Crosby Square, London, E.C. 3.

Prices

The prices of best quality tin metal fluctuate fairly widely, but late in June, 1941 were quoted in New York at from 52·40 to 52·75 cents a pound (American funds).

World Production

In 1939, the latest year for which complete figures are available, the Federated and Unfederated Malay States and Straits Settlements were the source of 30 per cent of the world output of tin. They were followed, in order, by the Netherland East Indies, Bolivia, Thailand (Siam), Nigeria, and China. Small quantities are also produced in England, Australia, Siam, and Burma.

Canada's Position

The small quantity of tin produced at Trail and the small domestic recovery of secondary tin fall far short of meeting the Canadian requirements of the metal, which in peace time amounted to about 2,700 tons a year but which are much larger at present. For the most part they are obtained from the Straits Settlements.

TUNGSTEN

Tungsten is used, for by far the most part, in certain types of steel or in cemented carbides for the manufacture of metal-cutting tools. The more common high-speed tool steels which are so essential for turning out the instruments of war contain 18 per cent of tungsten.

Occurrence and Formation

The two principal tungsten ores are wolframite and scheelite, the former an iron-manganese tungstate (Fe, Mn, WO_4), the latter, calcium tungstate ($CaWO_4$).

Wolframite

Wolframite and the closely related minerals ferberite and huebnerite are not common in Canada, occurring, so far as is at present known, in only about half a dozen isolated localities from New Brunswick to Yukon and the Northwest Territories. They are found in pegmatites and in veins associated with siliceous igneous rocks.

Scheelite

Scheelite is the tungsten mineral generally occurring in Canada. Although found in almost all types of rocks, it is principally associated with opaque white quartz veins, through which it is irregularly distributed as angular nodules, patches, or thin streaks, often being the only metallic mineral present. Recently it has been found in the ores of a number of producing gold mines throughout Canada. Quartz veins in gold regions should, therefore, be carefully examined for scheelite. Several deposits are known in which scheelite occurs in quartz veins associated with iron, copper, lead, zinc, and occasionally tin minerals. Massive white scheelite, which closely resembles barite (heavy spar), has as yet been found in only one locality, the Bridge River district of British Columbia.

Identification

Wolframite

Wolframite, which contains when pure about 76 per cent tungstic oxide (WO_3), occurs in crystals somewhat tabular in shape, or crystal aggregates. It has the following physical characteristics:

Hardness—5·0 to 5·5
Specific gravity—7·0 to 7·5
Colour—Dark brown to black.
Streak—Black to dark reddish-brown.
Lustre—Submetallic to metallic.
Tenacity—Brittle; cleavage perfect in one direction.

Minerals of the wolframite group are difficult to identify in the field because of their resemblance to many of the commoner heavy black minerals with bright lustre, but they are heavier and softer.

Wolframite fuses readily under the blowpipe to a bead which is magnetic.

Scheelite

Scheelite has a theoretical content of 80·6 per cent WO_3 and the following characteristics:

Hardness—4·5 to 5·0.
Specific gravity—6·0.
Colour—Yellow-brown, buff, sometimes grey or white.
Streak—White.
Lustre—Dull, greasy (as feldspar).
Tenacity—Brittle.

When scheelite occurs in quartz it can be identified in the field by its buff colour, heavy weight, and its relative softness (it can be scratched with a knife). It powders fairly easily when struck with a hammer and the fractured particles have smooth, flat, glassy surfaces. Iron-stained white rocks, particularly quartz, might, under some circumstances, be mistaken for scheelite, but quartz will scratch glass while scheelite will not. In some regions, particularly in British Columbia, a brownish-buff ankerite carbonate might be mistaken for scheelite but is much softer, light in weight, and effervesces when ground and treated with hot hydrochloric acid. This also applies to the buff-coloured calcite that sometimes occurs in quartz.

A groove cut with the blade of an ordinary knife in a piece of scheelite which has first been moistened with a drop of hydrochloric acid turns to a deep blue colour.

A canary yellow, weathered product, tungstite, is sometimes found in small quantities surrounding, or in the immediate vicinity of, tungsten minerals.

If a portion of rock containing scheelite is pulverized and panned, the tungsten mineral, on account of its heavy weight, will appear in the tails. Both scheelite and the wolframites occur in some placer gold deposits of British Columbia and Yukon, and whenever heavy minerals (black as well as light coloured), found in the tails of the pan or in the final clean-up of placer operations, are not recognized as the usual sulphides or magnetite, arrangements should be made to have them identified.

When scheelite occurs in rocks other than quartz and the typical buff colour is not observable, the only method of identifying it in the field by physical means is with a special mercury-vapour violet lamp and purple filter, under which scheelite exhibits in the dark a brilliant blue-white fluorescence. Neither wolframite nor tungstite fluoresces. Portable lamps* fitted with a dry battery are now being used by some mining companies and prospectors and have proved invaluable in searching for the mineral on the surface or underground.

If no lamp is available a small piece of the suspected mineral can be finely powdered and boiled in a test-tube with strong hydrochloric acid. After continued boiling, a deep yellow residue will appear at the bottom if

* *Particulars will be furnished on request to the Bureau of Mines, Department of Mines and Resources, Ottawa.*

scheelite is present. If a piece of zinc, aluminium, or tin is added (cigarette silver paper or galvanized iron with zinc on it will serve as a substitute), the solution turns blue and, later, brown. The yellow residue is soluble in ammonia.

Marketable Grades and Concentrates

In examining a promising prospect, consideration must be given to the question whether it is better to resort to selective mining, cob the tungsten mineral from the gangue and wall-rock, and ship it as high-grade ore, or to extract a mining width and mill the whole to a concentrate of shipping grade. Samples should therefore be taken across a mining width of, say, 3 feet or across and along the vein. Attention should be paid to the actual width of the vein. On a small scale, concentration can be effected by cobbing and sorting from a vein of tungsten mineral as small as 1 inch thick or by crushing and sluicing as for gold in placer operations.

On the large scale, concentration is achieved by ordinary wet gravity methods of jigging and tabling, which, because of the heavy weight of the tungsten minerals, present no difficulty, provided that the ores are relatively free from metallic sulphides. If these are present, combined gravity, flotation, and possibly magnetic roasting methods may have to be employed. Since the ore, especially scheelite, tends to slime, care must be taken in the grinding to avoid excessive loss from this tendency.

All complex ores should be tried out by preliminary concentration tests. As stated in the introduction to this pamphlet, arrangements can be made for the treatment of bulk samples from new properties in the laboratories at Ottawa.

The wolframite minerals must be converted into ferrotungsten before being added to steel, and for this purpose the concentrates must contain a minimum of 60 per cent tungsten oxide. Scheelite, on the other hand, can be added direct if its tungsten oxide content is not less than 70 per cent and it is practically free from harmful impurities, particularly lead, zinc, phosphorus, and arsenic, and if it contains less than 0·5 per cent sulphur.

Buyers

Wolframite has no domestic market because ferro-tungsten is not yet being made in Canada, but if of the requisite grade it can be sold in the United States.

The only Canadian buyer of scheelite ore is Atlas Steels, Ltd., Welland, Ontario, which will buy any concentrate likely to be produced in Canada provided it grades to specifications.

Prices and Other Economic Considerations

Tungsten concentrates, which usually have to contain 60 per cent or more of tungsten oxide (WO_3), are quoted on the short-ton unit basis, i.e. at so much per 20 pounds of contained WO_3. The Canadian price of scheelite concentrate at present (June 10, 1941) is $17 to $17.50 per unit (equivalent to 85·0 to 87·5 cents per pound of WO_3), delivered at Welland. A ton of concentrate containing 70 per cent WO_3 would therefore bring about $1,200 delivered. The United States price of imported wolframite concentrate (60 per cent WO_3) is about $24 per unit, delivered at New York, less a duty of $7.93 per unit, so that the price in Canadian funds is about the same as the domestic price of scheelite at Welland.

In order to be commercial at present prices, a deposit situated where transportation and power facilities are reasonably good and from which a fair tonnage could be treated daily should average not less than 0·5 per cent WO_3. For small operations in areas not very accessible, the average grade should be at least 1 per cent WO_3, and if the scheelite blobs are free, not less than half an inch in size, and constitute about one-quarter of the vein matter, hand-cobbing should prove profitable.

World Production and Canada's Position

The world production of tungsten in 1939 was 35,000 tons of concentrates containing 60 per cent of the oxide of tungsten (WO_3). China, Burma, United States, Portugal, and Bolivia, in that order, were the chief sources of supply, China being outstanding with its contribution of 12,000 tons. In 1940 the United States consumed about 12,000 tons of tungsten concentrates, less than half of which was derived from domestic sources. Canada produced a trifling amount only—a fact which clearly calls for every effort on the part of the prospector and miner to discover and produce this strategic war mineral.

VANADIUM

The principal use of vanadium is in the steel industry. It enables high-speed tool steels to better maintain their strength and hardness at high temperatures. Steels with vanadium and one or more other alloying elements are used mostly in springs and axles, crankshafts, pinion gears, and many other locomotive and automotive castings. In cast iron, vanadium tends to maintain a strong, tough structure.

It is used, but in much less quantity, as a catalyst and in the non-ferrous, glass, ceramic, and colour industries.

Occurrence and Formation

Vanadium is a widely distributed element, being found in small amounts in granites, sedimentary rocks and clays, as well as in many iron, lead, and copper ores, bitumens and petroleums. The chief ore minerals of vanadium are patronite, roscoelite, carnotite, and vanadinite. There are as yet no known occurrences of these minerals in Canada.

Vanadium is recovered as a by-product from other metal mining, from vanadates in the oxidized zones of some lead mines, and from vanadium ore in the western United States, Peru, and some other countries.

In the western United States the ores consist of carnotite, roscoelite, vanoxite and other less common vanadium minerals. They are replacement deposits along certain beds of Mesozoic sandstone and along brecciated zones in the same rocks. The ore is associated with gypsum and carbonized wood. In Peru a high-grade and very productive deposit of vanadium ore occurs as a lens along the bedding planes of Mesozoic shale. There, the ore is a complex sulphide called patronite associated with gypsum and greenish black masses of a hydrocarbon. The association with gypsum, carbonized wood, and hydrocarbons supports the generally held view that the ores were deposited from surface waters of the sulphate type and were aided in deposition by reaction with carbon or hydrocarbons in the sedimentary rocks.

The outlook for finding vanadium-bearing sediments or asphalts in Canada is not particularly promising, though the possibility of such occurrences should not be overlooked. Tests so far made of what appeared a most promising possibility, namely, the bituminous sands of Alberta, were disappointing, as also were those of the Upper Carboniferous sediments of New Brunswick and Nova Scotia, which held out promise because of their appreciable content of copper in various forms concentrated around carbonized wood or coaly matter.

As regards finding carnotite sandstones in Canada, so little is known of the origin of this mineral that no definite statement can be made one way or the other. Sandstones containing carbonized matter should be closely scrutinized, especially if showing evidence of any yellow stain or incrustation.

Identification

Patronite

Patronite is an impure vanadium sulphide of uncertain composition, with a content of from 19 to 25 per cent of vanadium. It occurs in non-crystalline masses associated with asphalt- and coke-like material. It has the following features:—

Hardness—2·5
Specific gravity—2·7 (= that of quartz)
Lustre—Metallic to dull.
Colour—Lead-grey to greenish black.

NOTE.—Coals, asphalts, and petroleums are known sometimes to contain vanadium, perhaps in the form of patronite. Ashes from these substances may run high in the metal.

Roscoelite

Roscoelite, or vanadium mica, is of doubtful composition, but is mainly a hydrous silicate of vanadium and aluminium, with about 29 per cent vanadic oxide (V_2O_5) when pure. It is found in minute scales or star- or fan-shaped groups of micaceous aggregates. The grains are sometimes so small that the ore looks like a shale, but the mineral usually impregnates a sandstone in which may occur petrified wood and a little carnotite. It has the following additional characteristics:

Hardness—2
Specific gravity—2·92 to 2·94
Colour—Green to brown.
Lustre—Dull to pearly or greyish.
Cleavage—Splits, like all micas, easily into thin plates.

NOTE.—Roscoelite might be confused with chlorite micas, but the latter are found only very rarely in sandstone.

Carnotite

Carnotite is a hydrated vanadate of uranium and potassium, with a content of from 3 to 5 per cent V_2O_5 in ordinary commercial ores. It occurs usually as a crystalline powder, sometimes as loosely cohering masses of minute scales. It has the following characteristics:

Hardness—Easily scratched with finger nail.
Specific gravity—4·1
Lustre—Dull.
Colour—Canary yellow.

Note.—The colour is sometimes red or black owing to association with other vanadium minerals.

Vanadinite

Vanadinite is a chloro-vanadate of lead containing in the pure state 19·3 per cent V_2O_5 and 73·1 per cent lead. Zinc, lime, iron, and copper are sometimes present in amounts up to about 1 or 2 per cent. It occurs in prismatic, sharply formed, hexagonal crystals, sometimes hollow. A large crystal may be made up of numerous smaller parallel ones, the whole group tapering to a slender point. Other physical characteristics of vanadinite are:

Hardness—2·5 to 3
Specific gravity—6·6 to 7·2
Colour—Bright red, orange-red.
Lustre—Adamantine; resinous on fracture.
Streak—White to pale yellow.
Tenacity—Brittle.

Concentration and Specifications

Most vanadium ores are not readily amenable to concentration. From the patronite deposit in Peru, a shipping product of about 11 per cent V_2O_5 is sorted, the lower grade ore being crushed and burned to yield an ash containing about 22 per cent V_2O_5. High-grade concentrates have been obtained from the roscoelite in a gold ore in California during the concentration of the ore for gold.

Vanadinite is easily concentrated by the ordinary gravity methods, but if wulfenite is present separation is difficult because it has about the same specific gravity. In Spain, the vanadinite ore, which contained 4 to 5 per cent V_2O_5 as mined, used to be hand-picked and concentrated to a 12 per cent product.

As ferrovanadium is the form in which vanadium is introduced into iron or steel, the vanadium ores from which this alloy is made in the electric furnace must contain little copper, molybdenum, tungsten, chromium, sulphur, lead, zinc, arsenic, phosphorus, alumina, and silica. For this reason buyers often demand complete analyses of vanadium ores and concentrates. The vanadium content of the grades of ferrovanadium marketed ranges from 30 to 45 per cent.

Buyers

Vanadium oxide for conversion into ferrovanadium is bought by:

Electro Metallurgical Co. of Canada, Ltd., Welland, Ont.

The principal Canadian consumers of ferrovanadium in 1940 were:

Atlas Steels, Ltd., Welland, Ont.

Dominion Foundries and Steel, Ltd., Hamilton, Ont.

Steel Company of Canada, Ltd., Hamilton, Ont.

Chromium Mining and Smelting Corporation, Sault Ste. Marie, Ont., is interested in securing or leasing promising vanadium-mineral properties.

The leading Canadian chemical companies (see page 33) are possible buyers of V_2O_5.

Prices

The United States quotation, June 26, 1941, on vanadium ore, in ton lots, was 27½ cents per pound contained V_2O_5, f.o.b. shipping point.

World Production and Canada's Position

In 1939 world production of vanadium ores, in terms of vanadium content, was about 3,000 tons, nearly all from four countries, of which Peru and the United States were the chief.

In addition, a certain amount of vanadium is recovered during the refining of bauxite in Italy; from boiler and stack soot of ships burning Mexican and Venezuelan oils; and, in Germany probably now, from the slag resulting in treating vanadium-bearing iron ores.

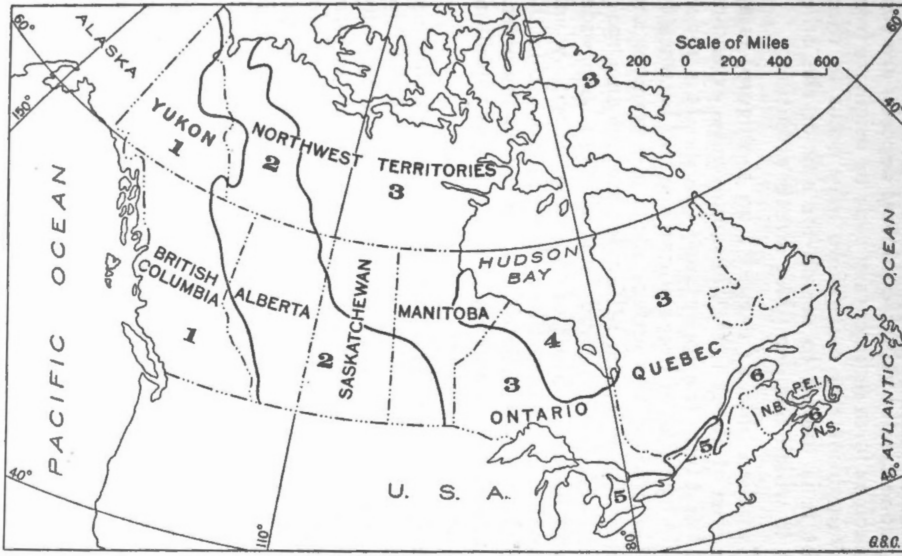
Canada is to-day dependent entirely upon imports.

GEOLOGICAL REGIONS IN RELATION TO STRATEGIC MINERALS

Canada, excluding the Arctic Islands, is geologically divisible into six regions, whose boundaries are represented on the figure.

The Cordilleran region (marked 1 on the figure) is about 400 miles wide, and extends along the west coast from the International Boundary to the Arctic Ocean. It is a region of mountains and plateaus underlain by strongly folded and faulted sediments and lavas together with a great variety and an immense volume of intrusive rocks such as granites and granodiorites. All of the minerals treated in this pamphlet have been found or may reasonably be expected to be present in this region.

The Great Plains region (marked 2 on the figure) lies between the Cordilleran region on the west and the Canadian Shield on the east. At the International Boundary it has a width of about 800 miles, but it



FIGURE—Geological Divisions of Canada: 1, Cordilleran region; 2, Great Plains and northern extension; 3, Canadian Shield; 4, Hudson Bay Lowland; 5, St. Lawrence Lowland; 6, Appalachian region.

narrows northward. The Great Plains are underlain by great thicknesses of nearly horizontal sedimentary strata and the economically valuable mineral deposits are confined to such as form sedimentary beds or originate from them. Vanadium and manganese may occur in these rocks but it is useless to search for any of the other minerals to which this pamphlet directs attention.

The Canadian Shield (marked 3 on the figure) is an immense area of about 1,800,000 square miles extending north and east from the upper Great Lakes. It is underlain wholly by rocks of Precambrian age and between 80 and 90 per cent of the surface rocks are granites and allied acid intrusives; the remainder are volcanic rocks and sediments. Folding and faulting have been widespread and intense. Most of the minerals with which this pamphlet is concerned have been found within the limits of the Canadian Shield but so far no important deposits of manganese and none of mercury or vanadium have yet been found.

The St. Lawrence and Hudson Bay Lowlands (marked 5 and 4, respectively, on the figure) are underlain by nearly horizontal sedimentary beds. The economically valuable mineral deposits are confined to such as form sedimentary beds or originate from them. Vanadium and manganese may occur in these rocks and fluorspar has been mined from veins at Madoc, Ontario, but it is useless to search for any of the other minerals to which this pamphlet directs attention.

The Appalachian region (marked 6 on the figure) includes most of Canada east of the St. Lawrence River. It is underlain by sedimentary and volcanic rocks in places invaded by granite or by bodies of basic rocks. Manganese deposits have been found in Nova Scotia and New Brunswick and on the Magdalen Islands. Chromite is associated with basic intrusives in the Eastern Townships and Gaspé Peninsula, Quebec. Tungsten-bearing minerals occur in New Brunswick and Nova Scotia.

List of Strategic Mineral Samples
Bureau of G & T

MINERAL SPECIMENS AVAILABLE AND PRICES

Specimens of a number of Canadian minerals and rocks can be purchased at 5, 10, and 15 cents each, according to size and quality, from the Bureau of Geology and Topography, Department of Mines and Resources. Sets of mineral chips and of rock chips, each set consisting of about 35 specimens and costing 50 cents, are also available for the prospector's use.

Of the strategic minerals dealt with in this pamphlet, specimens, about 1 inch square, of the following are on hand in limited supply at prices somewhat higher than those named above because they have mostly to be imported:

		Cents
Chromium Minerals....	Chromite..............	05
Manganese "	Manganese Ore (hard).	10
	Bog Manganese........	10
Mercury "	Cinnabar..............	25
Molybdenum "	Molybdenite...........	15
Tin "	Cassiterite............	30
	Stannite..............	30
Tungsten "	Scheelite..............	30
	Wolframite............	25
	Ferberite..............	30
Vanadium "	Patronite.............	15
	Carnotite.............	15
	Roscoelite............	15
Fluorspar..............	Fluorite..............	05
Graphite..............	Crystalline............	05
	Flake.................	05
	Amorphous...........	05
Mica..................	Muscovite............	05
	Phlogopite...........	05
		2.85

An order for specimens should be addressed to the above-mentioned Bureau and must be accompanied with payment in full by money order or certified cheque made out to the Receiver General of Canada.

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