CANADA

DEPARTMENT OF MINES

HON. CHARLES STEWART, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

GEOLOGICAL SURVEY

W. H. COLLINS, DIRECTOR

ECONOMIC GEOLOGY SERIES
No. 4

Arsenic-bearing Deposits in Canada

BY

M. E. Hurst

OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
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CHAPTER I

INTRODUCTION

Arsenic is the most powerful and most common mineral poison and its considerable importance in human affairs is due mainly to this fact. For centuries, in one form or another, it has been a staple article of commerce, but only within recent years has it attracted world-wide attention. This new interest was aroused and stimulated by an announcement from the United States Bureau of Entomology, in 1919, to the effect that calcium arsenate was the most economical and efficient insecticide yet discovered for checking the ravages of the boll weevil in the cotton fields of the southeastern states. This announcement came at a time when smelting companies in the United States were at a loss to know what use to make of the stocks of white arsenic that had been accumulating since 1917 when legislation was enacted prohibiting the discharge of arsenical fumes into the atmosphere. As the demand for calcium arsenate increased, the visible supplies of white arsenic diminished, until it soon was apparent that new sources of the commodity must be found if the greatly augmented requirements of the insecticide industry were to be met. Up to 1924 the output of arsenic-recovery plants in the United States was insufficient to meet the needs of that country, thereby leaving a considerable part of the domestic market open to foreign competition. Canada, in the past, has shared largely in this market, but can continue to do so only if new supplies of arsenic are discovered to replace those now being depleted. In this report, which has been written not only for the purpose of taking stock of the deposits already known, but also in the hope of stimulating the search for, and the development of, other sources of arsenic within the Dominion, an attempt has been made to present information that may be of service to prospectors, engineers, investors, and to the general public. Chapter IV, which deals with the occurrences and deposits of arsenic in Canada, is thought to include most of the information available on the subject, to the end of 1924.

USES OF ARSENIC

Arsenic was known to the Ancients, especially the Greeks and the Romans, chiefly in the form of its sulphides, realgar and orpiment. These minerals were valued as pigments, as poisons, and for their medicinal properties. Today they find a limited application in the manufacture of paints, dyes, fireworks, and depilatories.

Within recent years elemental arsenic has been used to a small extent in industry. It is employed chiefly in the manufacture of lead shot and in other alloys such as bronze for railway brasses, and copper for certain types of castings. It is further used in white bearing metals; in Muntz metal; and in the speculum metal for the mirrors of reflecting telescopes.

Formerly, arsenic was burned in oxygen to produce the so-called Indian fire used as a signal light for trigonometrical surveys. On exposure to air, arsenic slowly oxidizes to a grey powder which is sometimes sold as "fly powder".

The most important compound of arsenic at the present time is arsenious oxide or white arsenic. This is recovered chiefly from the fumes and flue dust given off during the roasting of arsenical ores and, in most cases, is simply a by-product of general smelting operations. Less than ten years ago this material was regarded only as a nuisance by the copper and lead smelters, and ores were penalized for their arsenic content. Today, smelters and refineries everywhere are striving to increase the production of white arsenic in an effort to keep pace with the demands of a rapidly expanding insecticide industry. Large quantities of the material are also consumed in the manufacture of glass and in the preparation of weed-killers. Smaller amounts of the oxide are required for medicinal and chemical preparations; for arsenical soaps; for preservative powders used in taxidermy; for making opalescent glass and enamels; for explosives; and for the manufacture of dyes and paints. During the war, white arsenic was used in the manufacture of poison gas.

The bulk of the white arsenic used in the insecticide industry is converted into lead arsenate, Paris green, and calcium arsenate. These compounds contain a high percentage of non-soluble arsenic. This makes them suitable for use on plant foliage and for the destruction of insects, like the boll weevil, which bite and swallow parts of the plant material. Other arsenicals that have a limited use are: Scheele's green, or copper arsenite, in some cases substituted for Paris green; London purple, which is a by-product from the manufacture of aniline dyes; sodium arsenite, for use in cattle dips; arsenites of lead, zinc, and calcium; and much white arsenic is used alone in poisoned baits to check invasions of grasshoppers or cut-worms. Not only have such preparations met an enormously increased demand in the United States during the last decade, but they have also become increasingly popular with the vine growers of France; the india-rubber planters of the East Indies and the Malay peninsula; the coffee growers of Brazil; the cattlemen of South Africa and Argentina; and the sheep raisers of Australia.

The abnormal demand within recent years for arsenical insecticides is largely the outcome of experiments carried on by the U.S. Bureau of Entomology at Tallulah, La. These experiments showed, and experience so far has proved, that periodic dusting of the cotton plants with calcium arsenate is the cheapest and most effective method yet devised for checking the boll weevil and increasing the cotton crop in the southern states. The weevil is said to have first crossed from Mexico into Texas in 1892, and since then it has spread north and east with such rapidity that by 1922[1] about 614,213 square miles, or 87 per cent of the cotton-producing territory, had been infested. In the United States the direct loss in non-production of cotton lint and seed due to the weevil invasion is estimated to be between $200,000,000 and $300,000,000 annually. This insect is also known to occur throughout Mexico, in Central America, and Cuba, and in Nyassaland.

[1] U.S. Dept. of Agr., Farmers' Bull., 1329, p. 2 (1923).

ARSENIC SITUATION

The key-note of the arsenic situation is its uncertainty. This condition is due largely to the fluctuating, almost unpredictable, and highly seasonal nature of the demand for calcium arsenate. The demand that has grown up within the last five years has called attention to the apparent, if not real, shortage of natural supplies of arsenic throughout the world. At the present time the output of white arsenic from the smelters and refineries varies with the condition of the metal market and with the arsenical content of the ores they receive; the amount of white arsenic consumed in making glass, weed-killers, and certain insecticides, although increasing, is fairly uniform, whereas the amount used in the manufacture of calcium arsenate fluctuates both with the supply available and with the immediate requirements of the cotton-planters, which depend on the cost of buying and applying insecticide, on the price of cotton, and on the yield an acre. The most obvious means by which the market can be stabilized is by the development of new resources of arsenic. This would assure the cotton-planters an ample supply of calcium arsenate at a reasonable and comparatively steady cost. Under such conditions the banks could then require all borrowers planting to cotton to buy crop insurance in the form of calcium arsenate. This would enable the insecticide manufacturers to estimate the demand for their products and to prepare in advance for the actual needs of the consumers.

Since the beginning of 1920 the market price of white arsenic has varied from 5½ cents a pound during October and November, 1921, up to almost 16 cents in February, 1923. Some idea of these fluctuations in price may be obtained from the following graph, compiled from the quotations appearing weekly in the Chemical and Metallurgical Engineering Journal.

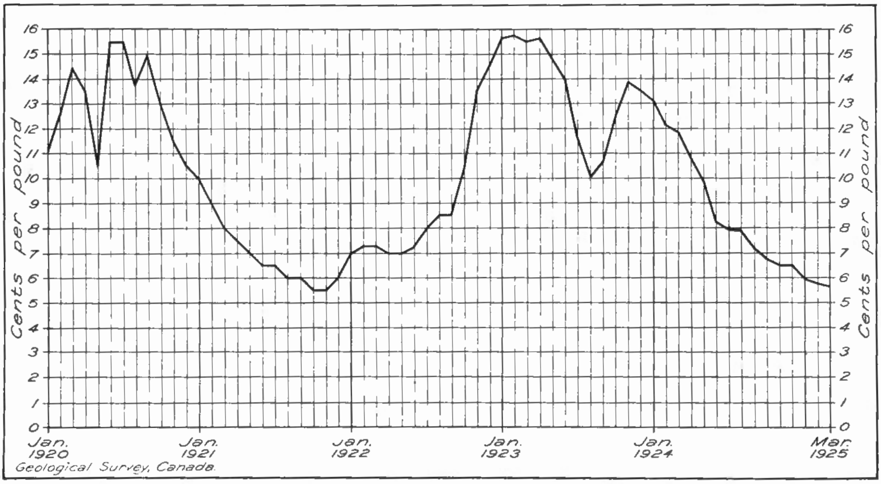

Figure 1. Graph showing fluctuations of wholesale price of white arsenic from January, 1920, to March, 1925. Compiled from weekly quotations in the Chemical and Metallurgical Engineering Journal.

PRODUCTION OF ARSENIC IN CANADA

White arsenic has been recovered in Canada almost continuously since 1885. Until 1903 the production came entirely from southeastern Ontario, but with the discovery of the cobalt-nickel-silver-arsenic veins at Cobalt a new source of arsenic became available and since 1905 this district has contributed the bulk of the Canadian output. Between 1907 and 1910 shipments of cyanided concentrates containing arsenopyrite were made from the Richardson mine at Goldboro, N.S. For a number of years the Hedley Gold Mining Company, at Hedley, B.C., shipped arsenopyrite-gold concentrates to the smelter at Tacoma, Wash., but only since 1917 has the arsenic content been recovered. During 1923 trial shipments of concentrates were sent to Europe by the Clark Gold Mines Corporation, Halifax county, N.S. At the present time (1927) about 80 per cent of the arsenic production of the Dominion is obtained from ores mined in Cobalt district (including South Lorrain township and the Gowganda field). The remainder is recovered from the Hedley concentrates and from occasional shipments from Nova Scotia. The principal arsenic refinery in Canada is that operated by the Deloro Smelting and Refining Company, Limited, at Deloro, Ontario, in connexion with the smelting of silver ores from Cobalt. Insecticides also are manufactured at this plant. Other refineries are operated by the Coniagas Alkali and Reduction Company, Limited, at Thorold, Ont., and by the Ontario Smelters and Refiners, Limited, at Welland, Ont.

Up to the end of 1923 about 37,000 tons of white arsenic valued at $4,750,000 had been recovered from arsenical ores mined in Canada. Of this total Ontario contributed over 96 per cent, British Columbia 3 per cent, and Nova Scotia less than 1 per cent. The production of white arsenic from Canadian ores for each year since 1885 is given in Chapter VI.

The chief market for Canadian white arsenic is in the United States. The refineries in that country have a combined capacity of about 35,000 tons of white arsenic per annum, but the actual production has never exceeded 20,000 tons a year and is usually much less. If the imports are added to the domestic production it will be found that the yearly supply available in the United States fluctuates between 7,500 and 27,000 tons. The minimum annual requirements of white arsenic by manufacturers in that country were estimated in 1922 by B. R. Coad[1] of the United States Bureau of Entomology to be as follows:

In the manufacture of—	Short tons
Lead arsenate	2,000
Paris green	1,200
Proprietary mixtures	750
Weed killers	1,500
Dips	1,000
Glass	2,000
Calcium arsenate	3,500
	11,950

This estimate is based on the assumption of a light insecticide year. During 1923 the supplies of white arsenic consumed in the United

[1] Coad, B. R., and Loughlin, G. F.: "Available Supply of Arsenic;" U.S. Department of Interior, 1923.

States amounted to 22,000 tons. Although nearly one-third of this total was converted into calcium arsenate, only 4·4 per cent of the acreage planted in cotton received arsenate treatment.

CONSUMPTION OF ARSENIC IN CANADA

About 28 per cent of the white arsenic recovered in Canada during 1922 was consumed within the country, the balance being exported, chiefly to the United States. Of the industries using this product those engaged in the manufacture of insecticides and glass are the most important. The consumption[1] in 1922 was as follows:

	Pounds
Insecticide preparations	768,000
Glass manufacturing	275,553
Acids, etc.	110,000
Medicines, etc.	2,130
Explosives	50
	1,155,733

In addition, small quantities of arsenic sulphide are imported from Germany, Great Britain, and the United States, to be used in paints, dyes, fireworks, and depilatories. Minor amounts of arsenate of soda are also imported for industrial purposes. The imports of arsenical products into Canada from 1913 to 1923 are given in the appendix.

FIELD WORK

The field work on which this report is based was carried out during the summer months of 1923 and 1924. June and July of 1923 were spent in making a survey of the arsenic occurrences in Nova Scotia. In this connexion all the important gold districts and other arsenic-bearing localities in the province were visited. The work was greatly handicapped by the inaccessible condition of the vast majority of the mine workings in the areas examined. Late in July a brief visit was made to an arsenical prospect at Stevens brook, near Bathurst, N.B. The months of August and September were devoted to deposits in Ontario, particularly in the vicinity of Howry creek, Sudbury, Timagami, and Cobalt; in South Lorrain township and in Hastings, and Lennox and Addington counties. During the latter part of September a number of deposits in Marmora, Madoc, and Elzevir townships were visited in company with Mr. M. E. Wilson, of the Geological Survey, who was mapping the geology of the area.

The field season of 1924 was devoted to the examination of the principal occurrences of arsenic in British Columbia. In this connexion a number of deposits were examined in the vicinity of Hedley, Hazelton, and Smithers, and in Bridge River district. In addition, the following properties were visited: the Aufeas and Emancipation near Hope, the Wisconsin group near Kootenay lake, the L and H at Silverton, the J and L north of Revelstoke, the Poplar Creek deposits, the realgar occurrence at Wolf lake, the Grey Eagle at Deer Park, and the Ample on Cayoosh creek. Owing to the fact that a large number of deposits occur at widely scattered points

[1] "Special Report on the Consumption of Prepared Non-metallic Minerals in Canada"; Dom. Bur. of Statistics, 1923.

and are, for the most part, difficult of access, so much time was consumed in reaching them that it was impossible to give to many of the properties more than a cursory examination.

ACKNOWLEDGMENTS

The writer wishes to express his appreciation of the many courtesies extended him by citizens, officials, engineers, and prospectors in the various districts of Nova Scotia, Ontario, and British Columbia visited during the field seasons of 1923 and 1924. Especially does he desire to acknowledge the cordial co-operation and assistance of Prof. A. E. Flynn of the Nova Scotia Technical College; of G. P. Jones and B. W. Knowles of the Hedley Gold Mining Company; and of J. D. Galloway, then resident engineer for the British Columbia Department of Mines at Hazelton, B.C., now Provincial Mineralogist. Furthermore, the writer is indebted to several members of the Geological Survey for information incorporated in this report, particularly to Mr. E. R. Faribault for data concerning deposits in Nova Scotia; to Mr. F. A. Kerr for a report on the Moose River mine, N.S.; and to Mr. C. E. Cairnes for suggestions and information about the Nickel Plate and Aufeas mines in British Columbia. The section of this report dealing with the arsenical deposits in Hastings county, Ontario, has been prepared by Mr. M. E. Wilson and is included under his name. During the field season of 1924 the writer was assisted by E. B. Gillanders who rendered willing and efficient service.

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CHAPTER II

MINERALOGY OF ARSENIC

In chemical behaviour arsenic occupies a position intermediate between the metals and the acid-forming elements. It acts in both capacities and consequently forms in nature an exceptionally great variety of compounds: the native element; an oxide, As_2O_3; two sulphides, AsS and As_2S_3; arsenides; a series of sulph-arsenites, RAs_nS_m; arsenates of the acid, H_3AsO_4; and sulph-arsenates of the acid, $H_3As_nS_4$. It is an essential constituent in about one hundred and forty minerals, which form almost 12 per cent of the known mineral species. Of this number the following are, directly or indirectly, of economic importance: arsenopyrite, enargite, smaltite-chloanthite, niccolite, cobaltite, löllingite, sperrylite, tennantite or tetrahedrite, the copper arsenides, proustite, realgar, orpiment, and scorodite. Though many of the remaining minerals may occur locally in some abundance, the vast majority of them are only of mineralogical interest.

This peculiar chemical activity of arsenic, and its consequent unusually wide distribution among mineral deposits, make it of particular interest to prospectors and geologists. To them it serves as an "indicator" in somewhat the same manner as litmus, or phenolthalein, enables the chemist to detect the presence of acids or alkalis. Its importance in this rôle is all the greater because arsenic is not uncommonly found associated with still more valuable metals, such as: gold at the Nickel Plate mine; silver at Cobalt; copper at Butte, Mont.; etc. It is well known, for example, that the distinctive pink colour of cobalt bloom, or erythrite, was one of the best signs to prospectors at Cobalt of the presence of the rich silver ores of that camp. At the surface of the ground, where they become subject to weathering conditions, the primary compounds of arsenic change readily to brilliantly coloured ones, such as erythrite and annabergite, and catch the eye of the observer. Arsenic itself has also a distinctive garlic odour easily created by heating any of its compounds. Accordingly, the mineralogy of arsenic is reviewed at considerable length in the following pages.

Arsenic is readily dissociated by heat from its naturally occurring compounds and is recovered chiefly in the form of crude white arsenic or arsenious oxide, obtained as a by-product of general smelting operations, or by the direct roasting of arsenical ores. Once a drug on the market, arsenic is now the basis of a most important and flourishing branch of the insecticide industry. The sulphides, realgar and orpiment, are in many cases used in the manufacture of paints, dyes, and fireworks. Lately, a process has been introduced in Utah to utilize scorodite directly in the manufacture of calcium arsenate, thus obviating the necessity of using white arsenic as a starting point in making the insecticide.

The discussion of the mineralogy of arsenic has been arranged in such a way as to be of most service to the prospector who wishes to detect, with a minimum of equipment, the presence of arsenic in mineralized samples he has collected.

For this purpose the most distinctive and easily applied tests for arsenic have been grouped together and described in detail. It has, likewise, been thought advisable, in describing the mineral species, to group together those occurring most commonly as alteration or weathering products, since their discovery and recognition by the prospector may reasonably lead to finding the bodies of unweathered or primary arsenical ore. In addition to these "guide" minerals only those which are, or may become, sources of arsenic have been included. A more exhaustive treatment would, probably, be useless and confusing.

TESTS FOR ARSENIC

Many prospectors and miners recognize arsenic in the field by its garlic-like odour which is readily detected when such minerals as arsenopyrite, smaltite, or niccolite are struck a sharp blow with a hammer; indeed, this effect may become actually nauseating when these minerals are drilled underground. The same disagreeable odour can usually be detected when fragments of arsenical minerals are heated; and if the fragments are inserted in a flame the arsenic present generally imparts a pale violet colour to the flame.

Equipment

The following items of equipment, although not indispensable, can be easily obtained; they can be carried in the field without inconvenience, and greatly facilitate the application of the tests. Most essential are a blow-pipe, a few blocks of compressed charcoal, some narrow, hard, glass tubing, and a source of heat such as a candle, or preferably, a spirit lamp. The glass tubing should be cut into 4 and 6-inch lengths, and the shorter pieces sealed at one end to make the "closed-tubes", so-called to distinguish them from the longer, unsealed pieces called "open tubes". As a rule the open tubes should have an inside diameter equal to that of a lead pencil. The closed tubes may be slightly smaller. Although it is in many cases convenient to have a few chemical reagents at hand when testing minerals, yet, in the case of arsenic, these can be largely dispensed with. A little sodium carbonate or borax is of great assistance as a flux for minerals that are infusible, and either or both should form a part of the equipment. In using the blow-pipe it will be seen that, for all practical purposes, the flame produced consists of two parts, an inner or blue cone, and an outer, colourless fringe. When a mineral fragment is held just beyond the tip of the blue cone it is said to be in the "reducing flame". If it be held about an inch or more beyond the point of the blue cone it is in the "oxidizing flame". This distinction is based on the chemical reactions which go on within the flame and although these need not be discussed here it is important to remember that results differ widely according to whether the oxidizing or reducing part of the flame is used.

The tests given below are arranged in the order in which they are generally applied.

Flame Test

On heating arsenic minerals in the reducing flame, arsenic is given off and imparts a pale violet colour to the flame.

Roasting on Charcoal

Metallic arsenic and its compounds with the metals, or with sulphur and the metals, yield white fumes when heated in the oxidizing flame. These fumes, which consist of arsenic oxide, condense on cooler parts of the charcoal block at a considerable distance from the assay and form a characteristic white coating. This coating, being volatile, quickly disappears when a flame is brought near. If the powdered mineral is heated rapidly at first, or if the reducing flame be used, elemental arsenic, instead of arsenic oxide, is driven off and the typical odour of garlic will become most pronounced. Antimony, which gives a similar but denser coating, has no distinctive odour.

In the case of arsenates, such as cobalt bloom and nickel bloom, intense ignition in the reducing flame is required before they yield a garlic odour and a sublimate of white arsenic.

Roasting in the Open Tube

Arsenic, its sulphides, and the arsenides when *slowly* heated in the open tube, give off fumes identical with those obtained by roasting on charcoal. These fumes form a white, ring-like sublimate or coating on the cooler parts of the tube at some distance from the assay. On heating, this coating is readily driven out of the tube. As a rule the garlic odour is not very perceptible unless the material be heated too quickly.

If a mineral such as arsenopyrite, which contains sulphur as well as arsenic, is heated too rapidly in the open tube there is likely to form, in addition to the usual coating of white arsenic, a yellow or yellowish brown sublimate consisting of arsenic and sulphur and a grey or black coating of elemental arsenic. These yellow and black coatings result from a deficiency of air in the tube and are exactly similar to the coatings which this mineral would give in the closed tube. If sufficient air circulate through the tube, sulphurous fumes will be given off, and a larger deposit of white arsenic will be formed.

Heating in the Closed Tube

Metallic arsenic and some of the arsenides yield a brilliant, black, ring-like coating when heated in the closed tube. This coating, often referred to as the "arsenic mirror", is usually grey near the hot end of the tube and black farther away. If the closed end of the tube be broken off and the arsenic volatilized, the garlic odour may be detected, thus distinguishing the arsenic mirror from other black sublimates.

In the case of arsenates, such as cobalt bloom or scorodite, which are readily fusible, it is necessary merely to insert a few splinters of charcoal into the closed tube with the powdered mineral before heating intensely in order to obtain the arsenic mirror. If the arsenate be infusible, as is seldom the case, the mineral powder may be fused with about four volumes of dried sodium carbonate and a little charcoal dust. This mixture in the absence of metals such as copper or lead will yield an arsenic mirror on intense ignition.

When antimony is present it is in many cases difficult to tell from the character of the sublimates obtained on charcoal or in the open tube whether arsenic also occurs in the mineral being tested. To settle this question the white coating obtained either on charcoal or in the open tube should be removed and placed at the bottom of a closed tube with a few splinters of charcoal directly above it. After the charcoal splinters are heated to redness, the flame should be held below the coating which will readily turn to vapour, and after passing over the hot charcoal a black ring or mirror will be formed in a cool part of the tube if arsenic be present. By breaking the tube and touching the flame to this mirror the resulting odour of garlic will confirm the presence of arsenic. In the closed tube, metallic antimony, unlike arsenic, is non-volatile except at very high temperatures and, moreover, it lacks the peculiar and distinctive odour which accompanies the vaporization of arsenic.

Sublimate on Gypsum

This test is given here more for the sake of completeness than for its general usefulness. If the powdered mineral be moistened with a few drops of hydriodic acid and heated gently on a gypsum or plaster tablet in the oxidizing flame, there will be formed, if arsenic be present, a volatile, orange-yellow coating; if antimony, a red coating which disappears in strong ammonia fumes; and if bismuth, a chocolate-brown sublimate which changes to brilliant red when exposed to ammonia fumes.

PRINCIPAL ARSENIC MINERALS

In the following descriptions of the chief arsenic-bearing minerals of practical concern an attempt has been made to divide them into: (1) a group of secondary minerals, due to weathering action of one sort or another and, therefore, apt to be localized near the surface of the earth, especially in Canada, where glaciation has swept away so much weathered rock-matter; and (2) a group of primary minerals due to igneous action or other deep-seated agency and, therefore, apt to form deposits that extend to considerable depths.

MINERALS OF SECONDARY OR SUPERGENE ORIGIN

The minerals listed below have been formed by the alteration of primary or original arsenical minerals that have been exposed to weathering processes such as oxidation and hydration. These alteration products are in many cases the first encountered in the field and their recognition may aid in the discovery of more valuable bodies of primary arsenical ore. They are: annabergite (nickel bloom), arsenolite, erythrite (cobalt bloom), mimetite (arsenical lead-chloride), olivenite, pharmacolite, pharmacosiderite, and scorodite. Certain other minerals, such as native arsenic, proustite, realgar (red sulphite of arsenic), and orpiment (yellow sulphide of arsenic) are generally regarded as being alteration products, but this opinion is by no means unanimous. They have, therefore, been placed at the end of this group.

Annabergite or Nickel Bloom

Nickel bloom is a soft, apple-green mineral that forms crusts or powdery coatings on or near nickel arsenides. It is an arsenate of nickel

($Ni_3As_2O_8 + 8H_2O$) and contains about 25 per cent arsenic. When heated in the closed tube with splinters of charcoal an arsenic mirror is formed and water is given off. It yields a sublimate of white arsenic on charcoal and usually the garlic odour is noticeable. The residue becomes magnetic when heated in the reducing flame. The mineral is soluble in hydrochloric acid.

The readiness with which the green coating of nickel bloom forms near deposits outcropping at the surface and on the walls of underground workings is in many cases of great help to the prospector or miner in locating masses of unaltered nickel arsenides. It should not be confused with the more common green carbonate of copper, malachite, which may occur in a similar manner. Annabergite is in many places associated with cobalt bloom and in a few cases with pharmacolite and arsenolite. Nickel bloom has been noted in a number of localities in Ontario, but principally in Timiskaming district. There it is in some cases mixed in such proportions with the pink cobalt bloom that the mixture is white or some other intermediate colour between green and pink.

Arsenolite

This mineral, which is identical in composition with the white arsenic obtained by roasting arsenical ores, forms soft, earthy encrustations on such minerals as arsenopyrite or smaltite, which have been exposed to weathering. It is usually colourless, white, or even yellowish, and has a vitreous or silky lustre.

It is an oxide of arsenic (As_2O_3) containing 75·76 per cent arsenic. When heated on charcoal arsenolite gives a white coating and the arsenic odour. It is soluble in hydrochloric acid and in hot water.

Although arsenolite never occurs in nature in sufficient abundance to be of commercial value, yet it may be an aid to the prospector in locating other arsenical minerals. It has been noted as a coating on native arsenic at Watson Bar creek, British Columbia, also at Cobalt, and at several other localities in Ontario.

Erythrite or Cobalt Bloom

Cobalt bloom in some cases occurs in small, needle-like crystals, but more commonly it is found as rounded or kidney-shaped masses, in rosettes, and as earthy encrustations that vary in colour from crimson- or peach-red, when unaltered, to grey in decomposed material. When nickel bloom is mixed with it, the two minerals give rise to a mixture called "white bloom". Cobalt bloom is an arsenate of cobalt ($Co_3As_2O_8+8H_2O$) that contains about 25 per cent of arsenic.

The powdered mineral is light red, but becomes lavender-blue when dried. When heated on charcoal it yields a coating of white arsenic and usually the garlic odour, the residue being magnetic. In the closed tube it gives an arsenic mirror if heated with charcoal. If fused with borax in the reducing flame the deep-blue colour indicating cobalt will be obtained. Erythrite is soluble in hydrochloric acid.

Like nickel bloom, erythrite occurs as a coating along crevices in or near altered arsenides. Its distinctive pink colour is a great aid in prospecting for minerals such as smaltite or cobaltite. In Cobalt district it is regarded as a promising indication of veins containing arsenides and native silver. It has been reported in a number of localities in Ontario and British Columbia and occasionally from the North West Territories and Yukon.

Mimetite

Mimetite often occurs as six-sided crystals that are typically honey-yellow in colour, but may be brown, orange-yellow, white, or colourless. The tendency to form globular, kidney-shaped or earthy masses is characteristic of this mineral. It lacks a distinct cleavage, is easily scratched with a knife, and gives a white streak or powder. It is an arsenate of lead $(PbCl)Pb_4(AsO_4)_3$, which contains about 15 per cent arsenic. In part, phosphorus may be present instead of arsenic and calcium in place of lead. It fuses readily on charcoal and usually gives a coating of white arsenic. In the closed tube it will give an arsenic mirror if heated with a few splinters of charcoal. If the powdered mineral be fused with soda in the reducing flame, globules of lead will be formed. It is soluble in nitric acid.

Crusts or masses of mimetite in many cases result from the decomposition of galena associated with arsenopyrite or other arsenical minerals. Occasionally it is mined as an ore of lead and in such cases only would its arsenic content be of value.

Olivenite

Olivenite occurs in crystalline, fibrous, or earthy forms. It is usually olive-green or blackish green, although the fibrous variety, called wood-copper, may be brown, straw-yellow, grey, or white. Rounded or kidney-shaped masses and earthy encrustations are the most common. It is easily scratched with a knife, giving an olive-green to brown powder in most cases.

Olivenite is a hydrous arsenate of copper $(Cu_3As_2O_8Cu(OH)_2)$ containing about 30 per cent arsenic. When heated on charcoal it fuses and colours the flame bluish green and gives off arsenical fumes. On heating in the closed tube with charcoal an arsenic mirror is formed. If the roasted residue be fused with soda in the reducing flame a globule of copper can be obtained. Olivenite is soluble in nitric acid.

Olivenite in some cases occurs in the gossan of copper-arsenic deposits, but has not been found in commercial quantities. It may serve, however, to suggest the presence of such minerals as arsenopyrite and chalcopyrite in a deposit.

Pharmacolite

This mineral occurs as delicate, silky fibres in many places in bunches or in rounded, spongy masses. It is usually white to greyish in colour, but may be pinkish or greenish, due to the presence of cobalt or nickel. It is quite soft and gives a white streak.

Pharmacolite is a hydrous arsenate of lime $(HCaAsO_4+2H_2O)$ which contains 34·7 per cent of arsenic. When fused with soda and charcoal in the closed tube it gives an arsenic mirror. If the mineral be dissolved in concentrated hydrochloric acid a white precipitate of calcium sulphate forms on the addition of sulphuric acid.

Pharmacolite occurs as an alteration product near arsenical cobalt and nickel minerals and also with arsenopyrite. It has not been recognized in Canada as yet.

Pharmacosiderite

Pharmacosiderite usually occurs in cubic crystals which vary from grass-green to yellowish brown or honey-yellow. Its streak is slightly paler than the mineral. It is somewhat softer, of lower density, and more easily fusible than scorodite which it strongly resembles.

Pharmacosiderite is an hydrous arsenate of iron ($6FeAsO_4.2Fe(OH)_3+12H_2O$), which contains about 28 per cent of arsenic. Some varieties contain potash. When heated on charcoal arsenic fumes are given off, a sublimate of white arsenic forms, and the residue fused with soda becomes magnetic. In the closed tube an arsenic mirror is obtained on heating the mineral with a fragment of charcoal. It dissolves in hydrochloric acid, giving a yellow solution.

Pharmacosiderite is usually found with limonite in the gossan formed by the alteration of arsenopyrite or löllingite. It has not been recognized in Canada.

Scorodite

Scorodite usually occurs as leek-green, bluish green to brown, fibrous or earthy masses and encrustations in the gossan of arsenical deposits containing arsenopyrite, enargite, or löllingite. It has a glossy to resinous lustre, a greenish white streak, and is easily scratched with a knife.

Scorodite is a hydrous ferric arsenate ($FeAsO_4+2H_2O$) which contains 32·4 per cent arsenic. On charcoal scorodite fuses easily, yielding an odour of garlic and a coating of white arsenic. If the roasted residue is fluxed with soda it becomes magnetic. Scorodite is soluble in hydrochloric acid, giving a yellow solution. It is somewhat harder than pharmacosiderite which it strongly resembles. Nickel bloom, besides being softer than scorodite, gives a green solution in hydrochloric acid.

It is only recently that scorodite has become of commercial importance. In Utah it has been found in sufficient quantities to be mined and converted into calcium arsenate for insecticide purposes. It has been reported from Cobalt district and from Hastings county, Ontario; also in Yukon.

Native Arsenic

Arsenic usually occurs in the native state in granular or variously shaped compact masses. It is tin-white, but readily tarnishes to dark grey or black. It has a very perfect cleavage, but this is seldom observed; it is quite brittle and gives a grey to brown or black streak when scratched with a knife.

In addition to elemental arsenic the naturally-occurring mineral may also contain some antimony and traces of iron, bismuth, cobalt, nickel, silver, and gold. When considerable antimony is present in the arsenic the mixture is called allemontite. When heated on charcoal the mineral imparts a violet colour to the flame, yields a strong odour of garlic, and a coating of white arsenic, and disappears entirely on continued heating. In the closed tube it gives an arsenic mirror.

Though of no commercial importance native arsenic is in many cases met with in silver-cobalt deposits and is generally regarded as being an alteration product of other arsenical minerals. It has been found in small amounts in several localities in British Columbia, Ontario, and Quebec.

Proustite

Proustite, or light ruby silver as it is in many cases called, occurs in six-sided crystals and in disseminated, branching, or compact masses and encrustations. It is scarlet-red, but darkens on exposure to light. It has a distinct cleavage, is soft and brittle, and gives a bright red streak.

Proustite (Ag_3AsS_3) contains 15·2 per cent arsenic, 19·4 per cent sulphur, and 65·4 per cent silver. In many places it contains a little antimony. On charcoal it is very easily fusible, yielding sulphurous and arsenical fumes and a coating of white arsenic when gently heated. If the roasted residue be fused with soda, a button of silver will be obtained. In the closed tube it gives an abundant sublimate which is red when hot and reddish yellow when cold. Proustite is decomposed by nitric acid with the separation of sulphur.

Proustite, an important ore of silver, occurs associated with antimonial ruby silver, galena, and other silver ores, usually in a calcite gangue. It has been reported from several localities in British Columbia and Ontario.

Realgar and Orpiment

These two minerals resemble one another so strongly both in physical and chemical properties and in mode of occurrence that they may well be described together. Realgar usually occurs in bright red to orange-yellow, granular, or compact masses, with a good cleavage and resinous lustre. Orpiment is lemon-yellow and commonly forms foliated or columnar masses having a perfect cleavage. Both minerals can be readily cut with a knife and when pulverized give powders slightly paler than the original minerals.

Realgar (AsS) contains 29·9 per cent sulphur and 70·1 per cent arsenic; orpiment (As_2S_3) 39·0 per cent sulphur and 61·0 per cent arsenic. Both minerals burn with a bluish white flame and give off a strong odour of arsenic when roasted. In the closed tube realgar gives a red coating and orpiment a yellow one. Realgar is partly soluble in caustic potash solution, but orpiment is wholly soluble.

In many instances orpiment is known to have formed from realgar. These sulphides are usually found in the oxidized zone and are generally regarded as being derived from other arsenic minerals. They are in many cases present in thermal-spring deposits. Realgar has been found near Wolf lake and at Watson creek, B.C.; in Hastings county, Ont.; and on Pan creek in Yukon.

MINERALS USUALLY OF A PRIMARY OR HYPOGENE ORIGIN

Of the minerals given under this heading the following are probably always of hypogene origin: arsenopyrite, löllingite, and sperrylite. Some doubt has been cast on the origin of the remaining minerals by statements suggesting that they too may be alteration products, but the consensus of opinion is that they are, in the great majority of cases, formed by hypogene processes.

Arsenopyrite or Mispickel

This mineral is silver white to light steel grey on freshly broken surfaces, but on exposure usually tarnishes to brass-yellow, dull grey, or black. Crystals flattened and shaped somewhat like an ax-blade are quite common and many show linear markings or striations on certain faces. The mineral also occurs in lath-like, straight, or divergent crystal growths. In most cases, the mineral forms compact or granular masses, or is intergrown with other minerals such as pyrite, chalcopyrite, or pyrrhotite. Although quite brittle, it is slightly harder than a knife-blade, and when scratched or pulverized it yields a greyish black powder. It usually shows a good cleavage.

Arsenopyrite is an arsenosulphide of iron (FeAsS) and contains when pure 46·0 per cent arsenic, 19·7 per cent sulphur, and 34·3 per cent iron. Some of the iron may be replaced by 3 to 9 per cent of cobalt, giving the variety called danaite. Glaucodot also resembles arsenopyrite, but contains almost equal amounts of cobalt and iron. In addition to cobalt, arsenopyrite may contain nickel, antimony, bismuth, silver, and gold. Its gold content is in many cases of commercial importance. Recently iridium has been found associated with arsenopyrite at Howry creek, Ont.

On oxidation, arsenopyrite gives rise to iron-stained weathering products, the commonest being scorodite, pharmacosiderite, pitticite, arsenolite, and a black coating of unknown composition.

Arsenopyrite will give tests for arsenic in the open or closed tubes and on charcoal. The residue or globule formed by heating on charcoal will be found to be magnetic.

Arsenopyrite is the most common and most widely distributed arsenic-bearing mineral. It occurs in many localities in Nova Scotia, Ontario, and British Columbia, particularly in quartz veins or in deposits associated with granitic rocks. At the present time it is being mined as a source of gold at Hedley, B.C., its arsenic content being recovered as a by-product. No arsenopyrite has been mined in Canada solely for the arsenic it contains.

Cobaltite

Cobaltite in many places occurs as silver-white, in many cases striated crystals that strongly resemble in shape those of ordinary iron pyrite. When in granular or compact masses the colour is usually steel-grey, with a reddish or violet tinge. The mineral is brittle, about as hard as a knife-blade, and gives a greyish black powder when scratched. It has a good cubic cleavage.

Cobaltite is an arsenosulphite of cobalt ($CoAsS$) and contains 45·2 per cent arsenic, 19·3 per cent sulphur, and 35·5 per cent cobalt. The composition varies somewhat, depending on the amount of iron present, which may amount to 12 per cent or more in the variety called ferro-cobaltite. It alters chiefly to cobalt bloom. An arseno-sulphide of nickel called gersdorffite ($NiAsS$) resembles cobaltite in most of its properties, but is much less common.

Cobaltite does not give an arsenic mirror in the closed tube, but when heated on charcoal sulphurous fumes are given off, a coating of white arsenic is formed, and the remaining globule becomes magnetic. If the residue left from roasting be fused with borax, the deep-blue colour of cobalt oxide will be obtained. Cobaltite is soluble in warm nitric acid with the separation of sulphur.

Cobaltite in many cases occurs associated with silver ores, as at Cobalt, Ont., where it is usually difficult to distinguish from the more common smaltite. It alters readily to cobalt bloom.

Enargite

Enargite usually occurs in greyish black to iron black, compact, granular, or columnar masses, which almost invariably show one or more distinct cleavages. This mineral is easily scratched with a knife and gives a brittle, greyish black powder.

Enargite (Cu_3AsS_4) contains 19·1 per cent arsenic, 32·6 per cent sulphur, and 48·3 per cent copper. In many places it has some iron or zinc replacing copper and some antimony in place of arsenic. It is quite resistant to weathering, but when once attacked the arsenic may be wholly carried away and enriched copper ores in some cases result. When heated on charcoal enargite gives off the garlic odour and a coating of white arsenic. In the open tube the powdered mineral when gently heated yields sulphurous and arsenical fumes, the latter condensing as white arsenic on the walls of the tube. Copper can be obtained from the roasted residue by fusing with soda.

Enargite, so far as is known, is of rare occurrence in Canada. At Butte, Mont., however, it is the chief source of the arsenic recovered from the copper ores mined there.

Löllingite

This arsenide is rarely crystalline and usually occurs as disseminated, granular, or needle-like aggregates and in compact masses, silver-white to grey. It has a fairly distinct cleavage and is quite brittle. A knife-blade barely scratches it, but when pulverized the powder is greyish black.

Löllingite ($FeAs_2$) contains 72·8 per cent arsenic and 27·2 per cent iron. In many cases it contains a fixed sulphur and a variable arsenic content and thus approaches arsenopyrite in composition. With decrease of arsenic it passes into leucopyrite (Fe_3As_4). Cobalt, nickel, bismuth, antimony, and gold are common impurities in löllingite. It usually weathers to scorodite. When heated on charcoal löllingite yields a garlic odour and a coating of white arsenic. The residue is strongly magnetic. In the closed tube it quickly gives an arsenic mirror, but no red coating, as does arsenopyrite.

Löllingite is not a common mineral, but does occur in commercial quantities along with arsenopyrite at Reichenstein in Silesia, where it is mined for its arsenic and gold content. It has been reported from Peterborough county, Ont.

Niccolite

This mineral is rarely crystalline, but occurs usually in dense masses and in lath-like, branching, or kidney-shaped forms. It is pale copper-red and tarnishes brown or greyish. It can be barely scratched with a knife, is brittle, and gives a brownish black powder when pulverized.

Niccolite is an arsenide of nickel (NiAs) consisting of 56·1 per cent arsenic and 43·9 per cent nickel. It usually contains a little iron and cobalt and also sulphur. When antimony is present it grades into breithauptite (NiSb). On exposure it becomes coated with green nickel bloom. When heated on charcoal or in the open tube a coating of white arsenic is deposited and the residue becomes yellowish green. In the closed tube it gives an arsenic mirror on intense ignition. It is soluble in concentrated acids, giving a green solution.

Niccolite is an important ore of nickel and arsenic and occurs in some abundance with native silver at Cobalt, Ont. It has also been found in minor amounts on Michipicoten island and on Silver islet, Ont.

Smaltite-Chloanthite

Smaltite usually occurs in compact, granular, or fibrous masses of tin-white to steel-grey colour which may be iridescent or greyish from tarnish. It is brittle, about as hard as steel, and yields a greyish black streak when scratched. In many places it exhibits a distinct cleavage. Chloanthite has the same properties.

Smaltite is essentially cobalt diarsenide ($CoAs_2$), but graduates with increase of nickel content into chloanthite ($NiAs_2$), from which it cannot be distinguished in a hand specimen. Both minerals contain about 71·9 per cent arsenic and 28·1 per cent of cobalt or nickel respectively. Analyses show that the arsenic content fluctuates only slightly, although the relative proportions of cobalt or nickel show wide variations. Iron may be present up to 18 per cent and imparts a grey colour to the minerals. Two other minerals, safflorite and rammelsbergite, the former having the same composition as smaltite, the latter that of chloanthite, differ from them in their crystal habit which resembles that of arsenopyrite. They are of no economic importance. On exposure to weathering, smaltite gives rise to the conspicuous, pink cobalt bloom, chloanthite alters to green nickel bloom, and arsenolite may form from both minerals.

Heated on charcoal, smaltite and chloanthite give the arsenic odour, and fuse to a brittle, greyish black, magnetic globule. In the closed tube it is in some cases difficult to obtain an arsenic mirror from these minerals. In order to test for cobalt the powdered mineral should be roasted on charcoal to drive off all the arsenic, the residue being then fused with borax in the reducing flame. If the mineral contain cobalt the borax will turn a deep blue colour even in the presence of iron, nickel, or copper. In the absence of nickel, smaltite dissolves in nitric acid, giving a rose-red solution. Chloanthite gives a greenish yellow solution if dissolved in nitric acid and no cobalt be present.

Smaltite and chloanthite are important ores of cobalt and nickel and are in many places associated with native silver, as in Timiskaming district, Ont. Together with cobaltite and niccolite they have formed the chief source of arsenic in Canada since 1905.

Sperrylite

Sperrylite is the only known compound, found in nature, that contains platinum. It occurs in tiny, tin-white crystals which are harder than steel and give a black powder when crushed.

Sperrylite ($PtAs_2$) contains 43·5 per cent arsenic and 56·5 per cent platinum. It may also carry small quantities of rhodium, iron, and antimony. On charcoal it gives a white sublimate of arsenious oxide. In the open tube a platinum sponge remains after driving off the arsenic by gentle heating. This platinum residue is insoluble in any single acid.

Sperrylite was first found at the Vermilion mine in Sudbury nickel district, Ont., where it is associated with the nickel ores. It has been mentioned here for the reason that recently a metal of the platinum group, probably iridium, has been detected in a gold-arsenopyrite deposit at Howry creek, about 60 miles south of Sudbury.

Tennantite or Tetrahedrite

These minerals, often referred to as grey copper ore, can in some cases be identified by their characteristic crystal form, which consists of four triangular faces. More commonly they occur in coarse to fine, granular, or compact masses varying from lead-grey to iron-black in colour. Tennantite shows no cleavage, is brittle, and easily scratched with a knife, giving a streak or powder which is usually black, but which may be reddish-brown in some zinc-bearing varieties.

Tennantite ($Cu_8As_2S_7$) consists of 17·0 per cent arsenic, 25·5 per cent sulphur, and 57·5 per cent copper. Strictly speaking, tetrahedrite ($Cu_8Sb_2S_7$) contains antimony instead of arsenic, but usually the latter is present, so that the two mineral species grade into one another. Grey copper ore may also carry a number of impurities such as iron, zinc, lead, manganese, more rarely nickel, cobalt, and selenium, and some silver or mercury in paying quantities.

Varieties of grey copper ore which contains considerable arsenic fuse easily and yield sulphurous fumes and a coating of white arsenic when heated on charcoal. By touching the reducing flame to this coating the resulting garlic odour will indicate the presence of arsenic. It is quite likely that the mineral will contain some antimony as well as arsenic. In order to detect the latter the white coating obtained by roasting on charcoal should be transferred to a closed tube and a splinter of charcoal placed above it. First heat the charcoal to redness and then warm the coating which will turn to vapour and after passing over the hot charcoal a shiny black mirror will be formed in the tube if arsenic be present. Copper can be detected in the mineral by the green colour it imparts to the flame, or by the blue colour obtained when a nitric acid solution of the mineral is neutralized with ammonium hydroxide.

Tennantite and tetrahedrite are in many cases associated with the sulphides of lead, zinc, copper, and iron in the so-called complex ores. Both minerals have been reported from a number of localities in British Columbia and Ontario.

Copper Arsenides

There are several naturally-occurring arsenides of copper to which such names as domeykite, whitneyite, mohawkite, and algodonite have been applied. Since these minerals have, in many cases, been found to be mixtures it will avoid confusion if they are described as a group rather than individually. They vary in colour from tin-white, steel-grey, to reddish white, and all tarnish readily to brown, purple, or black. They usually occur in fine, granular, or heavy, compact masses. With the exception of whitneyite, which is malleable, the other arsenides are brittle and all can be easily scratched with a knife.

These arsenides contain 11 to 28 per cent arsenic, from 65 per cent to 88 per cent copper, and up to 10 per cent of nickel or cobalt replacing the copper. When heated on charcoal they yield a coating of white arsenic. The presence of copper can be detected by the emerald-green colour it imparts to the flame; this becomes azure-blue if the mineral be first moistened with hydrochloric acid.

Domeykite has been reported from Michipicoten island, and from Silver islet, Ont. Recently, large quantities of the arsenides have been encountered in the Lake Superior copper mines, where they are being utilized for their arsenic content.

AN ARSENIC ORE

The bulk of the arsenic recovered throughout the world is obtained as a by-product of general smelting operations. In most cases, the ores are mined and treated primarily for the gold, silver, copper, or lead content and not for the small percentage of arsenic they carry. Strictly speaking, an ore of arsenic must contain sufficient of the element to make its extraction profitable. As the market price of white arsenic has fluctuated from $5\frac{1}{2}$ to nearly 16 cents a pound since 1921 it is obvious that what may be an ore when white arsenic is selling at the latter figure may be worthless if the price drop to $5\frac{1}{2}$ cents a pound. For the economical operation of an arsenic recovery plant the ore should contain at least 15 per cent arsenic. Lower-grade material requires concentration before its arsenic content can be utilized. In the absence of other values, it is doubtful if material containing less than 5 per cent arsenic could be mined, concentrated, treated, and the product marketed at a profit. An ore containing 1 per cent arsenic (20 pounds to the short ton) should give a theoretical yield of 1·32 per cent or 26·4 pounds of white arsenic (As_2O_3) a short ton of ore. In the practical operation of an arsenic recovery plant about 85 per cent of the arsenic content is recovered as As_2O_3, 2 to 3 per cent remains in the calcined material, and the balance is lost in flue dust or fumes. Ores to be treated in a plant of this kind should contain no antimony, cadmium, or mercury, as these elements contaminate the product. As a rule smelters will pay for gold, silver, copper, or lead content in the calcines and penalize for zinc in excess of certain limits.

CHAPTER III

GENERAL GEOLOGY

Although arsenic is quantitatively one of the rare elements in the earth's crust, of which it composes perhaps no more than 0·0003 per cent, it is more abundant than such well-known metals as tin, mercury, and silver. It is a component of a great number of minerals and enjoys a wide distribution, but essentially all the mineral deposits which are valuable for their arsenic content have been derived from igneous rocks by processes of concentration. In a general way it may be said that these deposits are associated in more cases with intrusive (batholiths, stocks, dykes, sills) than extrusive (flows) igneous bodies, and with acid rather than basic rocks. Such deposits have been formed under the most varied conditions of temperature and pressure. This is due to the fact that arsenic is an exceedingly mobile element and one which is readily transported in the gaseous state, in solution, and as a colloid. Evidence of this mobility is to be found in the frequency with which arsenic occurs in volcanic exhalations and at fumarolic vents; in springs and spring deposits; in mine waters; in organic matter, particularly coal deposits; and finally in sea-water.

Arsenic-bearing minerals occur in areas underlain by igneous rocks or in regions where the formations, sedimentary or metamorphic, have been invaded by igneous masses. In Canada such areas are present in the Cordilleran region, in the Canadian Shield, and in the Acadian province. Unfavourable for the occurrence of arsenic, because of the absence of igneous bodies, are the areas of sedimentary rocks which comprise the Great Plains region (including most of Alberta, the southern half of Saskatchewan, and the southwestern part of Manitoba); the Hudson Bay lowlands (territory west and south of James bay); and the St. Lawrence region (including southeastern Ontario).[1]

The Cordilleran region of Canada lies between the eastern foothills of the Rockies and the Pacific ocean, and stretches northward from the 49th parallel to beyond the Arctic circle. This vast tract of mountain ranges and plateaux varies in width from 300 to 500 miles and extends in a northwest direction for 1,200 miles. Almost all this rugged area of 350,000 to 400,000 square miles lies within British Columbia and Yukon. The region is underlain by great thicknesses of Precambrian, Palæozoic, and Mesozoic sedimentary and volcanic rocks which, during the Mesozoic and early Tertiary, were invaded by successive batholithic intrusions of granodiorite and quartz diorite, with subordinate proportions of more acid and basic types. The most important metallogenetic epochs in the history of the Cordilleran region accompanied or followed these intrusions. Affiliated with them are deposits of gold, silver, copper, lead, and zinc, in which conspicuous amounts of arsenic are present. The Tertiary period was also characterized by the eruption of vast flows of lava which cover thousands of square miles in central British Columbia. No arsenic deposits are

[1] For a general account of the geology and mineral resources of Canada, the reader may refer to the publication, "Geology and Economic Minerals of Canada," Economic Geology of Canada Series, No. 1. Special reports dealing with the iron ores, talc, lead, and zinc ores, and other classes of Canadian mineral deposits, are in course of preparation.

known to occur in these rocks. The eastern part of the Cordilleran region, namely the Rocky mountains and, to the north, Mackenzie mountains, is largely an assemblage of sedimentary strata; igneous rocks are limited to a few districts, and metalliferous deposits, and, therefore, those carrying arsenic, are rare.

The vast expanse of Precambrian rocks which forms the eastern half of Canada comprises what is known as the Canadian Shield. This region, which extends from St. Lawrence basin to the Arctic ocean and from the Great Plains to the Atlantic, has an area of approximately 2,000,000 square miles. The ancient rocks of which it is composed consist largely of granite and gneiss, with subordinate, but, nevertheless, very large amounts of volcanic rocks and closely associated sediments into which the granitic rocks penetrate. These rocks constitute what is in many cases referred to as the Basement complex. Here and there on the Shield and, in places, occupying large districts, are remnants of younger Precambrian sediments that were deposited on the Basement complex. These later formations nearly everywhere were invaded before Cambrian time by dykes and sills of diabase, and, in at least one district which borders Georgian bay, were invaded by granite. The various periods of igneous activity mark as many metallogenetic epochs during which deposits containing copper, nickel, gold, silver, and arsenic were formed.

The Acadian province includes that part of the Appalachian region of North America which lies within Canada. This region is underlain by a broad belt of folded and faulted Precambrian and Palæozoic rocks, which extends from Alabama to Newfoundland, a distance of approximately 2,000 miles. In Canada this belt covers an area of about 50,000 square miles and lies southeast of St. Lawrence River valley, within the provinces of Quebec, New Brunswick, and Nova Scotia. Towards the close of the Devonian period, batholithic masses of granite were intruded throughout the area. The gold-arsenopyrite-quartz veins of Nova Scotia are thought to be genetically connected with these irruptions.

In Chapter IV of this report are given descriptions of all the known occurrences of arsenic-bearing minerals in Canada irrespective of any considerations as to their probable value as possible sources of arsenic. The deposits referred to may be divided into: (1) mineralogical occurrences, and those about which little definite information is available as to their extent, mode of occurrence, and origin; and (2) those about which sufficient is known to permit of further classification. Deposits belonging to this latter group may be subdivided with regard to their origin, form, mineralogical composition, and mode of occurrence as follows:

(A) Hypogene deposits or those formed by ascending emanations:

(1) *Fissure Veins.* Under this heading are included those deposits which have resulted from the filling of fissures by mineral matter or from the injection of such material in tabular, dyke-like forms. These veins are characterized by distinct walls. The gangue usually consists of quartz, in fewer cases of carbonates or brecciated wall-rock. The principal types of arsenic-bearing fissure veins found in Canada are:

(*a*) Quartz-arsenopyrite-gold veins. These are associated with intrusions of granites, granodiorite, and diorite. Other minerals in many cases present are: pyrite, pyrrhotite, chalcopyrite, galena, scheelite, stibnite, fluorspar, calcite, and tourmaline. Examples are the gold veins of Nova Scotia; Hastings county, Ont.; Hope, B.C.; and Dublin gulch, Yukon.

(*b*) Silver-lead-zinc-arsenic veins. These are affiliated with bodies of granite or granodiorite. The minerals usually present are: galena, zinc blende, arsenopyrite, chalcopyrite, pyrite, tetrahedrite, jamesonite, quartz, carbonates, and in some cases gold. Examples are the Silver Standard and American Boy veins, near Hazelton, B.C.; and the J. and L. near Revelstoke, B.C.

(*c*) Calcite-realgar veins. Such veins are known to occur only in andesitic rocks near Wolf lake, Vancouver island.

(2) *Replacement Deposits.* These result from a process of mineralization which involves either the recrystallization or the removal of certain rock constituents and the simultaneous deposition of new minerals in their place. Such deposits are characterized by irregularity of form and by the lack of distinct walls. The types of arsenic-bearing replacement deposits found in Canada are:

(*a*) Contact-metamorphic deposits. These occur at or near the contacts of intrusive rocks such as granite, granodiorite, and gabbro. They are usually characterized by the presence of so-called contact minerals such as epidote, garnet, actinolite, and scapolite, in addition to calcite, quartz, and sulphides. Deposits of this type occur on Nickel Plate and Stemwinder mountains in Hedley district, B.C., and in Hastings county, Ont.

(*b*) Those in which there has not been a marked development of contact minerals. This group merges into the replacement type of veins described below, but differs from them in that the ore-bodies tend to be irregular in form rather than vein-like. These deposits are characterized by impregnations of arsenopyrite, pyrite, pyrrhotite, and chalcopyrite. Examples are the Big Dan, Timagami, Ont.; L. H., Silverton, B.C.; and the slate belts of Nova Scotia.

(3) *Replacement Veins.* These include vein-like deposits which owe their form to a combination of the processes involved in 1 and 2, that is, they have originated in part by the filling of open spaces and in part by the replacement of more or less shattered wall-rocks. The ore-bodies are usually lens-shaped. In this group belong:

(*a*) Silver-cobalt-nickel-arsenic veins. These consist chiefly of smaltite-chloanthite, niccolite, cobaltite, arsenopyrite, and native silver in a carbonate gangue. Veins of this type are found at Cobalt, Gowganda, and South Lorrain, Ont., where they are associated with sills of diabase.

(*b*) Silver-lead-zinc-arsenic veins. These are characterized by such minerals as galena, zinc blende, arsenopyrite, tetrahedrite, chalcopyrite, pyrrhotite, jamesonite, quartz, and calcite. Examples are the Mamie, Coronado, and Victory veins on Hudson Bay mountain, Smithers, B.C.

(*c*) Pyrite-arsenopyrite-gold veins. The gangue in deposits of this kind is usually calcite, quartz, and partly replaced wall-rock. The ore-bodies on the Crown Reserve and Associated Goldfields properties in Larder Lake area, Ont., and at the Native Son property in Bridge River district, B.C., belong to this class.

(B) Supergene deposits or those formed from hypogene deposits by the action of descending surface waters. These are characterized by the development of such products as arsenolite and scorodite from arsenopyrite; cobalt bloom from smaltite or cobaltite; nickel bloom from niccolite or chloanthite; and native arsenic from realgar or arsenopyrite. Deposits of this type are of little or no importance in Canada since the weathered parts of most of the arsenic-bearing veins and ore-bodies have been removed by glaciation.

Deposits of arsenic-bearing minerals similar to those found in Canada are known to occur in other parts of the world. In addition, there are certain types of commercially valuable arsenic deposits in foreign countries which are not represented in Canada. Among these may be mentioned the copper-tin-arsenic lodes of Cornwall; the realgar deposits of southwestern China; the enargite ores of Butte, Mont.; and the scorodite deposits of Gold Hill, Utah. Of these, the type least likely to be found in Canada is that containing large bodies of scorodite. This mineral is formed most extensively in the upper zones of arsenical deposits which have been exposed to weathering under arid conditions. In this country such zones have been largely removed by glaciation.

ARSENIC-BEARING AREAS

In a previous paragraph mention was made of the fact that the known occurrences of arsenic-bearing minerals in Canada are confined to the Cordilleran region, the Canadian Shield, and the Acadian portion of the Appalachian region. Within each of these geological provinces there are areas each characterized by the presence of arsenical deposits that show a striking resemblance to one another. The individual areas that thus hold deposits of geologically related types and age constitute what may be termed "genetic arsenic provinces". As an example may be cited a part of northern Ontario, comprising the Keweenawan diabasic intrusions, which includes Cobalt, Gowganda, South Lorrain, Sudbury, and Silver Islet, and even the copper-producing area in Michigan. Most of the arsenic-bearing deposits of this district are related, inasmuch as they are products of the igneous activity of late Precambrian (Keweenawan) time. At present the geological data available are insufficient for the delineation of all the genetic arsenic provinces in Canada. As exploration is carried on it is to be expected that new genetic arsenic provinces will appear and the boundaries of those already known will be enlarged. In the following paragraphs the salient features of the principal arsenic-bearing areas are briefly discussed.

CORDILLERAN REGION

The chief arsenic-bearing areas in the Cordilleran region occur along the eastern flank of the Coast range and in south-central British Columbia. The axis of the Coast mountains consists of a series of great granitic batholiths, 30 to 75 miles wide, which are exposed almost continuously from the 49th parallel to the vicinity of the Yukon-Alaska boundary, a distance of approximately 1,200 miles. These vast, intrusive bodies are composed largely of granodiorite, although locally the rocks may show a wide variation in composition. Towards the close of the Jurassic, or somewhat later, these batholithic masses were intruded into overlying sedimentary and volcanic rocks ranging from Precambrian to Mesozoic in age. Remnants of these formations lie within and along both margins of the intrusive belt.

In the region between Klondike river in the Yukon and Atlin lake in British Columbia, Precambrian to Mesozoic sediments, schists, and volcanics have been penetrated by bodies of granite, diorite, and diabase of late Jurassic or Cretaceous age. Affiliated with these intrusives are arsenic-bearing deposits such as the gold-quartz-arsenopyrite veins of Dublin gulch; the silver-lead and gold-quartz veins of Keno hill; the silver-lead veins of Idaho hill, and the quartz-silver-lead veins in Windy Arm district.

South from Atlin lake to Portland canal very little prospecting has been done along the east margin of the batholithic belt.

Numerous ore deposits, many of them containing arsenic, occur in the area of Mesozoic sedimentary and volcanic rocks which extends westerly from Babine lake to the batholithic area. The most important known arsenic-bearing deposits are in the vicinity of Hazelton and on Hudson Bay mountain west of Smithers. These districts lie within a genetic arsenic province about 2,500 square miles in area. This province is underlain by tuffs and sediments thought to be of Jurassic age, which, towards the close of that period, were intruded by stocks of granodiorite. The principal arsenic-bearing mineral is arsenopyrite which is almost universally present in the silver-lead-zinc veins found traversing the tuffs in the vicinity of the igneous bodies. Similar deposits also occur in Alice Arm district on the coast.

From Skeena river southward the batholiths of the Coast range penetrate late Palæozoic and Mesozoic sedimentary and volcanic rocks. In Bridge River district gold-quartz veins carrying arsenopyrite occur both in the sediments and in the intrusives. In Coquihalla area east of Hope similar veins are associated with the Ladner slate belt (Upper Jurassic).

A large part of south-central British Columbia is underlain by bodies of Jurassic to early Tertiary irruptive rocks which include granite, diorite, and gabbro or diabase. These penetrate sediments, schists, and volcanic rocks ranging from Precambrian to Mesozoic in age. Arsenic-bearing minerals occur in a number of deposits which are widely scattered throughout this area. In Hedley district, in Mesozoic sediments, gold-quartz veins and contact-metamorphic deposits containing arsenopyrite are associated with intrusions of diorite and gabbro. The most important ore-bodies are located on Nickel Plate mountain where they have been mined successfully for a number of years by the Hedley Gold Mining Company. Arsenical deposits also occur in the Precambrian and Palæozoic sediments adjacent to the Nelson granite batholith which is exposed over an area of about 4,000 square miles in south-central British Columbia.

Prospecting for arsenic in the Cordilleran region should be carried out along or near the contacts of the late Jurassic to Tertiary intrusions of granite, granodiorite, diorite, and gabbro referred to above. The most extensive contact of this kind is that which forms the eastern margin of the Coast Range series of batholiths.

CANADIAN SHIELD

Arsenic-bearing minerals have been found in a number of widely scattered localities in this vast region of Precambrian rocks. Prospecting has, so far, been confined to the most readily accessible parts of the Shield, but as transportation facilities become available the frontier of intensive exploration is being extended year by year into more remote sections of this great territory. As yet it is not possible to define clearly the various genetic arsenic provinces known to exist. Brief reference is made below to the principal known arsenic-bearing areas in this region.

Gold-arsenopyrite-quartz veins occur in the vicinity of Wekusko lake in west-central Manitoba, where intrusions of granite pierce rocks belonging to the early Precambrian igneous and sedimentary complex.

Gold-quartz veins containing arsenopyrite have been mined along the north shore of lake of the Woods. These and other occurrences in this general region are thought to be affiliated with bodies of granite which penetrate older sedimentary and volcanic rocks.

The most important arsenic-bearing area within the Shield extends from lake Huron to lake Abitibi. This area is underlain in part by the earlier Precambrian igneous and sedimentary complex, and in part by groups of sediments of later Precambrian age. These, during late Precambrian time (Keweenawan), were invaded by intrusions of diabase. Cobalt, Gowganda, and South Lorrain are in this area and these mining centres have, since 1905, furnished most of the arsenic produced in Canada. The arsenic is obtained as a by-product from silver-cobalt-nickel ores. These ores occur in replacement veins which traverse Keewatin greenstones and Huronian sediments, and are affiliated with sill-like bodies of diabase. Gold-arsenopyrite deposits of the replacement type occur near Timagami and in Larder Lake area. These deposits lie in Keewatin greenstones cut by dykes of porphyry. To the southwest, arsenical deposits occur in a district which extends from Sudbury to Georgian bay. In this area, the later Precambrian sediments are cut off to the east by batholithic masses of granite (Keweenawan). The gold-arsenopyrite-quartz veins of Howry creek, and the gold-arsenopyrite replacement deposits at Long lake, south of Sudbury, are thought to be genetically connected with these intrusions.

The first arsenic-bearing area to be recognized in Canada was the southeastern part of Ontario, which includes the region lying east of Georgian bay and south of Ottawa river. The eastern part of this area is underlain by Precambrian limestones and other sediments which have been intruded by masses of granite and gabbro-diabase. Associated with these intrusions are gold-quartz veins, contact metamorphic and replacement deposits containing arsenopyrite. Such deposits occur in a number of localities in Hastings, Peterborough, and Lennox and Addington counties. From 1885 to 1904 the ores mined in the vicinity of Deloro, Hastings county, were the principal source of arsenic in North America.

As already stated, arsenical ores in Canada are almost invariably associated in origin with bodies of intrusive igneous rocks. Therefore, prospecting for arsenic within the limits of the Canadian Shield should be carried on where the older volcanic and sedimentary strata of the Basement complex and the younger groups of sedimentary rocks are penetrated by igneous bodies.

ACADIAN PROVINCE

This region includes that part of the Appalachian belt of folded Precambrian and Palæozoic sediments which lies southeast of the St. Lawrence within the provinces of Quebec, New Brunswick, and Nova Scotia. Towards the close of the Devonian the early Palæozoic and the Precambrian rocks were penetrated by batholithic masses of granite. These intrusions are exposed in eastern Quebec, and over considerable areas in central and southern New Brunswick, and in southwestern Nova Scotia. In these areas deposits containing arsenopyrite are known to occur. In New Brunswick such occurrences have been reported from Gloucester and

Charlotte counties. In Nova Scotia arsenopyrite is present to some extent in the gold-quartz veins or slate belts of at least forty districts that lie within a genetic arsenic province which includes the seaward half of the peninsula (*See* Map 39A, Geological Survey, Canada).

Prospecting for arsenical minerals in New Brunswick should be carried on in the vicinity of the granite intrusions lying between Chaleur bay and Passamaquoddy bay. In Nova Scotia further search in the areas underlain by the Goldenville and Halifax slates and quartzites should lead to the discovery of additional gold-quartz veins and belts of slate mineralized with arsenopyrite. The presence of a surface mantle of glacial drift in many districts has hitherto prevented their intensive exploration. It is quite probable, however, that systematic prospecting will uncover from time to time deposits similar in character, extent, and value to those found during the past sixty years.

Of the arsenic-bearing areas referred to in the preceding paragraphs Cobalt district of Ontario is by far the most important. Since 1905 the silver-cobalt-nickel ores of this district have furnished the bulk of the arsenic recovered in Canada. Although the peak of the silver production was reached in 1911 and has since slowly declined, the output of arsenic has been fairly steadily maintained. During recent years the development of additional deposits in the adjoining districts of South Lorrain and Gowganda has to some extent compensated for the depletion of ore reserves in the Cobalt veins. These deposits will probably be the principal source of arsenic in Canada for some years to come.

Next in importance to Cobalt district is Hedley area, British Columbia. For a number of years the Hedley Gold Mining Company has produced arsenical concentrates, but only since 1917 has their arsenic content been recovered. Owing to the nature of the ore-bodies which the company has to mine it is difficult to estimate future ore reserves. This is especially so because within recent years development work has been very little in advance of actual mining operations. A number of other arsenical deposits occur in this area, but so far no important tonnages of ore have been developed.

The southeastern part of Ontario, particularly Hastings county, has, in the past, furnished considerable arsenic. From 1885 until the discovery of the Cobalt veins, all the arsenic recovered in Canada came from the gold-arsenopyrite-quartz deposits in this area. These deposits are numerous, but small and rather widely scattered; their arsenic content is irregular; and the gold values are low and inclined to be spotty. In spite of these disadvantages it is not improbable that some of the larger deposits such as those in the vicinity of Deloro will be re-opened and operated.

Another area which may contribute again to the arsenic production of Canada is the southeastern half of Nova Scotia. On several occasions in the past, shipments of arsenical concentrates have been made from this area. These concentrates were recovered as a by-product from the quartz veins and slate belts which were mined primarily for their gold values. At the present time the gold mining industry in this section of Canada is at a low ebb, so that the production of arsenic will be handicapped by this condition of affairs. Operations are now being carried on in Moose River district to determine whether arsenopyrite can be recovered cheaply and in commercial quantities from the slate belts in which it occurs. If it can, the probability is that other deposits of this type will be opened, and that a small but steady production of arsenic may be obtained.

In the Cordilleran region, in addition to Hedley district, there are a number of localities which may furnish arsenic. Chief among these may be mentioned: Hazelton and Smithers area; Windy Arm district; Bridge River district; Hope-Coquihalla area; Ymir-Kootenay Lake district; and the area north of Revelstoke, B.C.

SUGGESTIONS TO PROSPECTORS

(1) Arsenical deposits occur in regions underlain or penetrated by intrusions of granite, diorite, gabbro, diabase, or related rocks. Mineralization has in many cases taken place where such igneous bodies have come in contact with schists, greenstones, slates, limestones, or impure quartzites. Hence, particular attention should be paid to such contact zones in prospecting for arsenic.

(2) Look for
- *(a)* Quartz veins.
- *(b)* Iron-stained outcrops. These usually indicate the presence of such minerals as pyrite, pyrrhotite, arsenopyrite, or chalcopyrite.
- *(c)* Greenish or pink outcrops. Deposits containing arsenopyrite are in many cases marked by a greenish white capping of iron arsenate. Green nickel bloom indicates the presence of nickel arsenides and pink cobalt bloom of cobalt arsenides in a deposit.
- *(d)* Black outcrops. Occasionally arsenopyrite becomes covered with a black coating when exposed at the surface.

(3) Determine, if possible:
- *(a)* The minerals present in the showing.
- *(b)* The character of the deposit, whether a fissure vein, mineralized shear zone, replacement deposit, etc.
- *(c)* The extent of the deposit.

(4) In taking samples remember that, in most cases, channel, chip, or grab samples do not indicate correctly the arsenic content of a deposit. The most reliable data can be obtained from analyses of the concentrates recovered by milling a representative tonnage of the ore. Mill tests also afford information as to the number of tons of ore which must be crushed to yield one ton of concentrates. A testing laboratory equipped to carry on work of this nature is maintained by the Mines Branch, Department of Mines, Ottawa.

(5) If arsenopyrite is the principal sulphide in a deposit, select fresh, unoxidized samples and have them assayed for gold and silver. In this way some idea of the values to be expected in concentrates made from the ore may be obtained. It is not necessary to have samples of arsenopyrite analysed for arsenic, since the mineral contains a maximum of 46 per cent when pure. If galena, tetrahedrite (grey copper), smaltite, or niccolite are present have samples assayed for silver.

(6) It should be remembered that relatively few deposits containing arsenic can be worked solely for their arsenic content. Moreover, unless material containing more than 15 per cent arsenic can be mined directly, the ore will have to be milled and the arsenical minerals concentrated before they can be utilized in an arsenic-recovery plant. In complex ores in many cases the arsenic content is subsidiary in value to that of gold, silver, copper, lead, or zinc and, due to the presence of other minerals, it cannot be increased to 15 per cent by concentration. Such ores are usually shipped to a smelter for treatment, the arsenic being recovered as a by-product.

(7) The chief elements which are detrimental in arsenical deposits are antimony, mercury, and cadmium. Antimony may be present in such minerals as tetrahedrite, stibnite, and jamesonite; mercury may be contained in tetrahedrite and cadmium in zinc blende. Ores which contain zinc above certain limits are in many cases penalized by smelters.

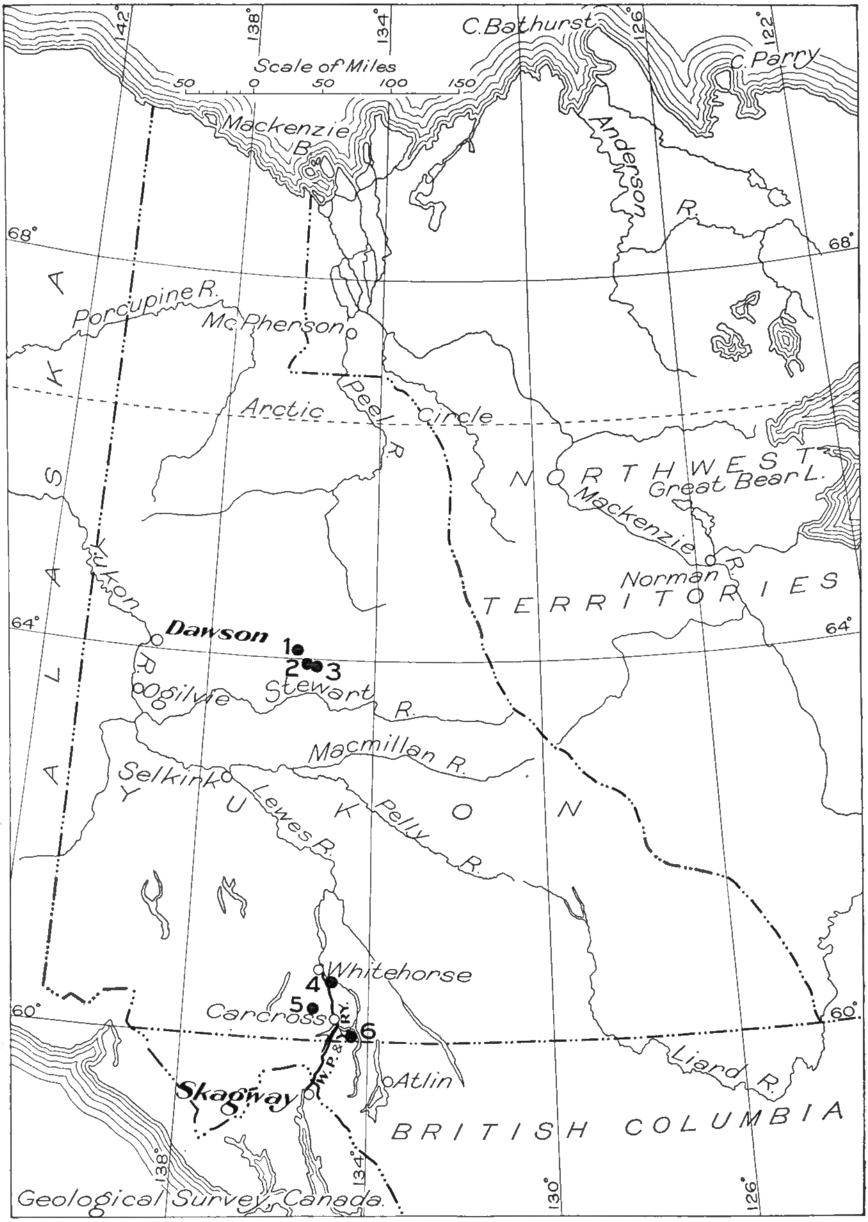


Figure 2. Index map of the Yukon showing location of arsenic-bearing occurrences. 1, Dublin gulch; 2, Christal creek; 3, Mayo district; 4, Valerie; 5, Wheaton River area; 6, Windy arm.

CHAPTER IV

DESCRIPTION OF OCCURRENCES

YUKON

1.[1] Dublin Gulch

Previous Descriptions

McLean, T. A.: "Lode Mining in the Yukon"; Mines Branch, Dept. of Mines, Ottawa, 1914, pp. 127-159.
Cairnes, D. D.: Geol. Surv., Canada, Sum. Rept. 1915, pp. 29-34.
Cockfield, W. E.: Geol. Surv., Canada, Sum. Rept. 1918, pt. B, pp. 7-10.

A number of arsenopyrite-gold-quartz veins are known in Mayo area, upper Stewart River district. According to W. E. Cockfield, from whose report the following information is derived, the most important locality is Dublin gulch, which lies on the east side of Haggart creek and flows southward into McQuesten river. The rocks outcropping in the vicinity of Dublin gulch belong to a complex of schistose and gneissoid rocks pierced by a body of grey biotite-granite about 3 miles long by 1½ miles wide. The quartz veins are in or near this body, some lying in the schist, others in the granite, and some passing from one rock into the other without apparent change.

The veins are seldom over 2 feet thick, average much less, and are mostly low grade. The outcrops are, as a rule, oxidized and stained with a greenish arsenate of iron. Considerable development work, consisting of trenches, adits, and drifts, has been done on the following groups of claims: Stewart-Catto, owned by J. Stewart and Dr. Wm. Catto, staked 1907; Carscallen, owned by F. Carscallen; and Olive, Blue Lead, and Eagle groups, owned by R. Fisher, staked 1908. Production in all cases nil. Arsenic content not known. The vein-filling is composed chiefly of quartz with varying amounts of arsenopyrite and pyrite. Numerous samples taken from the different veins show the ores to contain on the average from 0·35 to 0·45 ounce of gold and from 1 to 2 ounces of silver per ton.

Cockfield states that, "There is sufficient ore of a milling grade in sight on Dublin gulch to warrant the erection of a small milling plant in the vicinity. There seems to be no reason why concentrates of shipping grade could not be made from the deposits if a suitable plant were erected, and many of the deposits could doubtless be worked at a profit. It is evident, however, that none of the ores as known at present are of sufficient grade to pay for shipping to an outside point for treatment."

[1] This and the numbers attached to all locality names are locality numbers and appear on the various index maps (Figure 2, etc.)

2. Christal Creek

Previous Description

Cockfield, W: E.: Geol. Surv., Canada, Sum. Rept. 1918, pt. B, pp. 9-10.

Veins similar to those on Dublin gulch occur on Christal creek which joins the south fork of McQuesten river about 15 miles below McQuesten lake. The following statements are based on the account given by W. E. Cockfield. The property consists of one claim staked in 1917 by Axel Erickson and Fred Swanson and abandoned in 1918. Two adits have been driven into the hill where the vein croppings are exposed. The upper adit encounters a number of small veins, the lower adit is barren of any mineral showings. The veins are of the arsenopyrite-gold-quartz type, but are thin and not very persistent and not likely to prove of economic value. Small bunches and individual grains of quartz, arsenopyrite, galena, pyrite, and zinc blende also occur irregularly scattered through a sheared zone 3 feet wide. Samples from the various veins when assayed gave traces up to 0·27 ounce in gold and from a trace to 10·16 ounces of silver.

3a. Keno Hill

Previous Descriptions

Cockfield, W. E.: Geol. Surv., Canada, Sum. Rept. 1920, pt. A, pp. 1-6; Sum. Rept. 1923, pt. A, pp. 1-21.

Keno hill is about 42 miles by road, northeast of Mayo on Stewart river. It is a ridge 10 miles long and 5 miles wide, between Christal and Lightning creeks, and Ladue river. It is traversed by two sets of fissure veins and those of one set carry arsenopyrite as well as other minerals. The following description is a condensation of the reports by W. E. Cockfield who in addition has furnished a few hitherto unpublished details.

The area is underlain by crystalline schists of sedimentary origin, intruded by sills and laccoliths of greenstone, and by later dykes and sills of quartz porphyry and granite porphyry. The mineral deposits are fissure veins that have developed along fault-planes which may be divided into two classes, longitudinal and transverse, depending on whether they follow or cut across the trend of the strata. There are several veins of the former type and they carry gold, arsenopyrite, and pyrite in a quartz gangue. The largest of these veins varies from 3 to 7 feet in width. The maximum known gold content is said to be about $6 a ton; the arsenic content is unknown, but, presumably, is very low. The transverse type of veins is characterized by galena, freibergite, siderite, and zinc blende, which also occur as ore-shoots developed in later fractures in places in the longitudinal veins.

3b. Mount Cameron

Previous Description

Cockfield, W. E.: Geol. Surv., Canada, Sum. Rept. 1921, pt. A, pp. 5-6.

Arsenopyrite occurs on the northern slope of mount Cameron 45 miles in a direct line northeast of Mayo. The general area is underlain by schists, quartzites, and limestone, similar to those of Keno hill. On the

Mount Cameron property, according to W. E. Cockfield, mineralization has taken place along a fault-plane where this traverses a band of limestone. The mineralized outcrop is 50 feet wide and can be traced on the surface for 440 feet. The chief minerals present are pyrite, arsenopyrite, galena, sphalerite, chalcopyrite, limonite, manganite, siderite, and calcite. A sample of the galena carried 76 ounces of silver a ton and 56·83 per cent lead. The arsenic content is unknown; it probably is very low.

3c. Highet Dome

Quartz veins carrying much stibnite and a little arsenopyrite occur on Highet dome, Duncan mining district. (Geol. Surv., Canada, Sum. Rept. 1918, pt. B, p. 10.)

4. Valerie Claim

Previous Description

McConnell, R. G.: Geol. Surv., Canada, Pub. No. 1050, pp. 53-55 (1909).

Some arsenopyrite has been found on the Valerie claim in the southern part of the Whitehorse copper belt. This property is west of the head of Miles canyon, about 2½ miles by road from Wigan station on the White Pass and Yukon railway. The deposit, as described by McConnell, occurs at the contact of limestone and hornblende granite. Chalcopyrite is the principal ore mineral and forms three lenses outcropping at the surface, one of which, or possibly a fourth, was found in the underground workings at a depth of 84 feet. The ore-shoot encountered underground is bordered by a wide zone of altered and unaltered limestone and altered diorite, impregnated with arsenopyrite in grains and bunches, associated with minor amounts of chalcopyrite. The values in this belt are small, as the copper percentage is low and assays show only traces of gold and silver.

5a. Carbon Hill

Previous Descriptions

Cairnes, D. D.: Geol. Surv., Canada, Sum. Rept. 1915, p. 48. Geol. Surv., Canada, Mem. 31, pp. 120-129 (1912).

Two veins carrying arsenopyrite occur on Goodell's claims on the Wheaton River slope of Carbon hill in Conrad mining district. According to Cairnes, the veins are parallel, are 2 and 2 to 6 feet thick, respectively, and not more than 20 or 30 feet apart, and outcrop for a distance of 2,000 feet. They occur in the Coast Range granitic rocks and consist chiefly of quartz with disseminated particles of jamesonite and arsenopyrite.

5b. Idaho Hill

Previous Description

Cairnes, D. D.: Geol. Surv., Canada, Mem. 31, pp. 129-139 (1912).

A number of silver-lead veins carrying arsenopyrite occur on the eastern face of Idaho hill, which lies north of Wheaton river in Conrad mining district, southern Yukon. The following description has been derived from the account given by Cairnes.

The veins are confined chiefly to an area ა,000 feet long and 1,000 feet wide, included mainly in the two mineral claims which comprise the Union Mines group. A few veins have also been found to the south on the adjoining Nevada group of claims. The veins are twelve or more in number, cut arkosic rocks, and vary in width from 4 to 12 inches. They could, in 1909, be traced from 10 to 200 feet on the surface. The veins in part are very irregular and generally have indefinite walls. Development work was confined largely to the outcrops. Quartz and calcite are the chief gangue minerals; arsenopyrite and galena the principal metallic constituents. Zinc blende is generally present in minor amounts, pyrite only occasionally, and chalcopyrite rarely. The arsenopyrite occurs intimately mixed with galena or in solid masses, irregular or tabular in form, and roughly parallel to the walls of the deposits. Both arsenopyrite and galena in many cases replace the wall-rocks adjoining the veins. The main values are in silver and lead. The better grade of surface ores are said to carry about 50 ounces of silver a ton, and considerable portions of the veins contain upwards of 40 per cent lead. As a rule the gold values are low, varying from a trace to as high as $2 a ton. The veins on the Nevada group of claims contain less galena than do those on the Union Mines group. No figures are available concerning the percentage of arsenic which the veins carry. According to Cairnes the deposits were formed largely by metasomatic replacement of the arkosic sediments along such bedding planes or fractures as were penetrated by the mineral-bearing solutions.

5c. Mount Reid

Previous Description

Cockfield, W. E.: Geol. Surv., Canada, Sum. Rept. 1922, pt. A, p. 7.

A vein carrying some arsenopyrite occurs on the eastern slope of mount Reid, near the junction of Berney creek and Wheaton river, in Conrad mining district. Two claims have been staked, the Grandview by A. Birnie and the Rambler by C. I. Burnside. The vein, which occurs in andesites included in the Coast Range granodiorite, has been exposed on the surface by pits for a distance of 1,000 feet, but when examined by Cockfield was visible at one point only, where it has a width of 3 feet and consists of galena, pyrite, stibnite, and arsenopyrite in a gangue of quartz. The arsenopyrite is well developed.

6. Windy Arm

Previous Description

Cairnes, D. D.: Geol. Surv., Canada, Sum. Rept. 1916, pp. 34-44.

During 1904 and 1905 a considerable number of mining claims were located in the Windy Arm portion of Conrad mining district. These properties are readily accessible from Caribou Crossing, a point on the White Pass and Yukon railway, which serves as a distributing centre for Windy Arm district. Arsenopyrite has been found on a number of the claims, but principally on the Big Thing and the Venus. The following account is derived from the report by Cairnes.

BIG THING

The Big Thing is located about 5½ miles almost due south of Caribou Crossing and near the summit of Sugar Loaf hill. From 1905 to 1912 considerable development work was done on the property, which was allowed to lie idle until 1916, when further exploration was carried on. The ore deposit, which occurs as a fissure vein intersecting granitic rocks of Jurassic or Cretaceous age, has been developed by a shaft and an adit to a depth of 400 feet. The vein is said to vary from 2 to 8 and even 12 feet in thickness and is composed dominantly of quartz, which is fairly well mineralized, chiefly with pyrite, but also with some disseminated arsenopyrite and occasional particles of chalcopyrite, galena, and stibnite. In 1916 Cairnes estimated that about 75,000 tons of ore carrying $15 a ton in gold and silver had been blocked out in the workings.

VENUS

This property is located near the shore of Windy arm, 15½ miles by water from Caribou Crossing. The workings lie about 500 yards from the water's edge and 1,000 feet above the level of Tagish lake. On the Venus No. 1 claim only a small amount of work has been performed. On the Venus No. 2, considerable development work and some actual mining have been done. Two adits, or crosscut tunnels, one 195 feet below the other, have been driven to intersect the vein, which dips at an angle of 25 to 30 degrees into the hill. Further exploration has been carried out by means of drifts, winzes, and raises, and a small amount of ore was stoped and milled.

The Venus vein occurs in a fissure traversing andesitic rocks. The actual ore material ranges in width from 1 inch to 7 feet, but in most places in the underground workings it is 2½ to 3 feet thick. The vein filling consists chiefly of quartz, galena, pyrite, and arsenopyrite, with some jamesonite, chalcopyrite, and chalcocite. Arsenopyrite with some galena and tetrahedrite is said to be concentrated along the hanging-wall over a varying thickness of less than one foot. The values are mainly in silver, which is associated with the galena. Important amounts of gold also occur in the arsenopyrite. The precious metal content of the vein varies greatly. The ore in the higher-grade shoots contains on the average from $30 to $50 a ton in all values. Much of the vein, however, is very low grade, running from almost nothing to about $20 a ton. Cairnes estimated that there were 20,000 tons of ore in sight in 1916.

The Venus vein is also known to extend across the Venus Extension claim which adjoins the Venus No. 2 on the south. The mineralization and values are about the same. Other veins, as yet little explored, occur on the claims lying still farther to the south.

MONTANA

The Montana property is located 3 miles south of the Big Thing and 2½ miles from the shore of Windy arm, and 3,700 feet above it. The vein occupies a fissure intersecting andesites and basalts of Jurassic (?) age. It ranges in thickness, in most places, from 2 to 5 feet and is composed mainly of quartz with which are associated galena, pyrite, arsenopyrite, pyrargyrite, argentite, tetrahedrite, and native silver. The principal values are in silver, but the pyritic parts contain some gold. In places, the vein matter, especially adjoining the walls for thicknesses of 8 to 18 inches, is very highly impregnated with silver minerals, but the rest of the vein is of much lower grade.

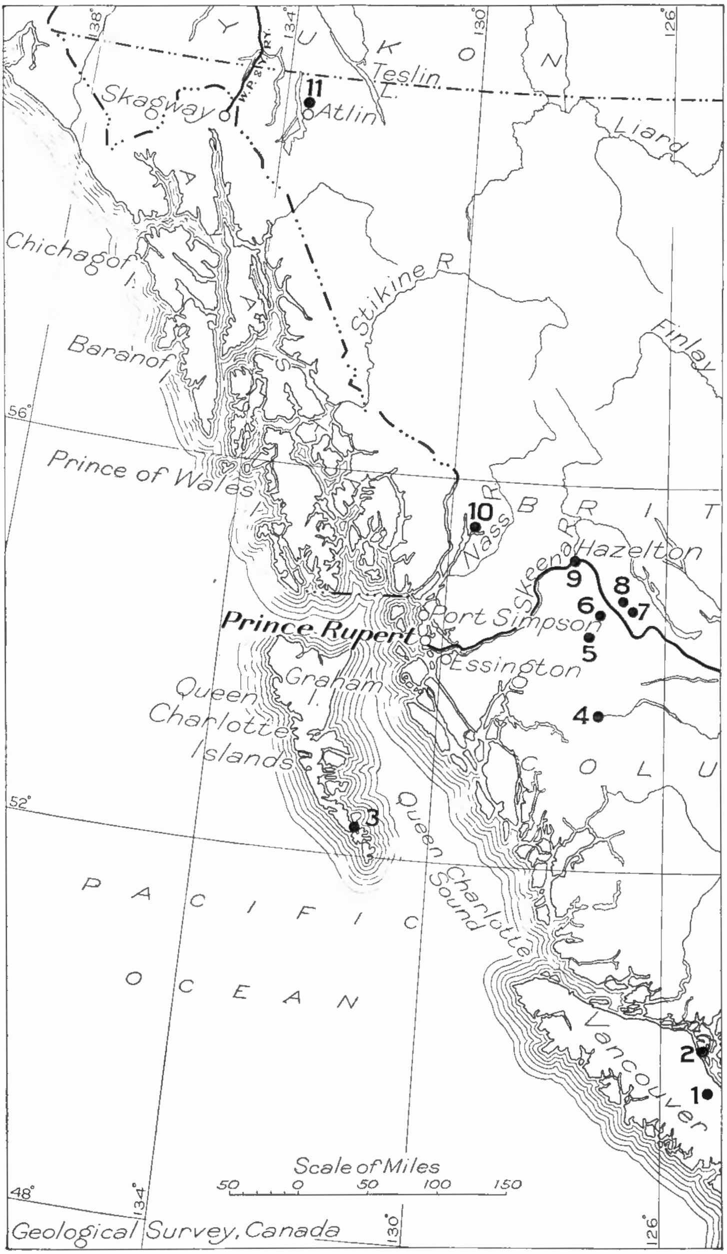
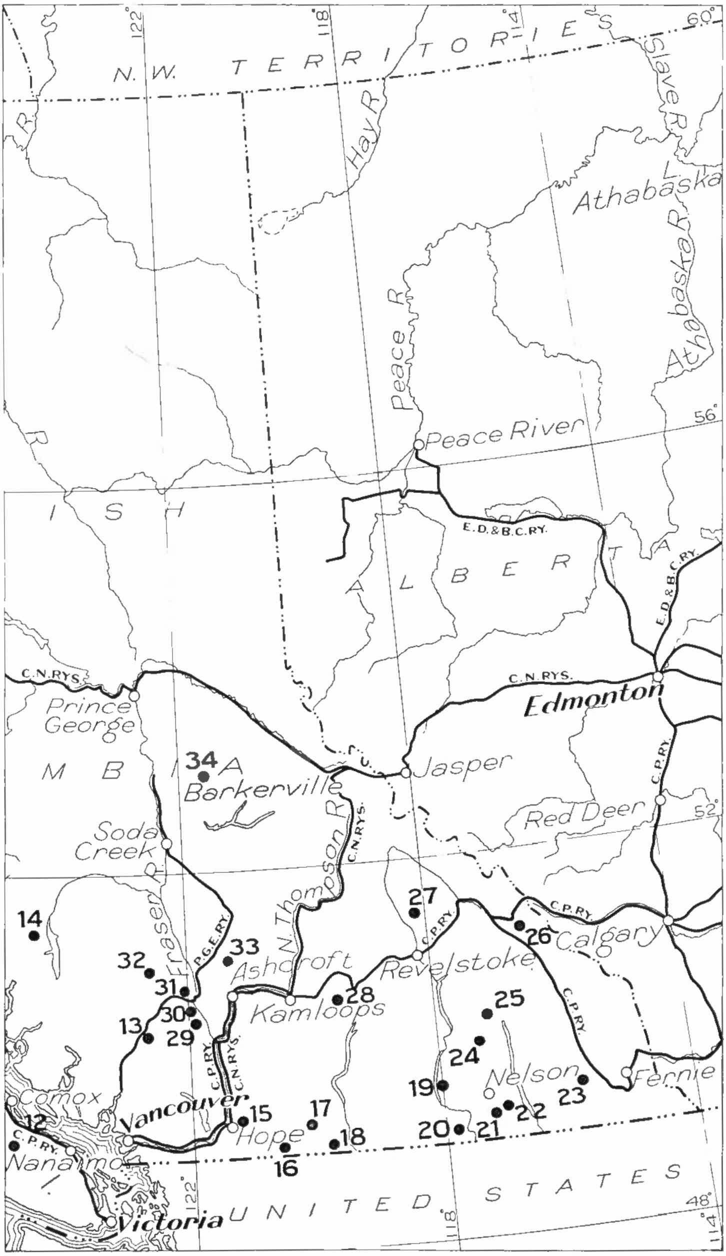


Figure 3. Index map of British Columbia showing location of arsenic-



bearing occurrences. For explanation of figure, *See* page 36.

Explanation of Figure 3 (Pages 34 and 35)

The localities indicated by numbers on Figure 3 are as follows:

1. Wolf lake
2. Quadra island
3. Alder island
4. Whitesail lake
5. Gabriel creek
6. Hudson Bay mountain
7. Dome mountain
8. Driftwood creek
9. Hazelton district
10. Alice arm
11. Crater creek
12. Alberni
13. Pemberton area
14. Tatlayoko lake and Perkins peak
15. Hope-Coquihalla area
16. Roche River area
17. Hedley mining area
18. Kruger mountain
19. Deer Park
20. Rossland
21. Ymir
22. Hughes creek
23. Sullivan mine
24. Silverton
25. Poplar creek
26. Ice river
27. Carnes creek
28. Barrett creek
29. Watson Bar creek
30. Texas creek
31. Cayuse creek
32. Bridge River district
33. Bonaparte river
34. Barkerville

BRITISH COLUMBIA

Although arsenic-bearing minerals are widely distributed in British Columbia, most of the occurrences are only of mineralogical interest. Most, if not all, the deposits are too small or too low grade to be worked for arsenic alone. There are, however, a number of arsenical deposits which contain values in gold, silver, lead, or zinc and from which in the future arsenic may be obtained as a by-product, as has already been done at Hedley. The development of such properties, and hence the production of arsenic, will obviously depend on their possibilities as metal mines and on the state of the metal markets. The principal arsenic-bearing areas in British Columbia are as follows:

(*a*) Hedley district
(*b*) East and south of Hope
(*c*) Bridge River district
(*d*) Hazelton district
(*e*) Smithers (Hudson Bay mountain) district

In addition, there are isolated deposits such as the Wisconsin group near Kootenay lake, and the J and L property on Carnes creek, which have promising showings.

1. Wolf Lake

(*See* Figure 4)

This property consists of two unsurveyed claims, the Good Hope No. 1 and No. 2, in the vicinity of a small creek flowing northeasterly into the west end of Wolf lake. The claims are reached from Headquarters camp of the Comox Logging Company, 12 miles north of Courtenay. A trail about 3 miles long leads southwesterly from Headquarters to the east end of Wolf lake. From this point a canoe trip of 2 miles is necessary to reach the west end of the lake, where a rough trail of about one-half mile has been cut to the deposit, which lies at an elevation of 850 feet, or 260 feet above the lake. The property is owned by E. Morrison and associates, of Vancouver, B.C.

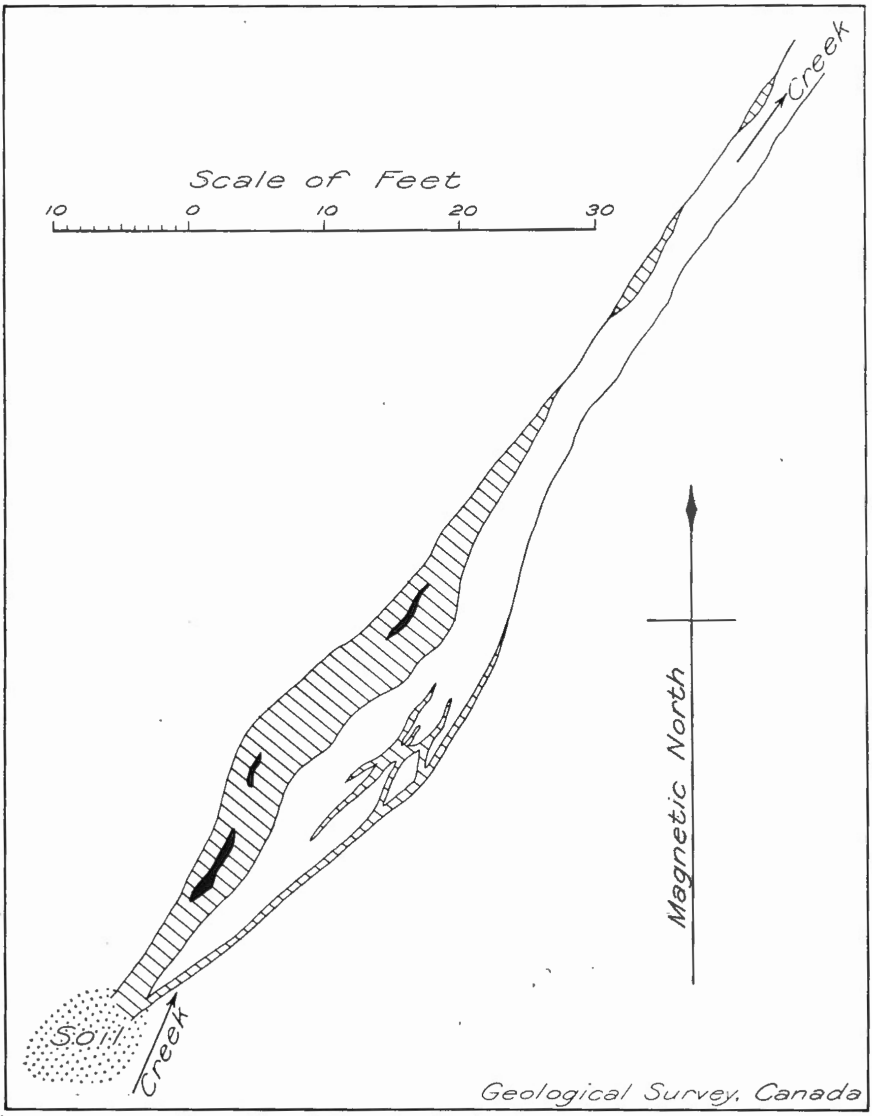


Figure 4. Realgar deposit, Good Hope claim, Wolf lake, Vancouver island, B.C. Small bodies (black) and particles of realgar lie in lenses and veins of calcite (diagonal ruling) within a zone of brecciated andesite.

The showings occur in a creek bed which, at the time of inspection (August, 1924) was almost dry. For about 250 feet the creek follows, and has exposed, a brecciated zone in andesitic rocks. This brecciated zone varies from 2 to 12 feet in width, strikes north 35 degrees east (magnetic), and appears to dip steeply to the southeast. It contains lenses and veins of calcite, some as much as 6 feet wide, in which numerous, angular fragments of the shattered andesite are embedded. These bodies of calcite outcrop at intervals for about 150 feet along the creek bottom and contain occasional lenticular masses of realgar. The largest exposure of the arsenic sulphide, and the one for which the claims were originally staked, measures 4 feet in length with a maximum width of 9 inches. Another lens is 30 inches long and 8 inches at the widest point. Several smaller stringers of realgar were also seen at various places along the shear zone. Tiny veinlets of arsenopyrite occur here and there in the andesitic wall-rocks.

The minerals found in the shear zone are chiefly calcite and realgar, with minor amounts of quartz and arsenopyrite. Realgar appears to be confined to the calcite and arsenopyrite to the andesite. Small amounts of arsenopyrite occur in the andesitic fragments embedded in the calcite and it is conceivable that the sulphide may have been deposited either before or after the brecciation of the andesite. The realgar, on the other hand, was obviously introduced after the andesite was fractured. Hence the realgar may have been derived from the alteration of arsenopyrite or have been deposited contemporaneously with, or later than, the latter mineral. The writer is inclined to the view that, following the brecciation of the andesite and the cementation of the zone by calcite, arsenic-bearing solutions ascended along this line of weakness and deposited selectively, arsenopyrite in the andesite and realgar in the calcite. No evidence was observed to further the idea that the realgar might have been derived from the arsenopyrite by alteration, since the two minerals do not occur together. The only evidence of secondary action noticed was the replacement of realgar by native arsenic due to the leaching out of sulphur.

Practically no work had been done on the deposit up to the time it was visited and the only outcrops visible were those exposed by stream erosion. As the brecciated zone passes out of the creek within a distance of 250 feet and is there covered by soil, stripping and trenching will be necessary in order to explore the continuation of the mineralized belt. The quantity of realgar in sight, as indicated by the measurements given above, is small. No other values are known to be present in the deposit.

2. Quadra Island

Minor amounts of arsenopyrite associated with grains of galena, chalcopyrite, and needles of tourmaline occur in crystalline limestone on the Triangle claim on Quadra (South Valdes) island, Nanaimo mining division. On the Sunrise group, sparsely disseminated arsenopyrite and other sulphides occur in metamorphosed limestone and volcanics. (Geol. Surv., Canada, Mem. 23, p. 134 (1913); Sum. Rept. 1913, pp. 64-67, 72-73).

3. Alder Island

Small amounts of native arsenic are reported to be present in a narrow calcite vein associated with a basaltic dyke which outcrops on Alder island lying off the north end of Burnaby island, Queen Charlotte islands. (Ann. Rept., Minister of Mines, B.C., 1922, p. 41).

4. Whitesail Lake

Arsenopyrite has been reported to occur with galena, zinc blende, pyrite, and chalcopyrite, on the Silver Tip claim, on Chikamin mountain near the south side of Whitesail lake. The mineralization is confined to narrow veinlets traversing a shear zone in tuffs. The arsenopyrite, if present, is in exceedingly small quantities. On the Cariboo claims on the south shore of Whitesail lake, 17 miles west of the outlet, sheared and fractured tuffs are seamed with veinlets of calcite and quartz in which are small lenses, a few inches to 6 feet long, of galena, zinc blende, pyrite, chalcopyrite, and very small amounts of arsenopyrite. (Geol. Surv., Canada, Sum. Rept. 1920, pt. A, p. 92; 1924, pt. A, pp. 53-55).

5. Gabriel Creek

Arsenopyrite, with grey copper, native silver, quartz, and calcite is reported to occur replacing andesitic rock along a dyke on the Snowflake group 12 miles up Kitnaiakwa river, which joins Zymoetz river 28 miles from its mouth. The claims are on Gabriel creek, about one-half mile from Kitnayakwa river. (Ann. Rept., Minister of Mines, B.C., 1921, p. 94).

6. Hudson Bay Mountain

Previous Descriptions

Leach, W. W.: Geol. Surv., Canada, Sum. Rept. 1907, p. 22; 1908, pp. 44-45.
Galloway, J. D.: Ann. Repts., Minister of Mines, B.C., 1914 to present.

Hudson Bay mountain lies west of Smithers on the Canadian National railway and attains an elevation of over 8,500 feet. This mountain mass has an area of 75 square miles and consists dominantly of volcanic tuffs and breccias belonging to the Hazelton formation. Numerous dykes crosscut the rocks. The mineralization within the area closely resembles that found in Hazelton district to the north. It occurs chiefly along shear zones or in fissure veins intersecting the fragmental volcanic rocks. The principal deposits are on the southern slope of the mountain, which is reached from Smithers by a wagon road about 15 miles long. The mineral association consists of galena, zinc blende, arsenopyrite, pyrite, chalcopyrite, and occasionally freibergite and ruby silver. All these sulphides are not usually present and in some veins arsenopyrite and zinc blende, or galena and zinc blende, or pyrite and arsenopyrite, form the bulk of the mineralization. The gangue, for the most part, is brecciated, altered, or silicified country rock with occasionally ankerite and free quartz. Considerable development work has been done on the Mamie, Coronado, and Victory properties, which are described below in some detail.

6a. MAMIE

(*See* Figure 5)

Previous Descriptions

Galloway, J. D.: Ann. Rept., Minister of Mines, B.C., 1919, p. 103; 1920, p. 107; 1922, pp. 107-109.
Bateman, A. M.: Private report.

This property is on the south slope of Hudson Bay mountain, 14½ miles by wagon road from Smithers. The workings are at elevations of from 4,200 to 4,600 feet. In 1919, J. Aldrich, the owner of the property, bonded it to J. F. Duthie, of Seattle. Work was commenced in December, of that year and ceased in March, 1920. Later, the Duthie Mines, Limited, was organized and development work was carried on at intervals during 1921 and 1922. In 1923 the Federal Mining and Smelting Company took over the Mamie, together with the adjoining Henderson property, and exploratory work on the former was continued until June, 1924, when the company withdrew from the district entirely.

The vicinity of the Mamie vein is underlain by andesite-porphyry and tuffs. These rocks are usually dark grey when unaltered, but near the vein many present a light-coloured, bleached appearance. Microscopic study shows that they have undergone hydrothermal alteration. The feldspars are more or less replaced by sericite, the ferromagnesian minerals by carbonates, and silicification is quite general. These changes are most pronounced in the brecciated fragments within the shear zone and in the adjoining wall-rocks.

Mineralization occurs along a shear zone in the tuffs. This zone strikes east-northeast and has been exposed by surface stripping and open-cuts for several hundred feet on the gently sloping hill-side. In this distance it varies from 18 inches to 8 feet in width and consists of brecciated fragments of tuff partly replaced by zinc blende, arsenopyrite, and chalcopyrite, or cut by veinlets of these sulphides. The gangue is chiefly altered tuff, quartz, or ankerite. An adit, elevation 4,427 feet (*See* Figure 5), was driven beneath the surface showings for 200 feet and two winzes, 33 and 42 feet deep, were sunk from this level. Throughout the adit the mineralized zone maintains an average width of 3 to 4 feet. The sulphides present, in order of abundance, are zinc blende, arsenopyrite, chalcopyrite, and occasionally galena. To obtain more depth on the vein than was possible by drift tunnelling, the Duthie management began a crosscut adit in the gorge of Henderson creek a short distance to the east. This adit was located about 325 feet below the upper adit. It was estimated that the crosscut would cut the vein within 950 feet. Before the property changed hands this adit had been driven about 156 feet in a northerly direction. Instead of continuing this work the Federal Mining and Smelting Company drove an adit at an elevation of 4,273 feet or 154 feet below the upper workings. At this level the shear zone was found to be poorly defined and the mineralization disappointingly meagre in comparison with that occurring in the upper adit or in the surface showings. A few narrow stringers carrying zinc blende and arsenopyrite we e encountered, but the values, particularly in gold, were decidedly low. The adit was continued to and beyond a point below the winze put down near the portal of the upper adit (*See* plan) without striking important amounts of ore. Owing to the unsatisfactory results obtained from this development work, and to the depletion of ore reserves on the Henderson property, the company discontinued operations in July, 1924.

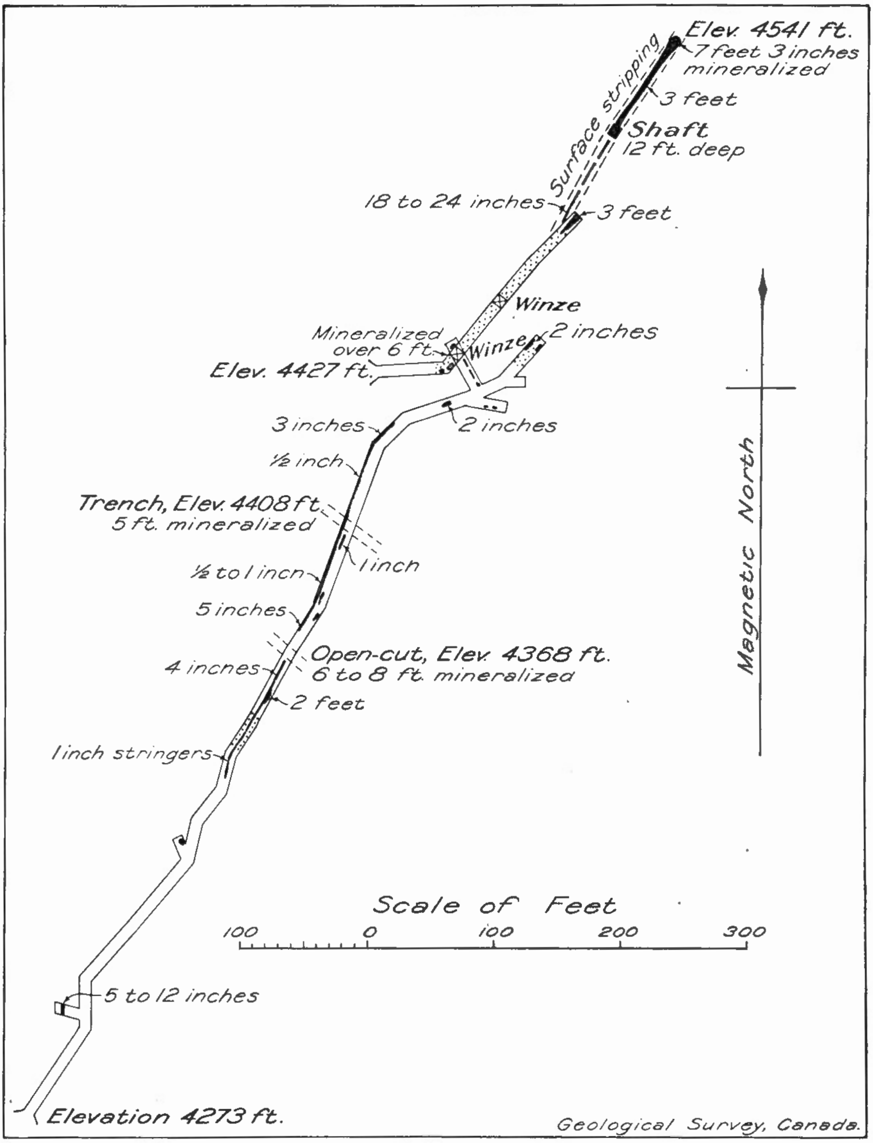


Figure 5. Plan of workings, Mamie property, Hudson Bay mountain, Coast district, B.C. Veins and veinlets in adits and in surface stripping shown by heavy black and heavy broken lines; mineralized areas in adits by dotted pattern.

The workings on the Mamie property were thoroughly sampled by the Federal Mining and Smelting Company, but the results are not available for publication. A selected sample containing arsenopyrite and some zinc blende was taken from the open-cut just above the upper adit. This was assayed by the Mines Branch, Ottawa, and yielded 0·62 ounce of gold and 2·13 ounces of silver a ton and 26·54 per cent of arsenic. These results represent in a general way the values to be expected in concentrates made from the ore.

6b. CORONADO

(*See* Figure 6)

Previous Descriptions

Leach, W. W.: Geol. Surv., Canada, Sum. Rept. 1908, p. 44.
Galloway, J. D.: Ann. Repts., Minister of Mines, B.C., 1914, pp. 213-215; 1919, p. 102.

The Coronado group of claims lies on the southern slope of Hudson Bay mountain, a short distance above Silver Creek flat and just west of the Mamie property. The main wagon road to Smithers passes within several hundred feet of the lowest adit. In 1919, the Skeena Mining and Milling Company was organized to develop the Coronado and Victory groups, and work was carried on at intervals during the year. Since then the property has lain idle.

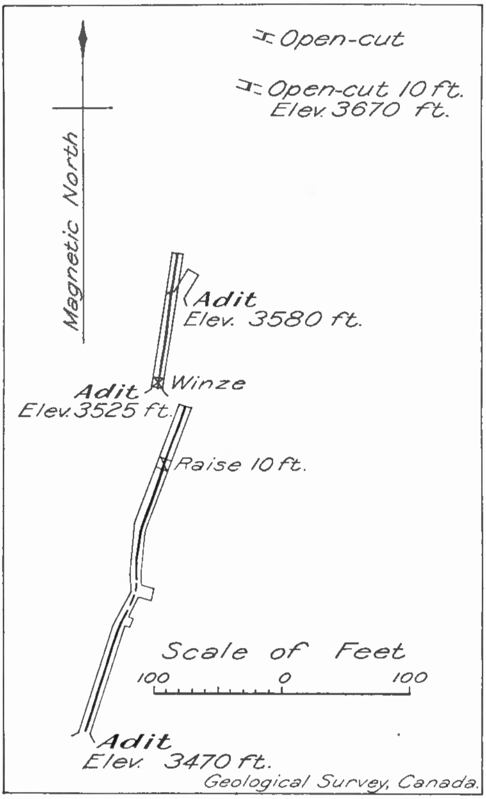


Figure 6. Plan of workings, Coronado property, Hudson Bay mountain, Coast district, B.C. Veins in adits and at surface shown by heavy black lines.

The main vein on the property occupies a shear zone in volcanic tuffs and breccias similar to those found at the Mamie. This zone has been traced, by open-cutting and trenching, for about 800 feet. It strikes roughly north 15 to 20 degrees east (magnetic), dips steeply to the east, and varies from a few inches to 2 feet in width. Several drift adits have been driven on the most promising outcrops. The mineralization consists chiefly of arsenopyrite, galena, zinc blende, chalcopyrite, and pyrite. The gangue is brecciated, hydrothermally altered, and silicified wall-rock. The sulphides occur as disseminated particles or patches replacing the bleached and fractured tuffs, or as veinlets cutting or cementing the fragments. That movement has taken place since the ore was deposited is indicated by the sheared or gneissic appearance of the galena. In the lowest adit (elevation 3,470 feet) the vein carries from 2 to 18 inches of sulphides throughout the length of the adit, 270 feet. In the middle adit (elevation 3,525 feet) 6 to 18 inches of sulphides are exposed for 100 feet along the vein. No mineralization of importance was found in the highest adit at an elevation of 3,580 feet. Stringers of galena and arsenopyrite occur where the zone has been uncovered by trenching at several points above this level.

Another vein on the west bank of Sloan creek, near the eastern boundary of the property, has been explored by a drift adit 60 feet long. This vein is similar in character and mineral content to the main vein, but was found to be less continuous and well-defined.

Some idea of the ore values may be obtained from the following assays and analyses quoted in the report of the Minister of Mines for British Columbia in 1914.

No.	Description	Oz. per ton		Per cent	
		Gold	Silver	Lead	Zinc
1	No. 1 (lowest) tunnel, sample across 10 inches...	0·45	129·4	38·1	14·4
2	No. 2 (middle) tunnel, average vein at face.....	0·30	16·5	4·8	45·3
3	Open-cut, vein 10 inches wide..................	0·76	4·9	0·8	19·2
4	First-class ore dump, No. 2 tunnel.............	0·24	51·4	27·0	21·6
5	Ore dump, No. 1 tunnel.........................	0·20	46·0	23·5	15·4
6	Second-class ore dump, No. 2 tunnel............	0·20	6·0	2·2	16·5

The arsenic content in the ore has not been determined, but probably is fairly high. Reliable information concerning the values carried by a complex ore of this type can only be obtained by milling a considerable tonnage and by assaying or analysing the resulting concentrates, middlings, and tailings.

6c. VICTORY

(*See* Figure 7)

Previous Descriptions

Leach, W. W.: Geol. Surv., Canada, Sum. Rept. 1908, pp. 44-45.
Galloway, J. D.: Ann. Repts., Minister of Mines, B.C., 1914, pp. 216-218; 1923, pp. 109-110.

The Victory group of three claims lies west of the Coronado group on the southern slope of Hudson Bay mountain. A wagon road 15 miles long connects the property with Smithers. The claims are owned by Donald C. Simpson, who has carried on development work single-handed for a number of years. In 1919 the Skeena Mining and Milling Company was organized to develop both the Victory and Coronado properties, but very little was done.

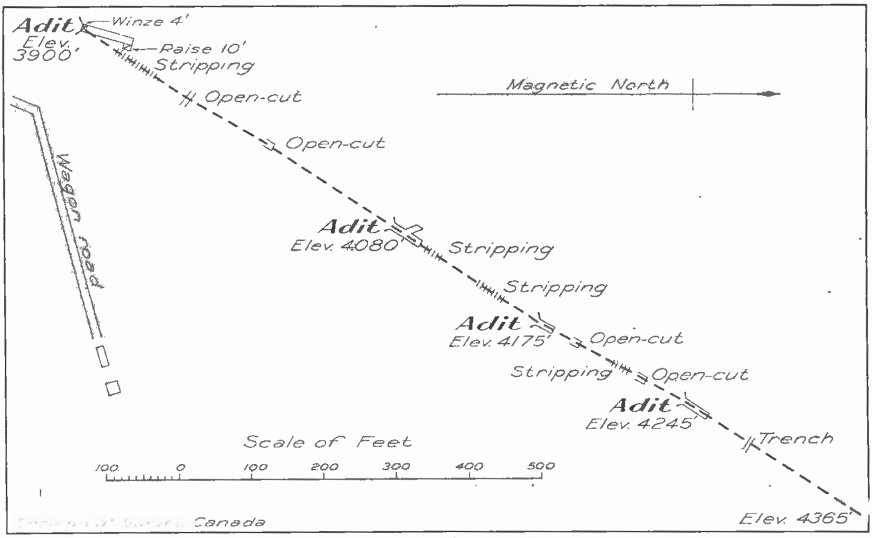


Figure 7. Plan of workings, Victory property, Hudson Bay mountain, Coast district, B.C. Mineralized shear zone shown by heavy broken line.

The main vein lies along a shear zone in tuffs similar to those on the Coronado and Mamie properties to the east. This zone dips westerly at a high angle and has been exposed by trenching and open-cutting for over 1,000 feet in a northeasterly direction up the hill-side. In this distance it varies in width from a few inches to 3 feet. The ore minerals are (in order of abundance): zinc blende, arsenopyrite, galena, pyrite, and chalcopyrite. They occur in a gangue composed largely of altered and silicified wall-rock. The sulphides are present in the form of disseminated particles or bunches replacing the tuffs, or as veinlets cutting fragments of wall-rock w thin the zone of shearing. The ore closely resembles that on the Coronado and Mamie properties. The mineralized zone has been explored by several drift adits, as indicated in the accompanying plan. In these the irregular distribution of the sulphides along the shear zone is even more apparent than in the surface workings. The best showing occurs in the adit at an elevation of 4,080 feet, where the vein contains from 18 to 30 inches of sulphides throughout the 45-foot long adit. The following assays of samples taken from this adit are quoted from the Report of the Minister of Mines, B.C., for 1923.

Description	Ounces per ton		Per cent	
	Gold	Silver	Lead	Zinc
Sample across $2\frac{1}{2}$ feet on hanging-wall	0·10	31·0	25·0	23·0
Sample across 4 feet	0·20	6·0	5·5	18·0
Sample of hand-sorted ore	0·10	56·0	38·0	15·0

A sample consisting of arsenopyrite and some zinc blende was taken from the face of the adit referred to above. This was assayed by the Mines Branch, Ottawa, and yielded 0·35 ounce of gold and 1·34 ounces of silver a ton. The gold values are, probably, largely in the arsenopyrite, and the silver values in the galena. As in the case of the Mamie or Coronado properties the arsenic content appears to be fairly high, but reliable information on this point can be obtained only by milling a quantity of the ore and analysing the products.

6d. OTHER DEPOSITS

Other arsenic-bearing deposits in the vicinity of Hudson Bay mountain are: (1) The Dome; (2) Newcastle and Dominion; (3) Myrtle; (4) Iron King; (5) White Swan; (6) Humming Bird; (7) Copper Queen and Iron Mask; (8) Evelyn; (9) Cascade.

(1) The Dome claim adjoins the Henderson group on the north and some development work was carried on while the Federal Mining and Smelting Company was operating the Henderson. The Dome vein occupies a shear zone in volcanic tuffs. This zone has been traced northeasterly by open-cutting for several hundred feet and in that distance varies from 2 to 8 feet in width. The mineralization consists of zinc blende, arsenopyrite, galena, pyrite, and chalcopyrite in a gangue of brecciated tuffs. These sulphides occur in bunches or stringers at intervals along the shear zone. The principal development consists of a shaft 14 feet deep. A sample containing arsenopyrite and a little zinc blende was taken from a streak of ore near the collar of the shaft. This was assayed by the Mines Branch, Ottawa, and yielded 0·33 ounce of gold and 0·66 ounce of silver a ton. Samples of pure galena from this property are said to carry about 80 ounces of silver to the ton.

(2) The Newcastle and Dominion claims, as described by Galloway, are on the east bank of Sloan creek near its head, and are owned by C. Hastings. The mineralization consists of zinc blende, arsenopyrite, and pyrite, with subordinate amounts of galena and chalcopyrite, and occurs along the walls of a dyke which intersects the brecciated volcanic rocks. The vein has been exposed for some distance by trenches and open-cuts. The following assays have been made:

No.	—	Oz. per ton		Per cent
		Gold	Silver	Zinc
1	General run of the ore	0·29	12·40	....
2	Arsenopyrite	0·18	0·55	....
3	Average sample of 4-foot zone exposed in an open-cut	0·17	2·7	3·8

1 and 2. From W. W. Leach, Geol. Surv., Canada, Sum. Rept. 1908, p. 45.
3. From J. D. Galloway, Ann. Rept., Minister of Mines, B.C., 1914, p. 216.

(3) The Myrtle claim is at an elevation of 5,500 feet on the south slope of the mountain. It is owned by J. Aldrich. Stringers carrying arsenopyrite and zinc blende have been exposed by open-cutting. Samples from

the showings assayed from a trace to 0·30 ounce in gold and from 2·3 to 5·2 ounces of silver per ton. (Galloway, J. D.: Ann. Rept., Minister of Mines, B.C., 1914, p. 216).

(4) The Iron King claim lies up-hill from the Myrtle and is owned by J. Aldrich. Stringers carrying arsenopyrite, zinc blende, and chalcopyrite occur across a width of 8 to 10 feet. A sample across 3 feet of the best-looking material assayed: gold, trace; silver, 3·6 ounces a ton; copper, 0·8 per cent; zinc, 15·8 per cent. (Galloway, J. D.: Ann. Rept., Minister of Mines, B.C., 1914, p. 216).

(5) The White Swan group lies east of the Coronado and is owned by Mark Hannah and Geo. Charlton. Stringers of arsenopyrite and zinc blende have been exposed by open-cutting. (Galloway, J. D.: Ann. Rept., Minister of Mines, B.C., 1914, p. 215).

(6) The Humming Bird claim lies up-hill from the White Swan and is owned by Mark Hannah and Geo. Charlton. A vein carrying in places 10 to 12 inches of zinc blende, arsenopyrite, galena, and pyrite has been exposed by open-cutting. The mineralization is irregular and somewhat sparse. A sample taken by Leach assayed: gold, 0·03 ounce, and silver 10·37 ounces a ton. Another sample taken by Galloway yielded: gold, 0·36 ounce, and silver 16·6 ounces, a ton; lead, 12·1 per cent; zinc, 21·1 per cent. (Leach, W. W.: Geol. Surv., Canada, Sum. Rept. 1908, p. 45; Galloway, J. D.: Ann. Rept., Minister of Mines, B.C., 1914, p. 216).

(7) The Copper Queen and Iron Mask claims lie near the head of Lyons creek on the eastern slope of the range. The mineralization occurs in decomposed andesites and consists of arsenopyrite in a quartzose gangue. A specimen of the ore assayed: 0·40 ounce of gold, and 0·52 ounce of silver, a ton. (Leach, W. W.: Geol. Surv., Canada, Sum. Rept. 1907, p. 22).

(8) The Evelyn group consists of four claims on the northeastern slope of one of the northerly peaks of Hudson Bay mountain and about 4 miles from Evelyn station. The claims are owned by A. McLean and J. A. MacDonald, of Smithers. The showings occur at an elevation of about 5,000 feet and along a fractured zone in altered volcanic rocks, which is sparsely mineralized with pyrite, arsenopyrite, galena, and zinc blende. A selected sample of the ore assayed: 0·04 ounce of gold, and 174 ounces of silver, a ton, and 26 per cent of lead. (Galloway, J. D.: Ann. Rept., Minister of Mines, B.C., 1923, p. 110).

(9) The Cascade group is on the easterly slope of Hudson Bay mountain about 3½ miles by trail from Lake Kathlyn station. On this property a shear zone 18 to 20 feet wide is traversed by bands of quartz sparingly mineralized with pyrite, arsenopyrite, and a little zinc blende. (Galloway, J. D.: Rept. of the Minister of Mines, B.C., 1923, p. 110).

7. Dome Mountain

Previous Descriptions

Galloway, J. D.: Ann. Rept., Minister of Mines, B.C., 1922, pp. 100-104; 1923, pp. 111-113.

The following account has been derived from the reports by Galloway. Dome Mountain camp is in the Babine range about 23 miles east of Telkwa on the Canadian National railway. The route to the camp is by wagon road for 8 miles and by good trail for about 18 miles. A considerable number of claims have been staked on the mountain, and of these, the more important were secured under option of purchase by T. E. Jefferson in 1921. During 1922 the most promising showings on the Forks, Cabin, and Gem claims were partly developed. In 1923 the Jefferson interests were taken over by the Federal Mining and Smelting Company and a new company, the Dome Mountain Gold Mining Company, was organized. Work was continued until the summer of 1924, when, owing to the disappointing results obtained, the company ceased operations.

The deposits occur in quartz veins intersecting schistose andesitic rocks. The veins vary from a few inches to many feet in width and are continuous over long distances. The mineralization consists of pyrite, arsenopyrite, galena, chalcopyrite, and zinc blende in a gangue of quartz or occasionally of calcite and siderite. The main value in the ores is the gold, which probably is associated chiefly with the iron sulphides.

8. Driftwood Creek

A vein of galena and some grey copper with, it is reported, some arsenopyrite, pyrite, and chalcopyrite, occurs along the contact of rhyolite and sheared argillite on the Hyland Basin group of claims. This group, owned by Martin Cain and Thomas King, is situated near the head of Cronin creek on the Babine Lake slope of the Babine range. The property is distant about 20 miles from Smithers. Small shipments have been made of selected ore containing a high silver content. (Galloway, J. D.: Ann. Rept., Minister of Mines, B.C., 1922, pp. 105-106; Hanson, G.: Geol. Surv., Canada, Sum. Rept. 1924, pt. A, p. 32).

9. Hazelton District

Previous Descriptions

Leach, W. W.: Geol. Surv., Canada, Sum. Rept. 1909, pp. 65-67; 1910, pp. 91-98.
Robertson, W. F.: Ann. Rept., Minister of Mines, B.C., 1911.
Galloway, J. D.: Ann. Repts., Minister of Mines, B.C., 1911 to present.
Malloch, G. S.: Geol. Surv., Canada, Sum. Rept. 1912, pp. 103-106.
McConnell, R. G.: Geol. Surv., Canada, Sum. Rept. 1912.
O'Neill, J. J.: Geol. Surv., Canada, Mem. 110 (1919).

Hazelton district embraces about 225 square miles south, east, and north of Hazelton, B.C. It includes the mineral claims on Ninemile, Fourmile, Glen, and Rocher Déboulé mountains. The Canadian National railway, which follows Bulkley and Skeena rivers, practically bisects it.

The area is underlain, for the most part, by sedimentary tuffs belonging to the Hazelton series and thought to be of late Jurassic age. These rocks have been intruded by batholithic masses of granodiorite and bosses or dykes of granodiorite porphyry. A number of mineral deposits occur both in the intrusives and in the tuffs or silicified sediments surrounding them. These may be roughly grouped as follows: (1) those characterized by silver, lead, and zinc, such as the Silver Standard and American Boy; (2) those in which copper and gold values predominate, such as the Rocher de Boule mine; and, lastly, the gold-arsenopyrite type in which cobalt, molybdenum, or tungsten may be present and of which the Red Rose and Hazelton View are examples. Arsenic is found to some extent in all three types of deposits. It occurs chiefly in the form of arsenopyrite, although such minerals as tennantite, safflorite, and löllingite have been detected. In the following pages the principal arsenic-bearing deposits examined by the writer are described. The location of each is indicated on the geological map which accompanies Memoir 110, by J. J. O'Neill. A number of other prospects holding arsenic-bearing minerals occur in the district, but none of these is likely to be of value as a producer of arsenic. Indeed, even those deposits which do carry considerable arsenic are, for the most part, small, widely separated, and rather difficult of access.

9a. HAZELTON VIEW

(*See* Figure 8)

Previous Descriptions

Galloway, J. D.: Ann. Rept., Minister of Mines, B.C., 1916, pp. 114-115; 1916, pp. 103-104; 1918, pp. 112-113.
O'Neill, J. J.: Geol. Surv., Canada, Mem. 110, pp. 20-23 (1919).

This property is on the west face of Rocher Déboulé mountain. The main workings are at an elevation of about 5,500 feet. A pack-trail leads to the camp from Carnaby on the Canadian National railway, a distance of 5 miles. The property consists of six claims and two fractions and is owned by the new Hazelton Gold Cobalt Mines, Limited. Development operations were suspended in 1918. The following description is largely based on the reports of O'Neill and Galloway.

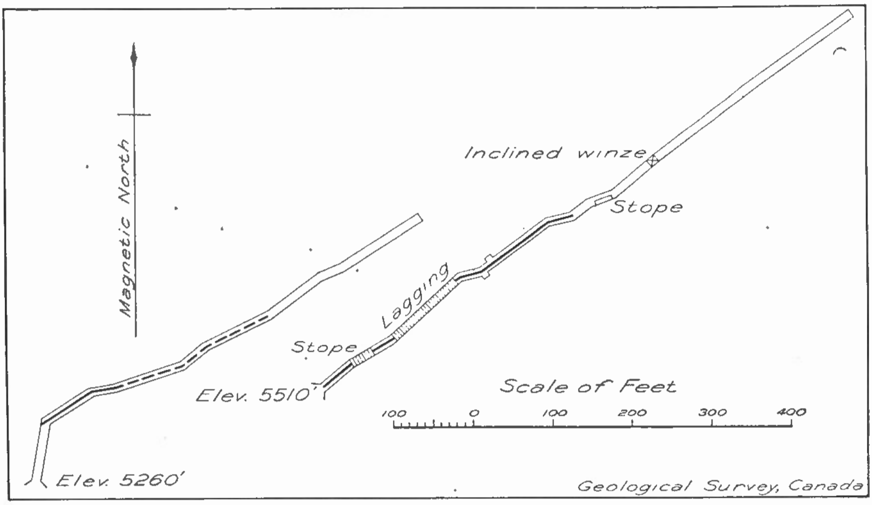


Figure 8. Plan of workings, Hazelton View property, Rocher Déboulé mountains, Coast district, B.C. Actinolite quartz zone shown by heavy black lines; unmineralized continuation of shear zone by heavy broken line.

The main vein on the property follows a shear zone in the granodiorite forming the core of Rocher Déboulé mountain. This zone strikes north

55 degrees east (magnetic) and dips 60 degrees to the northwest. It is said to have been traced for 2,200 feet horizontally and through a vertical distance of over 1,100 feet. The workings consist of two drift adits. The upper one, driven for about 800 feet along the shear zone, runs parallel to a 2-foot dyke of granodiorite porphyry throughout most of its course. The vein, in part represented by an open fissure, may be traced for about 400 feet along the upper adit. It varies in width from a few inches to 2 feet and consists chiefly of actinolite, quartz, calcite, and gouge, with variable amounts of sulphides. These are, in order of abundance, arsenopyrite, safflorite, löllingite, molybdenite, pyrite, pyrrhotite, and chalcopyrite. They occur as crystals, bunches, or bands, particularly along the hanging-wall of the vein. The lower adit was driven to crosscut the shear zone 250 feet below the upper workings. The zone was encountered at 75 feet from the portal and followed it for 300 feet to where it disappeared. The zone at this level contains 1 to 18 inches of actinolite and altered granodiorite, with occasional bunches of sulphides.

Due to the irregular distribution of the sulphides in the deposit, the gold, cobalt, molybdenum, and arsenic values are subject to wide variations. Samples of the arsenopyrite-actinolite rock, representing probably the highest-grade ore, were selected from the dumps for assay by the Mines Branch, Ottawa. The sample from the dump at the upper adit contained 3·35 ounces gold and 0·81 ounce silver a ton. That from the lower dump carried 7·42 ounces gold and 1·05 ounces silver a ton. These results indicate in a general way the values which might be expected from hand-sorted material or from mill concentrates. In 1918[1] a carload of ore was shipped to the Mines Branch, Ottawa, for testing purposes. The car contained 53,288 pounds (dry weight) of ore, which gave on analysis: gold, 1·24 ounces; MoS_2, 1·40 per cent; MoO_3, 0·18 per cent; cobalt, 1·12 per cent; nickel, 0·60 per cent; and arsenic, 8·98 per cent. By using table concentration it was found that 72·6 per cent of the cobalt, 84·9 per cent of the arsenic, and 83·5 per cent of the gold content could be recovered. By using flotation 54·4 per cent of the molybdenite was saved. It is apparent from the above assays that the gold and other values in the deposit are fairly satisfactory, but before the property can be considered a possible source of arsenic, a tonnage of ore considerably greater than is now known will have to be developed.

9b. RED ROSE

(*See* Figure 9)

Previous Descriptions

Galloway, J. D.: Ann. Rept., Minister of Mines, B.C., 1914, pp. 190-191.
O'Neill, J. J.: Geol. Surv., Canada, Mem. 110, pp. 18, 19 (1919).

The Red Rose property consists of eight unsurveyed claims situated at the head of Balsam (Red Rose) creek which flows westward into Juniper creek. The workings are on the north side of the creek at elevations of 5,200 to 5,800 feet. A wagon road leads from Skeena Crossing on the Canadian National railway, up Juniper creek to the mouth of Balsam

[1] Ann. Rept., Minister of Mines, B.C., 1918, p. 113.

creek, a distance of about 8 miles. From this point the claims are reached by a pack-trail 2 miles in length. The property is owned by Charles Ek, of Kispiox, B.C.

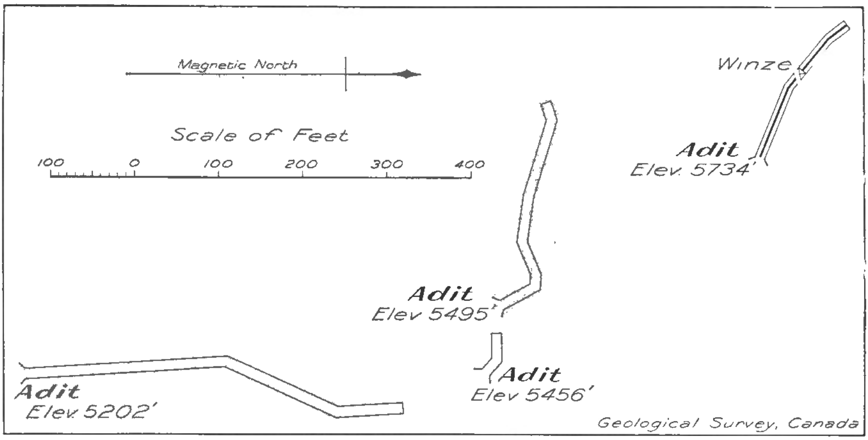


Figure 9. Plan of workings, Red Rose property, Rocher Déboulé mountains, Coast district, B.C. Mineralized zone shown by heavy black line.

This property is on the west margin of the main granodiorite mass which forms Rocher Déboulé mountain. The rocks in the vicinity consist of tuffs belonging to the Hazelton series, through which portions of the granodiorite protrude. The main vein on the property intersects both the sediments and the intrusive. It varies in width from 12 inches to 4 feet and can be traced up the hill-side for 1,000 feet or more. The vein has been partly explored by three adits. A fourth adit was driven to crosscut the vein, but was abandoned after going 450 feet without striking ore. The principal showings are in the top adit. There the vein occurs between walls of altered diorite, strikes north 70 degrees east (magnetic), and dips 50 degrees southwest. It varies in width from 12 to 36 inches and consists essentially of quartz, altered rock, and occasional patches of arsenopyrite, chalcopyrite, and pyrrhotite. Oxidation is so pronounced that in places the sulphides are almost completely decomposed. The best showings occur at 30 feet from the adit mouth, at a winze, and at a point 20 feet from the adit face. In the next lower adit the rocks are so decomposed that it is impossible to tell whether the vein is present or not. Very little evidence of mineralization was seen. The extensive alteration found in these workings is no doubt due to the fact that they pass under watercourses in the overlying slide rock.

The chief values present in the deposit are gold, copper, and arsenic. Selected specimens of arsenopyrite, taken from the vein at a point 30 feet from the portal of the top adit, and submitted to the Mines Branch, Ottawa, for assay, yielded: 0·75 ounce gold and 0·78 ounce silver a ton. This gives some idea of the values to be expected in concentrates made from the ore. Analyses quoted in the Report of the Minister of Mines for B.C. in 1915, show the copper content of the several samples taken to vary between 2·1 and 8 per cent.

9c. GOLDEN WONDER

Previous Description

O'Neill, J. J.: Geol. Surv., Canada, Mem. 110, p. 24 (1919).

This property is on the lower western slopes of Rocher Déboulé mountains, a short distance north of where the Rocher de Boule aerial tramway crosses the Hazelton-Skeena Crossing wagon road. The workings are at an elevation of 1,290 feet. The following account is mainly derived from the report by O'Neill.

There are three veins on the property, the north, middle, and south. The north vein is 12 to 15 inches wide, strikes north 85 degrees east (magnetic), and dips 75 degrees northwest. It consists chiefly of ground-up country rock, quartz, tourmaline, pyrite, chalcopyrite, arsenopyrite, and pyrrhotite. The middle or main vein occurs in a zone 10 to 30 inches wide, which strikes north 40 degrees east (magnetic) and dips 80 degrees northwest. This zone traverses grey tuffs of the Hazelton series and contains in places 6 to 12 inches of sulphides which, in order of abundance, are pyrrhotite, chalcopyrite, and arsenopyrite. They occur as solid bunches or as particles disseminated through and replacing the silicified tuffs. Little or no vein quartz is present. A shaft has been sunk 50 feet on this zone. The south vein is exposed near the road, about 300 feet south of the centre vein. It strikes north 60 degrees east (magnetic) and dips 60 degrees northwest. In a 25-foot shaft the mineralization consists of about 2 feet of pyrrhotite and minor amounts of arsenopyrite. As in the case of the centre vein this deposit appears to be due to the replacement of the tuffs along a shear zone. None of the veins has been traced very far on the surface.

9d. SILVER STANDARD

Previous Descriptions

Malloch, G. S.: Geol. Surv., Canada, Sum. Rept. 1912, pp. 105-106.
O'Neill, J. J.: Geol. Surv., Canada, Mem. 110, pp. 27-32 (1919). (Includes mine plans and sections).
Galloway, J. D.: Ann. Rept., Minister of Mines, B.C., 1911, and later.

The Silver Standard mine, owned by the Silver Standard Mining Company, is on the northwest slope of Glen mountain, about 6 miles by road north of New Hazelton. Shipments of hand-sorted ore were made from the property between 1913 and 1917. In 1918 a mill was put in operation, and lead and zinc concentrates were recovered and shipped until early in 1922, when the property closed down. It has since remained idle.

For a detailed description of this property the reader is referred to the report of J. J. O'Neill, from which and the reports of J. D. Galloway, the following account is derived. The country rocks in the vicinity of the Silver Standard consist chiefly of tuffs belonging to the Hazelton series. Nine veins are known to occur on the property, but only two have been important producers. They are roughly parallel, strike north 20 to 35 degrees east (magnetic), and dip steeply southeast. The veins have been opened up by a 400-foot inclined shaft; by drifts and crosscut adits. The vein-filling consists essentially of quartz and siderite, with irregularly distributed patches of sulphides. These are chiefly galena, zinc blende, arsenopyrite, tetrahedrite, pyrite, pyrrhotite, chalcopyrite, and jamesonite. The galena and tetrahedrite carry high silver values, and free gold has been observed in the arsenopyrite. The gross value of the production from the property is about $500,000. This was obtained from 14,500 tons of ore which contained approximately 1,100 ounces of gold, 626,000 ounces of silver, 1,225,000 pounds of lead, and 1,400,000 pounds of zinc. No data are available concerning the concentration ratio of the ore. A sample of jig concentrates stored at the mill was submitted to the Mines Branch, Ottawa, for assay. It yielded 0·17 ounce of gold, 35·22 ounces of silver, and 2·11 per cent arsenic. The lead concentrates are said to carry from 200 to 225 ounces of silver to the ton and the zinc concentrates from 80 to 100 ounces to the ton.

9e. AMERICAN BOY

(*See* Figure 10)

Previous Descriptions

Malloch, G. S.: Geol. Surv., Canada, Sum. Rept. 1912, pp. 104-105.
Galloway, J. D.: Ann. Rept., Minister of Mines, B.C., 1914, pp. 197-199; 1917, pp. 104-106.
O'Neill, J. J.: Geol. Surv., Canada, Mem. 110, pp. 32-33 (1919).

This property, consisting of six claims, is on the southwest slope of Ninemile mountain. The workings are reached by a switchback trail

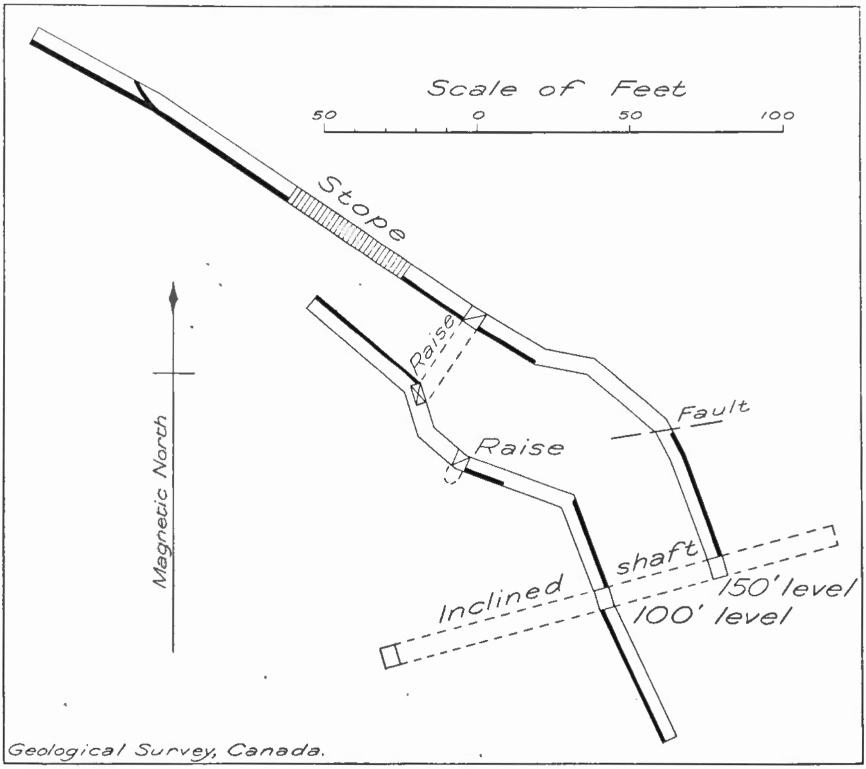


Figure 10. Plan of workings, main vein American Boy property, Ninemile mountain, Coast district, B.C. Veins shown by heavy black lines.

from a road that passes about 1,100 feet below the camp and leads to New Hazelton, a distance of 8 miles. The property is owned by Harris Mines, Limited. The following account is based on the previously published descriptions by Galloway and by O'Neill.

The country rocks in the vicinity of the American Boy are tuffs and sediments of the Hazelton series. Several parallel fissure veins intersect these rocks; strike north 30 to 40 degrees west, and dip steeply northeast. Three veins, varying from 2 inches to 3 feet in width, have been partly developed. The principal vein has been opened up by a 180-foot shaft inclined at an angle of 45 to 50 degrees, and by drifts at the 100 and 150-foot levels. This vein varies in width from 2 to 30 inches and consists essentially of quartz with patches and bunches of sulphides scattered irregularly through it. The ore minerals are, in order of abundance, galena, zinc blende, arsenopyrite, tetrahedrite, pyrite, and chalcopyrite. Both the galena and the tetrahedrite carry high silver values. The arsenopyrite carries from $6 to $10 a ton in gold, but probably is not present in sufficient amounts to be of much economic importance. No data are available relating to the quantity of concentrates obtainable from each ton of ore, nor to the arsenic content which they may contain.

9f. OTHER OCCURRENCES

Other deposits in Hazelton district which are reported by O'Neill to contain minor amounts of arsenic-bearing minerals are the Rocher de Boule, Great Ohio, Preston, Cap, and Brian Boru, all on Rocher Déboulé mountain; the Silver Cup and the Sunrise on Ninemile mountain. Of these only the last two properties were visited by the writer and in both cases the arsenic content appeared to be negligible. Arsenopyrite is reported to occur on the Erie group, located on Sixmile mountain. This occurrence, also of minor importance, has been described in the reports by Leach, Malloch, and the Minister of Mines, B.C., already referred to.

10. Alice Arm

Arsenic occurs at several points in the vicinity of Alice arm, Skeena mining division.

The ore of the Hidden Creek mine at Anyox contains some arsenopyrite in addition to pyrite, pyrrhotite, chalcopyrite, zinc blende, and magnetite. (Geol. Surv., Canada, Sum. Rept. 1922, pt. A, p. 21).

Arsenopyrite occurs with zinc blende, galena, freibergite, pyrite, pyrargyrite, and native silver in a quartz vein varying in thickness from 3 feet to merely a streak, and occupying a fault zone in argillites on the Esperanza claim, which is situated about a mile north of Alice arm and west of Kitsault river. (Geol. Surv., Canada, Sum. Rept. 1922, pt. A, pp. 31-32 and 46-47).

Very small amounts of arsenopyrite and other sulphides occur in a 6-foot quartz vein on the Golkish property on the shore of Deep bay, 3 miles south of Anyox. (Geol. Surv., Canada, Sum. Rept. 1922, pt. A, pp. 29-30).

A silver deposit, consisting of a number of quartz veins, none exceeding 8 inches in width, occurs on a contact between argillites and altered granodiorite exposed on Roundy creek at a point about 3½ miles by trail from Silver City on the east side of Alice arm and 1½ miles from the beach. The metallic minerals in order of abundance are: zinc blende, pyrrhotite, galena, arsenopyrite, pyrite, chalcopyrite, and native silver. (Geol. Surv., Canada, Sum. Rept. 1922, pt. A, p. 33.)

A number of nearly parallel quartz veins occur in a series of argillites and sandstones near the north shore of Alice arm, about 4 miles from the village of Alice Arm. Three of the more persistent veins, formerly worked by the Molybdenum Mining and Reduction Company, contain, locally, veinlets composed of the following metallic minerals, given in order of abundance: zinc blende, pyrite, arsenopyrite, galena, chalcopyrite, molybdenite, and native silver. (Geol. Surv., Canada, Sum. Rept. 1922, pt. A, pp. 30-31.)

11. Crater Creek

Previous Description

Cairnes, D. D.: Geol. Surv., Canada, Mem. 37, pp. 109-113 (1913).

According to Cairnes, silver-lead deposits carrying arsenopyrite occur in the vicinity of Crater creek, a tributary of Fourth-of-July creek which flows southwesterly into Atlin lake, north of Atlin. The deposits occur in diabase dykes intersecting the surrounding granitic rocks. On the Big Canyon property, which, in 1910, was the most important in the area, two mineralized dykes have been partly explored. The farther north dyke, of the two dykes, has an average thickness of about 30 feet, and can be traced on the surface for at least several hundred feet. The bulk of the mineralization is confined to a zone about 10 feet wide in the middle of the dyke. In this zone galena and arsenopyrite are the prevailing minerals, but pyrite, zinc blende, ankerite, calcite, and quartz are also present. The sulphides occur partly in fissure veins and veinlets, and partly in irregularly shaped bodies, evidently replacements of the diabase. Along the foot-wall of the dyke there is a band about a foot wide composed mainly of galena, arsenopyrite, and altered diabase.

The southern of the two dykes varies from 8 to 15 feet in width and is traceable for at least 3,000 feet on the surface. From 4 to 12 feet of this dyke is heavily mineralized, mainly with galena, zinc blende, and arsenopyrite, but pyrite, as well as chalcopyrite, also occurs. As in the upper dyke the mineralization is due both to the filling of open spaces and to the replacement of the original dyke rock.

These deposits are said to carry less than $4 a ton in gold. The lead and silver values are thought to be of more importance, although definite figures are not available.

12. Alberni

"Native arsenic has been found at Port Alberni" (Geol. Surv., Canada, Mem. 74, p. 30) and arsenopyrite occurs in gold-bearing, quartz-pyrite veins in the vicinity of China creek, which flows into Alberni canal south of Port Alberni. (Ann. Rept., Minister of Mines, B.C., 1893, p. 1080; Bull. No. 1, 1896, p. 7).

13. Pemberton Area

Previous Description

Cairnes, C. E.: Geol. Surv., Canada, Sum. Rept. 1924, pt. A, p. 84.

The following account is derived solely from the report by Cairnes who states that in the district bordering the head of Lillooet lake and extending 20 miles northwest, arsenopyrite occurs associated with magnetite, hematite, pyrrhotite, pyrite, sphalerite, chalcopyrite, and galena in replacement deposits usually in limestone near to, and genetically related to, intrusions of diorite, granodiorite, etc., belonging to the Coast Range batholith. In the same general district are vein deposits in which the gangue is usually largely of quartz, and the other important constituents, in about their order of abundance, are pyrite, arsenopyrite, galena, and sphalerite.

The Margery group of claims lies 1½ miles northeast of the wagon road between the head of Lillooet lake and the railway. The metamorphosed Triassic sediments contain lenses mineralized with pyrite, magnetite, sphalerite, arsenopyrite, and chalcopyrite.

Various properties have been located on either side of the head of Tenquille creek, a stream that flows east into Birkenhead river, 9 miles above the railway (*See* map accompanying Cairnes' report). These properties are accessible from Pemberton, by a road 15 miles long, to Taylor's ranch, whence a trail 7 miles long leads up the mountain to the claims. The Li-li-kel group of eight claims contains thirty-three small quartz veins carrying pyrite, arsenopyrite, galena, sphalerite, and chalcopyrite. A sample taken by Cairnes yielded a trace of gold and 10·85 ounces of silver a ton. One vein 12 inches wide, situated at an elevation of about 5,700 feet, contains a large percentage of arsenopyrite and is reported to carry fair values in gold.

14. Tatlayoko Lake and Perkins Peak

14a. MORRIS MINE

This property was examined in 1924 by V. Dolmage, of the Geological Survey, and is described in the Summary Report 1924, part A, pages 70-73. The deposit of the Morris mine owned by the Tatlayoko Lake Gold Mines, Limited, was discovered in 1907 by I. T. Morris, of Vancouver, who is still a principal shareholder.

The deposit is situated 3 miles southeast of the south end of Tatlayoko lake at an elevation of 5,900 feet, or 3,200 feet above the lake. A good road extends south from the lake for about one mile to a sawmill; thence a trail leads to the mine. The deposit consists of three quartz veins outcropping on the side of a gulch, and veins cutting Triassic argillites, sandstone, and conglomerate. A short distance northeast is a stock of quartz diorite probably connected with the Coast Range batholith. The sediments, also, are cut by many dykes ranging from diorite to basalt, and mostly younger than the veins. The main vein is exposed vertically for 450 feet and horizontally for 850 feet. It has been followed underground for 382 feet by an adit commencing at the lowest outcrop. The vein is 8 inches to 5 feet wide, averaging about 2 feet.

At 345 feet southwest of this adit and 200 feet lower, is No. 2 vein. It cannot be traced along the steep surface, but is followed 240 feet underground by an adit. The vein and adit are both crooked. The vein is about 8 inches wide.

Above the main adit, and nearer the quartz-diorite stock, is No. 3 vein which is similar to the other veins. The veins are composed of quartz with evenly disseminated arsenopyrite, pyrite, stibnite, and two or three undetermined minerals visible only under the microscope. The rock adjoining the veins has been altered hydrothermally to dense, chert-like, grey-green material.

Samples collected from the tunnels by Dolmage and assayed by the Mines Branch, gave the following results.

No.	Location	Width sampled	Gold	Silver	Antimony	Arsenic
		Inches	Ozs.	Ozs.	Per cent	Per cent
1	204 feet from entrance main adit........	18	1·68	46·05	1·79	5·54
2	21 feet from entrance lower adit........	12	0·19	3·17	0·3	2·0
3	164 feet from entrance lower adit.......	12	1·19	7·59	3·9	4·11

Samples were also collected by W. F. Robertson, Provincial Mineralogist, in 1910, and by J. D. Galloway of the British Columbia Department of Mines in 1916, and were analysed for gold and silver. (Ann. Rept., Minister of Mines, B.C., 1910, pp. 156-157; 1916, p. 170.)

Tests made by G. S. Eldridge and Company, Vancouver, on a 200-pound sample of the ore supplied by the owners, showed that 92 per cent of the gold and silver values were recoverable; that the gold is associated with the arsenic and the silver with the antimony; that concentrates could be made assaying 7·5 ounces gold and 107·9 ounces silver to the ton, and that if either the arsenic or antimony or both could be recovered, which was considered possible, the value of the concentrates would be greatly enhanced.

A sample of a small quartz vein carrying pyrite and arsenopyrite, found by the writer on the mountain just north of Franklyn arm, gave 6·46 per cent arsenic, 6·46 ounces silver, and 0·38 ounce of gold to the ton. The vein is only 5 inches wide and was traceable for only a few feet.

During the season (1924) Mr. Morris, discoverer of the Morris mine, and Mr. Feeney discovered some arsenopyrite veins in the mountains west of Tatlayoko lake, but the gold content of the ore was found to be disappointingly low. (V. Dolmage, Geol. Surv., Canada, Sum. Rept. 1924, part A, pp. 69-70.)

14b. PERKINS PEAK

The following account of this deposit is by V. Dolmage and will appear in a report by Mr. Dolmage in the Summary Report 1925, part A, pages 162, 163.

A gold-arsenic deposit is situated on the north side of Perkins peak at an elevation of 7,500 feet. Perkins peak lies about 20 miles southwest of Tatla Lake post office on Tatla lake. The deposit is reached by a branch trail from the trail leading from One Eye lake to Perkins peak. The ore-bearing veins occur in a series of sedimentary rocks composed of black argillites, dark brown, argillaceous sandstones, and fine, cherty conglomerates overlain conformably by thick beds of coarse volcanic breccia, which form the summit of Perkins peak. The strata strike north 60 to 70 degrees east and dip southeast 40 to 45 degrees. Fossils found in the near vicinity of the veins are reported to be of Lower Cretaceous age. The rocks are cut by the Coast Range batholith, the contact of which makes a U-shaped bend around the southwest side of Perkins peak and is 2 miles southeast, $4\frac{1}{2}$ miles southwest, and $1\frac{1}{2}$ miles northwest of the deposits. A small diorite stock less than one-fifth mile in diameter, similar to and probably a part of the batholith, outcrops in a small cirque $\frac{3}{4}$ mile southeast of the deposit.

The mineral is in large quartz veins or silicified zones which strike north and are nearly vertical and, therefore, extend up the steep valley wall. There are two groups of showings, which may be referred to as the "east" group and the "tunnel" group, situated $\frac{3}{4}$ mile to the west along the strike of the beds. The "east" showings consist of five large open-cuts exposing several irregular and poorly defined silicified zones 10 to 20 feet wide, in which are small quantities of disseminated arsenopyrite. The showings are quite large, but the amount of contained gold unfortunately is small. The "tunnel" showings consist of several small open-cuts and one small adit 12 feet long driven into the cliff in a southerly direction. In the face and floor of the adit are six irregularly-shaped veins of solid arsenopyrite ranging in width from 4 to 13 inches and totalling about $3\frac{1}{2}$ feet. Gold is not present in commercial quantities. Several silicified zones were examined below the adit, but were found to contain only small amounts of arsenopyrite. They, therefore, probably contain only minute quantities of gold.

15a. Aufeas Mine

(*See* Figure 11)

Previous Descriptions

Brewer, Wm.: Ann. Rept., Minister of Mines, B.C., 1915, pp. 255-256.
Cairnes, C. E.: Geol. Surv., Canada, Sum. Rept. 1920, pt. A, pp. 35-36.
Campbell-Johnston, R. C.: Report for company, 1923.
Cairnes, C. E.: Geol. Surv., Canada, Mem. 139, pp. 148-151 (1924).

The Aufeas mine is on the southeast side of Wardle creek, a tributary flowing northeastward into Silver creek, which joins Fraser river about $1\frac{1}{2}$ miles below Hope, B.C. A good wagon road leads from Hope, up Silver creek to the mouth of Wardle creek, a distance of nearly $3\frac{1}{2}$ miles. Just north of this point a trail branches off to the mine which lies 3,000 feet from, and 1,000 feet above, the road. (*See* Map 1988, accompanying Memoir 139.)

The principal workings are on the Jumbo claim, one of a group of five staked on either side of Wardle creek. In 1914 a light aerial tramway was constructed from the portal of the lower adit to the Silver Creek road, but only a small part of the 140 tons of ore mined and partly sacked during the year was shipped because, presumably, of the high transportation charges. Since then the property has lain idle and the tramway and mine equipment have either fallen into disrepair or been destroyed. The property is controlled by A. E. Raab and L. B. Cleaves of Hope, B.C.

The country rock in the vicinity of the Aufeas mine consists of quartz diorite belonging to what may be an outlying part of the Coast Range batholith and is probably of late Jurassic age. It is commonly gneissoid and is intersected by fissures and shear zones. Along such lines of weakness were deposited the quartz-arsenopyrite-gold veins.

The principal or "A" vein outcrops about 250 feet above Wardle creek and 242 feet above the portal of the lower adit. It occurs in a shear zone striking north 60 degrees east (magnetic) and dipping southeast at an angle of 45 to 50 degrees. The vein is exposed in an open-cut, near the centre of which it attains a maximum width of 15 inches. To the southwest of this point it narrows and finally disappears in about 30 feet; to the northeast it narrows until, at a distance of 40 feet, its continuation is marked by 2 to 3 inches of red gouge. The vein-filling consists chiefly of arsenopyrite with minor amounts of chalcopyrite, pyrite, and quartz. The wall-rock, although sheared and altered for several feet above and below the vein, is only sparsely mineralized.

An adit has been driven to crosscut the "A" vein from a point 42 feet below its outcrop. A veinlet of arsenopyrite, about 1 inch wide, which is exposed near the portal, was encountered 6 feet inside the adit. It strikes north 10 degrees west (magnetic) and dips east at an angle of 46 degrees. At 50 feet from the portal, a vein, hereafter designated as the "B" vein, was intersected. Drifts were run along the vein for 10 feet to the southwest and 7 feet to the northeast. The "B" vein strikes north 56 degrees east (magnetic), dips 50 to 55 degrees to the southeast, and consists of 2 to 6 inches of arsenopyrite, pyrite, and quartz. The adit was continued for 64 feet from the portal, or 14 feet beyond the "B" vein, without finding any additional veins. For this reason the idea has been advanced that the "B" vein is the downward continuation of the "A" vein. If this be so, the dip of the "A" vein must become much steeper than at the outcrop, or else the vein has branched on its way down. Despite the fact that the "B" vein has not been found on the surface the writer is inclined to concur with Brewer in the belief that the two veins are distinct. If this be the case, then, by continuing the adit in its present direction, the "A" vein should be intersected within a few feet.

A third vein, designated as the "C" vein in this report, outcrops about 55 feet east of the portal of the upper adit. This vein strikes north 56 degrees east (magnetic), dips 20 degrees to the southeast, and contains $2\frac{1}{2}$ to 3 inches of arsenopyrite, pyrite, and quartz. It could be traced for only about 20 feet on the surface.

A lower crosscut adit has been driven at an elevation of 1,315 feet, that is, 242 feet below the outcrop of the "A" vein or 200 feet below the upper adit. At a point 190 feet from the portal irregular bunches of quartz containing a little arsenopyrite and pyrite were encountered and followed for 60 feet in a southwesterly direction until cut off by a shear zone. At 383 feet from the portal a vein striking north 45 to 60 degrees east (magnetic), and dipping 47 to 52 degrees southeast, was struck. Reference to the accompanying Figure 11 will show that this vein coincides with the projection of the "B" vein on the 1,315-foot level. A few

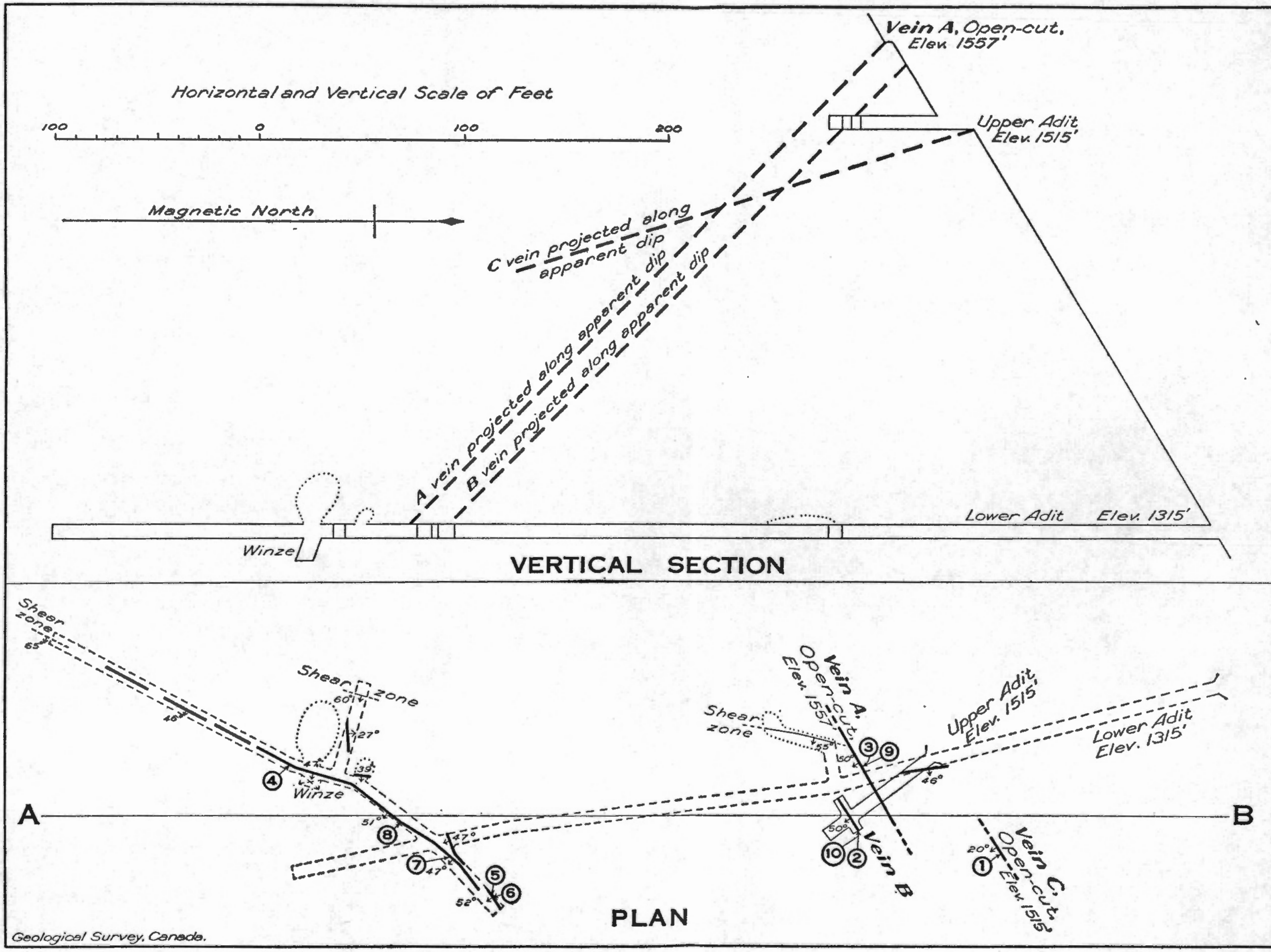


Figure 11. Plan and vertical section of workings of Aufeas mine, near Hope, B.C. Vertical section is a projection of the workings on a plane through the line A-B. Sample localities shown by numerals enclosed in circles.

feet farther south the adit intersected another vein striking north 35 to 40 degrees east and dipping 47 degrees southeast. This possibly represents the downward extension of the "A" vein as is suggested by Figure 11. Hereafter these two veins will be referred to respectively as the "B1" vein and the "A1" vein. A drift was run for 45 feet to the northeast along both veins and to the southwest for 214 feet along the hanging-wall or "A1" vein. The adit was continued 70 feet farther south, passing first through altered diorite for 50 feet and then into fresh diorite.

In the northeast drift the two veins occur in a shear zone. The "B1" vein can be traced for 15 feet, to where it pinches out for an equal distance and finally comes in again near the face. It varies in width from a fraction of an inch to 8 inches; consists of arsenopyrite and quartz, and is bordered on either side by several inches of gouge and altered diorite in which are scattered crystals of arsenopyrite. The "A1" vein lies next to the hanging-wall of the shear zone and about 3 feet from the "B1" vein. At the entrance to the drift it contains 6 inches of arsenopyrite and quartz, but gradually becomes narrower and finally pinches out at 15 feet from the face. The hanging-wall of the zone consists of silicified diorite. The area between the two veins is composed of altered diorite and gouge, the shearing being greatest towards the foot-wall, which is rather indefinite.

In the southwest drift, what is regarded as the "A1" vein has been followed more or less continuously for about 180 feet. In this distance the strike of the vein changes from north 36 degrees east to north 25 degrees east, and the dip averages about 50 degrees southeast. The vein adheres closely to the hanging-wall of the shear zone in which it lies. Where this vein pinches out about 30 feet from the face of the drift, the shear zone has a width of about 2 feet and consists of gouge and altered diorite. Another vein containing from 2½ to 4 inches of arsenopyrite and quartz was encountered at a point 40 feet along the drift. This vein lies 3·4 feet to the west of the "A1"; strikes north 6 degrees east; dips 39 degrees to the east, and may represent either the continuation of the "B1" vein or a branch of the "A1" vein. Both veins are exposed in a small stope. A crosscut was run westerly for 48 feet from a point 60 feet along the main drift. This crosscut passes through diorite, intersects several stringers of arsenopyrite, and penetrates a shear zone a few feet from the face. Just south of the crosscut a winze was sunk for 15 feet and a raise extended upward for 48 feet on the "A1" vein. The winze was full of water at the time the property was examined. In the raise or stope the vein varies in width from 4 to 12 inches; consists chiefly of arsenopyrite with some quartz, calcite, and gouge, and lies between walls of altered diorite. On the north side of the stope the vein divides into two diverging stringers, one of which follows the hanging-wall and the other continues towards the foot-wall.

The veins exposed in the different workings vary in width from a fraction of an inch to 15 inches, but probably do not average more than 4 to 5 inches. The vein-filling consists chiefly of auriferous arsenopyrite and quartz, with some chalcopyrite, pyrite, and calcite. Mill tests have not been made on a large scale, but some idea of the grade of ore encountered in the workings may be obtained from the assays quoted below. The precise location of each sample is indicated on the accompanying Figure 11.

Sample No.[1]	Description	Troy oz. a ton		Per cent	
		Gold	Silver	Copper	Arsenic
1	Across width of 2½ inches at outcrop of "C" vein	6·21	1·06	....	28·27
2	Across 3 inches of "B" vein in northeast drift, upper adit	0·21	0·09	nil	33·86
3	Across width of 6 inches at outcrop of "A" vein	1·66	2·36	1·35	31·00
4	Across 2 inches of "A" vein south of winze, lower adit	0·63	0·50	....	22·94
5	Across 4 inches of "B" vein, northeast drift, lower adit	0·30	0·18	....	32·67
6	Across 6 inches of "B" vein, northeast drift, lower adit	1·01	1·09	....	....
7	Across 5 inches of "A" vein, northeast drift, lower adit	0·45	0·34	....	....
8	Across 6 inches of "A" vein, 20 feet along southwest drift, lower adit	0·17	0·17	....	....
9	Across 6 inches of "A" vein at outcrop	1·05	0·60	nil	....
10	Across 8 inches of "B" vein, northeast drift, upper adit	0·24	0·20	nil	....

[1] Samples Nos. 1 to 5 were taken by C. E. Cairnes, samples Nos. 6 to 8 by M. E. Hurst, and were assayed by the Mines Branch, Dept. of Mines. The last two assays, Nos. 9 and 10, are quoted by Brewer in the Ann. Rept., Minister of Mines, B.C., 1915, pp. 255-256.

As no ore has been definitely blocked out in the mine, an estimate of positive ore cannot be made. If the veins found in the lower adit represent the downward extensions of those exposed at the surface or in the upper adit, then the probable ore can be placed conservatively at 2,000 tons. In addition, a larger tonnage of lower grade, milling ore is thought by the owners to have been developed, but its quality and extent can be ascertained only by extensive sampling. Although the property is essentially a gold proposition, the percentage of arsenic in the veins is sufficient to afford a valuable by-product. The mine is easily accessible and convenient to transportation. The tonnage of payable ore that can be developed appears to be confined to the narrow arsenopyrite-quartz veins.

With regard to the origin of the deposit, it may be repeated that the veins occupy fissures or shear zones in quartz diorite. These openings formed as a result of the structural deformation which preceded or accompanied the intrusion of large bodies of granitic rocks to the south and east of Wardle creek. These lines of weakness are in many places marked by the presence of carbonates and gouge developed by shearing and hydrothermal alteration of the diorite. The mineral association is characteristic of veins formed under moderate conditions of temperature and pressure. The granitic intrusions mentioned above might conceivably be the source of the mineralizing solutions. If this be the case, then the area of older batholithic rocks (*See* Map No. 1988, Memoir 139) lying between Wardle creek and the later intrusives exposed to the south and east is likely to contain other gold-arsenic deposits.

15b. Emancipation Mine

Previous Descriptions

Robertson, W. F.: Ann. Rept., Minister of Mines, B.C., 1920, p. 170.
Cairnes, C. E.: Geol. Surv., Canada, Mem. 139, pp. 136-140 (1924).

The Emancipation mine has been fully described by Cairnes, from whose account the following has been compiled. The mine is situated at an elevation of 2,500 feet on the east side of the valley of Coquihalla river about 2 miles north of Jessica station on the Kettle Valley railway. It is owned by the Liberator Mining Company, of Vancouver.

The deposit consists of quartz veins which lie on either side, or dip across the contact between the greenstones of the Cache Creek series (Pennsylvanian) and the slates of the Ladner series (Jurassic). The contact zone in places is greatly crushed, intersected by a plexus of quartz veins, and sparsely mineralized with pyrite, pyrrhotite, arsenopyrite, and some chalcopyrite. The principal veins are the Dyke and Boulder veins. The former is less than 18 inches wide on the average and carries arsenopyrite, with which are associated high, but spotty, gold values. The Boulder vein has an average width of 8 feet and consists of milky quartz with minor amounts of sulphides. These veins have been explored by drift adits and crosscuts, but as yet only a small tonnage of ore has been shipped to the mill erected near the railway.

15c. Ladner Creek

Arsenopyrite occurs in, or adjoining, quartz veins on the Snowstorm, Idaho, Rush of the Bull, Gem, and Pipestem claims, situated between the south and middle forks of Ladner creek, a stream flowing southeastward into Coquihalla river 2½ miles north of Jessica, on the Kettle Valley railway. The deposits lie at or near a slate-greenstone contact along which fracturing has taken place. The mineralization consists essentially of quartz with minor amounts of arsenopyrite, pyrrhotite, pyrite, and chalcopyrite, both in the quartz and in the adjoining wall-rocks. Gold values are present in many of the veins. (Cairnes, C. E.: Geol. Surv., Canada, Mem. 139, pp. 140-146 (1924).)

15d. Morning Group

Quartz veins sparingly mineralized with pyrite and arsenopyrite occur near a slate-greenstone contact on the Morning group of claims located on the east side of Coquihalla river above the mouth of Dewdney creek. (Cairnes, C. E.: Geol. Surv., Canada, Mem. 139, pp. 146-147 (1924).)

15e. Twentythreemile Camp

Arsenopyrite occurs on a number of claims in the Twentythreemile camp, situated near the junction of Skagit and Sumallo rivers. The deposits are of the contact-metamorphic type and are confined chiefly to narrow beds of limestone belonging to the Cache Creek series (Carboniferous) which has been intruded by masses of quartz diorite. The mineralization consists largely of pyrrhotite, with minor amounts of arsenopyrite, chalcopyrite, zinc blende, galena, and molybdenite in a gangue of calcite or lime silicates. The principal values are in gold or copper. (Cairnes, C. E.: Geol. Surv., Canada, Sum. Rept. 1920, pt. A, pp. 39-41; Sum. Rept. 1922, pt. A, pp. 108-123.)

15f. Summit Camp

Arsenopyrite occurs in minor amounts in the Summit mining camp, on the east slope of the divide between the headwaters of Amberty and Sutter creeks, tributaries of Tulameen river, and of Dewdney creek, which flows westward into the Coquihalla. The ore-bodies are found in or adjoining narrow fissure veins which traverse Jurassic and Cretaceous sediments intruded by granodiorite or quartz diorite. The mineralization consists of galena, zinc blende, chalcopyrite, pyrrhotite, and pyrite, and minor amounts of magnetite, arsenopyrite, and tetrahedrite in a gangue of quartz and carbonates. (Cairnes, C. E.: Geol. Surv., Canada, Sum. Rept. 1922, pt. A, pp. 95-107.)

16. Roche River Area

Arsenopyrite associated with bornite, chalcopyrite, and pyrite occurs in talc schist on the Red Star and Anaconda claims located near the junction of Roche and Pasayten rivers. (Geol. Surv., Canada, Sum. Rept. 1906, p. 50.)

17. Hedley Mining Area

Previous Descriptions

Camsell, C.: Geol. Surv., Canada, Mem. 2, 1910. Ann. Repts., Minister of Mines, B.C., 1900 to present.
Cairnes, C. E.: Geol. Surv., Canada, Sum. Rept. 1922, pt. A, p. 123.

This area is situated in Similkameen district, south-central British Columbia. For the purpose of this report it may be regarded as including the territory within a radius of 8 miles of the town of Hedley. About 16 square miles of this area lying north and east of Hedley were mapped and studied in detail by Camsell in 1907 and 1908. In his report the geological formations and ore deposits in the vicinity of Nickel Plate mountain are more fully discussed than in the following brief summary.

The area is largely underlain by a thick assemblage of limestone, quartzites, argillites, volcanic tuffs, and breccias formerly regarded as of Carboniferous age, but now known to be, in part at least, of Mesozoic age.[1] They have been divided into four formations on the basis of lithological characteristics. The most important horizon from an economic standpoint is the Nickel Plate formation which consists of limestone with interbeds of quartzite; both rocks in places are highly altered and the limestone much silicified. The principal ore-bodies, including those in the Nickel Plate mine, occur in this formation. The sediments have been intruded by stocks, dykes, and sills of gabbro and diorite. These igneous intrusions are regarded by Camsell as the source of the mineralizing solutions. Later batholithic masses of granodiorite cut off the sediments on all sides, leaving them in the form of a roof pendant.

[1] Schofield, S. J.: Geol. Surv., Canada, Sum. Rept. 1919, pt. B, pp. 38-39.

17a. NICKEL PLATE MINE

(*See* Figure 12)

This property is on the east slope of Nickel Plate mountain at an elevation of 5,750 feet. Claims staked in 1898 were taken over in 1899 and prospected by the Yale Mining Company. By 1902 sufficient ore had been developed to warrant the installation of an electric railway and cable tramway from the mine to the mill erected near the mouth of Twenty-mile creek some 4,000 feet below. In 1909 the property was taken over by the present operators, the Hedley Gold Mining Company. Since then the mine and milling plant have been shut down on a few occasions for several months or a year owing to lack of water, shortage of power, or temporary depletion of ore reserves. Over $8,000,000 in gold have been produced from the mine since it was opened. Until 1917 no returns were made to the company for the arsenic content of the concentrates shipped to the smelter. Since that date about 4,000 tons of white arsenic, valued at over $275,000, have been recovered from the Hedley ores.

At the present time the work of the Hedley Gold Mining Company is confined to the deposits at the Nickel Plate mine. In past years a considerable tonnage of ore was taken from the Sunnyside and Silver Plate workings, but these have since been abandoned. The underground workings have been extended by an inclined shaft, known as the Dickson incline, to the 1,500-foot level. In this distance six ore-bodies have been discovered. The relationship of these ore-bodies to the limestone beds of the Nickel Plate formation and to the gabbro sills is shown on the accompanying profile (Figure 12) through the Dickson incline. The ore-bodies, as was shown by Camsell, pitch to the northwest and, in general, occur overlapping one another in such a way that the lower ends of the bodies successively extend farther and farther down the slope. They extend obliquely across the dip of the limestone beds, which is to the west. The ore-bodies lack definite walls, the stoping widths being determined largely by assay boundaries. The source of the mineralization has been ascribed to solutions which ascended along a zone of weakness now occupied by the ore-bodies. These solutions are thought by Cairnes to have originated probably with the gabbro-diorite intrusive complex; the same author is of the opinion that the courses pursued by the mineralizing solutions may have been influenced by the presence of a nearly vertical gabbro porphyry dyke (*See* Figure 12). Mineralization is by no means confined to the ore-bodies; in fact, these form but a small fraction of the total mineralized area (as indicated by diamond drillings),the bulk of which, however, has little commercial value at the present time. The ore consists essentially of arsenopyrite with some chalcopyrite and pyrrhotite in a gangue of epidote, garnet, and calcite, and silicified limestone and gabbro. The principal values are in gold and arsenic, with minor amounts of silver. The gold is confined chiefly to the arsenopyrite, in which it occurs in spots rather than uniformly distributed.

The ore is sent to the mill where it is crushed, cyanided, and the concentrates recovered. The tonnage treated is between 200 and 225 tons a day. About one ton of concentrates is obtained from 25 to 30 tons of

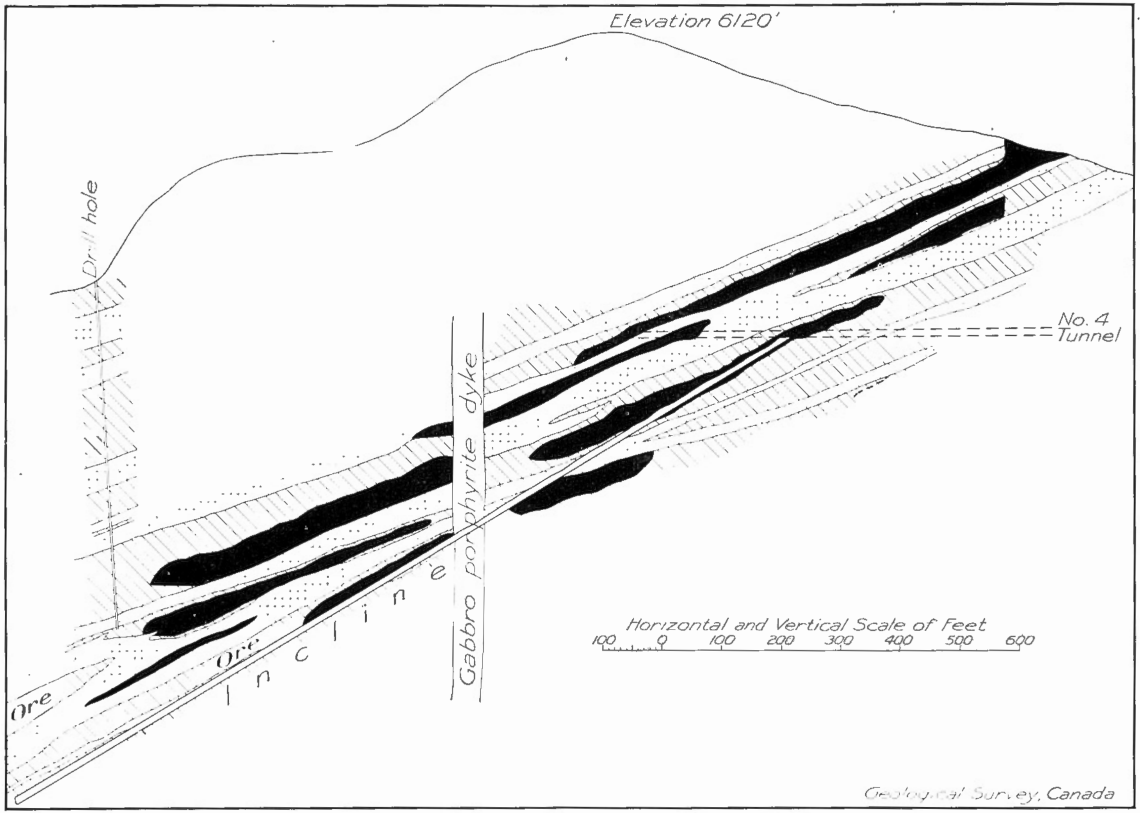


Figure 12. Vertical section through the Dickson incline, Nickel Plate mine, Hedley, B.C. Stopes shown by solid black; limestone (variously altered) by diagonal ruling; intrusive gabbro-diorite bodies by dotted pattern.

ore. The concentrates contain 25 to 35 per cent arsenic, 2 to 2½ ounces of gold, and 1 ounce of silver a ton. These are shipped to the American Smelting and Refining Company's smelter at Tacoma, Wash., for treatment. Only since 1917 has the Hedley Gold Mining Company received anything for the arsenic content in its ore. Had an arsenic-recovery plant been installed by the company at that time, white arsenic could have been produced and marketed at a considerably greater profit than under the present arrangement. Within recent years, however, development work on the property has not been much in advance of actual mining, with the result that the ore reserves blocked out were hardly sufficient at any one time to warrant the erection of an arsenic plant. Moreover, the gold values in the ore have gradually declined from around $12 to about $7 a ton. It is evident, therefore, that new ore-bodies of payable grade must be found if the mine is to continue operations. At the present time (1924) the mill is closed down, and exploration by diamond drilling is being carried on from the 1,500-foot level.

17b. KINGSTON GROUP

The Kingston group of five claims is on the west slope of Nickel Plate mountain overlooking the valley of Twentymile creek. The workings are chiefly on the Kingston, Metropolitan, and Warhorse claims and are situated between elevations of 3,500 and 3,700 feet. The property is owned by the Kingston Gold and Copper Company of Quebec, Que. Not for some years has any work been done on the property.

As described by Camsell, the rocks in the vicinity of the workings are silicified limestone, quartzite, and tuffs belonging to the upper part of the Nickel Plate formation. All the beds have been highly metamorphosed and largely converted to lime silicates by intrusive bodies of diorite porphyry, diorite, and gabbro. The deposits are confined to the areas of altered sediments bordering the intrusives. The ore-bodies have been explored to some extent by open-cuts, adits, and shafts. In these workings they are seen to be extremely irregular in outline and to lack definite walls. This renders prospecting both difficult and costly. The mineralization consists of chalcopyrite, arsenopyrite, pyrrhotite, and galena in a gangue of silicified limestone, garnet, epidote, and calcite. The ore strongly resembles that at the Nickel Plate mine. The principal values are in copper and gold, but the distribution of the latter is especially erratic. The arsenic content of the ore appears on the whole to be quite low, although without mill tests no data can be obtained on this point.

17c. STEMWINDER MOUNTAIN

Stemwinder mountain rises just north of the town of Hedley and forms the western slope of the valley of Hedley or Twentymile creek. It consists chiefly of limestone belonging to the Aberdeen formation, which has been intruded by masses of diorite and granodiorite. This formation appears to strike north and south and dip steeply to the west. Deposits of arsenopyrite occur in places along the intrusive contacts or in the diorite. The principal showings are on the Crackerjack claim belonging to D. Woods and on the Whirlwind and Cyclone claims held by J. A. Robinson and associates, all of Hedley, B.C.

Crackerjack

This claim lies on the southeastern slope of the mountain overlooking the valley of Hedley creek. The showings are at an elevation of 2,700 feet, or 700 feet above the creek. At one point on the claim a vertical band of limestone, about 60 feet wide, lies between walls of granodiorite. The contacts are marked by garnet and silicified limestone in which small amounts of pyrrhotite, chalcopyrite, and arsenopyrite occur. Several hundred feet northeast an incline has been put down for 12 feet on a quartz-arsenopyrite vein in diorite. This vein strikes north 70 degrees east (magnetic) and dips 35 degrees to the northwest. It varies from 4 to 16 inches in width and appears to occupy a shear zone in the diorite. This zone could be traced for a short distance only, owing to the steepness of the cliff along which it outcrops. The mineralization consists of quartz and crystalline arsenopyrite, with occasional specks of pyrrhotite, pyrite, and chalcopyrite. The vein matter shows considerable oxidation. A sample of arsenopyrite from this vein was submitted to the Mines Branch, Ottawa, for assay, and was found to contain 0·62 of an ounce of gold and 2·25 ounces of silver a ton.

Whirlwind

This claim is situated on the eastern slope of Stemwinder mountain, overlooking the valley of Hedley creek. The property was reported on by C. E. Cairnes[1] in 1922 as follows:

The principal workings on the Rawhide (the Whirlwind claim is referred to) claim occur in a body of crystalline limestone, a member of the Aberdeen formation............ The limestone forms a very massive bed near the workings, but is apparently only a small remnant of a once more extensive stratum that has been reduced by erosion and cut off, below, by a diorite intrusive. The ore mineralization occurs near the contacts with the diorite..... At an elevation of about 3,750 feet an adit has been driven for 50 feet along a metamorphosed zone in this limestone. Here, heavy mineralization occurs across a width of several feet and marks the position of an ore-body pitching into the hill, or to the west, at from 60 to 70 degrees. The ore-body is, however, irregular in outline and has been subjected to minor faulting near the face of the tunnel. Arsenopyrite is the most abundant ore mineral near the centre and towards the hanging-wall of the ore-body. Pyrrhotite is also abundant near this wall, but nearer the foot-wall chalcopyrite is most conspicuous and is associated with a smaller proportion of zinc blende..... Calcite is the chief gangue mineral..... Garnet, epidote, and pyroxene are also characteristically developed in the zone of metamorphism. The surface exposure of this ore deposit is only a few square yards. The depth is a less certain factor, but from the angle of pitch into the hill and the occurrence of coarse intrusive outcrops a few yards from the present workings, it is probably not great. Gold values are associated with the arsenopyrite and chalcopyrite is the only important copper mineral. Picked samples containing the latter were said to run as high as 13 per cent copper and a more general sample taken along 16 feet of the foot-wall averaged 3½ per cent.

Cyclone

The mineralization on this property has been described by Cairnes.[2] The workings on the Cyclone lie about 300 yards west and 200 feet below those on the Whirlwind claim. The principal showing occurs in a narrow band of limestone caught up in an intrusive mass of diorite. An adit has

[1] Cairnes, C. E.: Geol. Surv., Canada, Sum. Rept. 1922, pt. A, pp. 124-125.
[2] Cairnes, C. E.: Geol. Surv., Canada, Sum. Rept. 1922, pt. A, p. 125.

been driven for 35 feet along one limestone-diorite contact. It passes through a zone consisting of a dark green, fine-grained silicate rock originally part of the limestone but now composed of scapolite, hornblende, and epidote. White crystalline limestone outcrops immediately west of the adit and diorite to the east. Inclusions of limestone also occur within the diorite. The main contact appears to run north and south and to dip steeply to the west. The mineralized zone consists of arsenopyrite and lesser amounts of pyrrhotite and chalcopyrite disseminated through the silicate rock and in the diorite. It appears to be about 7 feet wide and parallels the limestone-diorite contact. In places, solid masses of arsenopyrite occur where replacement has been more extensive. A sample of arsenopyrite submitted to the Mines Branch, Ottawa, for assay, yielded 7·99 ounces of gold and 1·25 ounces of silver a ton. Since the contact zone is rather narrow and the mineralization irregular it is unlikely that large bodies of arsenopyrite will be found. The size of the deposit depends, of course, on the extent of the limestone band and on the amount of metamorphism and replacement it has undergone.

17d. STIRLING CREEK

Snowstorm

This property is on the east side of Stirling creek about 2 miles from, and 2,600 feet above, its point of junction with Similkameen river. A wagon road runs westward from Hedley to the mouth of Stirling creek, a distance of 4½ miles. From this point a rather steep trail leads southerly to the showings at an elevation of 4,400 feet. The claim is held by J. A. Robinson, of Hedley, B.C. During the summer of 1924 assessment work was being done to ascertain, if possible, the extent and value of the deposit.

The workings are located near the summit of the ridge, which here slopes gently westward toward Stirling creek. The bedrock is overlain by soil and drift from 3 to 5 feet thick. The principal showing occurs in a shaft sunk to a depth of 23 feet on a vein of arsenopyrite and pyrite enclosed in grey, cherty limestone. On the west side of the shaft the vein consists of 6 to 12 inches of partly oxidized sulphides bordered by 2 to 3 inches of calcite and altered wall-rock. On the east side of the shaft the sulphides occur as an irregular mass lacking any definite structure or direction. The vein appears to strike east and west and dips about 60 degrees to the northwest.

Several trenches and pits have been put down through the surface soil in the direction along which the vein is assumed to strike. On one of these, located about 90 feet north 70 degrees west (magnetic) of the shaft, a zone 18 to 24 inches wide was uncovered. This consisted of highly oxidized arsenopyrite between walls of partly decomposed shaly limestone. Other pits sunk along the same general line were, at the time the property was examined, too shallow to prove beyond doubt the continuation of the vein exposed in the shaft.

The vein, if such it can be termed, lacks distinct walls in places and appears to represent in part, at least, the replacement of impure limestone by arsenopyrite and pyrite. Calcite is the chief gangue mineral, quartz being almost, if not entirely, absent. The following assays have been made on samples of the sulphides taken from the showing in the shaft.

No.	Troy ounces a ton		Per cent
	Gold	Silver	Arsenic
1	0·47	0·21	21·41
2	0·34	trace	30·1
3	0·28	0·25	not det.

1. Mines Branch, Dept. of Mines, Canada. Taken by C. E. Cairnes.
2. Granby Consolidated Mining, Smelting, and Power Co., Ltd. Taken by N. E. Nelson, Allenby, B.C.
3. Mines Branch, Dept. of Mines, Canada. Taken by M. E. Hurst. Selected sample of solid sulphides from a depth of 20 feet in the shaft.

Hub

The Hub claim, or Golden Canyon as it was formerly called, is located on the east side of Stirling creek about 2½ miles from its mouth. A wagon road and trail follow the west side of the creek to a point across from the showings. The property is owned by Nick Pickard, a resident of the vicinity. It is referred to in the Report of the Minister of Mines, B.C., for 1901, pages 1,165-6.

On the steep slope above the creek several parallel veins are exposed. These occur at intervals up to an elevation of 2,800 feet, or about 200 feet above the creek; strike nearly north and south; and dip into the hill. The uppermost consists of 12 to 14 inches of arsenopyrite, pyrite, and quartz covered by a greenish white capping and enclosed between iron-stained and altered sediments. A pit 8 feet deep has been sunk on the oxidized showing and in it the vein appears to strike north 33 degrees west (magnetic) and to dip 60 degrees to the northeast.

About 100 feet lower down an open-cut and adit were driven for 20 feet to intersect a second vein containing from 12 to 18 inches of quartz and crystalline arsenopyrite. The strike of the vein is uncertain, but it appears to be about north 20 degrees west (magnetic). The showing at this point, although the best on the property, has not been developed.

The third or lowest showing occurs about 50 feet above the creek. The outcrop consists of greenish white, porous material in which several shallow open-cuts have been made. In these the vein is seen to consist of 8 to 12 inches of quartz, with irregular bunches of partly decomposed arsenopyrite, pyrrhotite, and pyrite scattered through it. The vein strikes north 10 degrees west (magnetic) and dips about 60 degrees to the east. The wall-rocks are chiefly chert or highly altered sediments.

The development work is too meagre to give any idea of the extent or even nature of the veins. Moreover, oxidation is so widespread that sampling is likely to be misleading. A crosscut adit could be readily driven to intersect the veins exposed at the surface.

17e. INDEPENDENCE MOUNTAIN

Independence mountain lies about 8 miles due east of Hedley. A large number of claims have been staked and restaked at various times both on the flanks and across the summit of the mountain. The most important of these is the Nelson group. Others, such as the Apex, Dominion, Lake View, and White Grouse, contain arsenic in relatively negligible amounts. These properties are best reached from the Nickel Plate mine by a wagon road which runs past the south end of Hedley lake, a distance of 6 miles from the mine. From this point a trail branches off along the east side of the marsh crossed by the road and leads southeasterly for 3 miles to the claims.

A number of claims have been staked at different times on Northey mountain, which lies to the east of Independence mountain. The showings are said to consist largely of pyrrhotite with only very minor amounts of arsenopyrite.

Nelson Group

Previous Descriptions

Ann. Rept., Minister of Mines, B.C., 1919, p. 170; 1922, p. 163.
Cairnes, C. E.: Geol. Surv., Canada, Sum. Rept. 1922, pt. A, p. 126.

The Nelson group consists of four claims and a fraction, staked across the summit of Independence mountain, between the headwaters of Winters (or Sixteenmile) creek flowing south into Similkameen river and Dry Gulch creek draining northeast into Keremeos creek. The workings are situated on either side of the ridge and at elevations varying between 7,000 and 7,200 feet. The group is owned by J. McNulty, of Hedley, B.C.

The area covered by the claims is underlain by cherts, argillites, and limestone tentatively correlated with the Cache Creek series, of Carboniferous age. In this vicinity these rocks are intruded by a mass of diorite which is exposed chiefly on the western and southern flanks of the mountain. As a result of the contact metamorphism accompanying this intrusion a silicate zone composed chiefly of epidote was developed in some of the thinner limestone members of the sedimentary series. It is to such altered parts of the limestone strata that the mineralization on the claims is largely confined.

The principal showings are on the Nelson claim and lie on the northeast slope of Independence mountain facing the Apex or Dry Gulch basin. At an elevation of 7,050 feet, an adit 25 feet long and running south 42 degrees west (magnetic) was driven through 5 feet of surface material into iron-stained and altered limestone. A winze was put down for 6 feet in the dark green silicate zone encountered near the face of the adit. The mineralization in this zone consists of disseminated crystals of arsenopyrite, together with some chalcopyrite and pyrrhotite. A sample of this silicified and epidotized limestone, containing considerable arsenopyrite, was submitted to the Mines Branch, Ottawa, for assay and yielded gold 3·23 ounces per ton and silver 0·46 of an ounce per ton. About 100 feet northeast of the tunnel, and 25 feet below it, another showing has been exposed by open-cutting. There a body of arsenopyrite 6 to 18 inches wide outcrops for 15 feet. As in the previous case the mineralization occurs in altered limestone. No definite connexion could be established between the two showings which appear to be independent, of small extent, and irregular in outline. Further development would be necessary to define more clearly the size and character of each deposit. It has already been pointed out that the mineralization is confined chiefly to the replaced and metamorphosed parts of the limestone bands. This fact, together with the limited extent of such strata on this slope of the mountain, suggests that large ore-bodies are not to be expected.

On the Independence claim, lying on the southern slope of the mountain, a quartz vein 6 to 18 inches wide has been exposed in an open-cut for 12 feet. This vein strikes due east and west (magnetic) and appears to be vertical. It occurs in a shear zone in diorite. The vein contains streaks and lenses of arsenopyrite and pyrite, having a maximum width of 4 inches but usually much less. Additional cuts put down along the strike of the vein have since caved in.

Although the deposits on this group of claims hold the promise of fairly high gold values the possible tonnage of ore indicated by the present development is negligible.

Apex Group

Previous Descriptions

Ann. Rept., Minister of Mines, B.C., 1906, pp. 168-169; 1911, p. 179; 1919, p. 179.
Camsell, C.: Geol. Surv., Canada, Sum. Rept. 1922, p. 217.

The Apex group, consisting of seven Crown-granted claims, lies on a spur running northeast from Independence mountain. This property adjoins the Nelson group on the north. Some development had been done on the claims prior to 1905, when they were bonded by the B.C. Copper Company. After the company ceased operations in 1906 the property was idle until 1911, when further underground work was done. Since that time nothing further has been attempted.

The workings lie at an elevation of about 7,000 feet. They consist of an adit 200 feet long which connects with the bottom of a 100-foot shaft. The deposit, like others on Independence mountain, occurs in variously coloured limestone somewhat metamorphosed by intrusions of diorite. The mineralization, consisting of pyrrhotite, chalcopyrite, and very minor amounts of arsenopyrite, is confined chiefly to the irregular zones of silicate minerals developed in the limestone as a result of these intrusions. This greenish contact phase is composed largely of epidote and calcite in which the sulphides occur as veinlets, bunches, or disseminated particles, the last indicating replacement. Owing to the character of the deposit great variability is to be expected in the copper and gold values both as to distribution and concentration.

17f. GOLDEN ZONE

Previous Descriptions

Ann. Rept., Minister of Mines, B.C., 1901, p. 1,163; 1909, p. 136.
Camsell, Chas.: Geol. Surv., Canada, Mem. 2, pp. 204-6 (1910).

The Golden Zone group, consisting of four Crown-granted claims, lies on the divide between the east and north forks of Hedley (or Twentymile) creek. The workings are situated at an elevation of 5,800 feet. A disused wagon road 11 miles in length connects the property with Hedley. It is about fifteen years since any work has been done on the property. The claims are now held by D. Woods, of Hedley.

According to Camsell the rocks in the area covered by the claims consist of limestones, quartzites, and tuffs similar to those found at Hedley, with interbedded sheets of diorite and gabbro. The sediments have been invaded successively by intrusions of fine-grained granite and granite porphyry. "The claims have been staked on a well-defined and persistent quartz vein, that can be traced in an east and west direction for over 1,200 feet. This vein cuts both the fine-grained granite and the sediments. In the former it occupies a strong fissure varying in width from 2 to 4 feet, but on passing into the sediments it appears to split up into four or five smaller veins"...... The vein-filling consists of white quartz which contains the following sulphides, stated in order of relative abundance; pyrite, arsenopyrite, zinc blende, galena, and chalcopyrite. The arsenopyrite is fine grained, and occurs intimately intergrown with the more coarsely crystalline pyrite.

The principal workings consist of two shafts 250 feet apart and sunk to depths of 115 and 47 feet, respectively, on the vein. The trend of the deposit is also marked by numerous open-cuts and trenches. The underground workings were not accessible at the time the property was visited. A sample of former Wilfley concentrates collected at the mill was submitted to the Mines Branch, Ottawa, for assay and analysis, and was found to contain 1·10 ounces of gold and 3·78 ounces of silver a ton and 24·98 per cent of arsenic.

18. Kruger Mountain

Previous Descriptions

Ann. Rept., Minister of Mines, B.C., 1913, pp. 172-4, 177; 1914, p. 356.
Camsell, C.: Geol. Surv., Canada, Sum. Rept. 1912, pp. 212-213.

Arsenopyrite with pyrrhotite, magnetite, and chalcopyrite occurs near a granodorite-limestone contact on the claims of the Dividend-Lake View Consolidated Gold Mining Company, Limited, situated on Kruger mountain 6 miles from the town of Oroville, Wash., and 2 miles north of the International Boundary. According to Camsell the deposits are restricted to the limestone; the gangue is the limestone variously altered to a lime-silicate rock; and the metallic minerals are pyrite, pyrrhotite, chalcopyrite, arsenopyrite, and magnetite. Arsenopyrite is abundant in the Dividend workings, which, in 1912, consisted of two adits, one 150 feet below the other, connected by a raise. The principal values in the deposit are in gold.

19. Deer Lake

Arsenopyrite and pyrite occur in veinlets intersecting quartzite on the Grey Eagle claim, situated at an elevation of 3,950 feet or 2,550 feet above and about 3½ miles from Deer Park on the east side of Lower Arrow lake. The mineralized zone does not exceed 12 inches in width and can only be traced for a few feet on the surface. Gold and silver values are quite low. The owner of the property is E. Schwartzenhauer, of Deer Park.

20. Rossland

The following occurrences of arsenic minerals have been noted (Geol. Surv., Canada, Mem. 77, pp. 70, 76, 78 (1915)) in the vicinity of Rossland; gersdorffite associated with pyrrhotite and chalcopyrite in the Kootenay, War Eagle, and Evening Star mines; arsenopyrite at the Giant mine and as a prominent mineral in the Coxey-Novelty vein on the west slope of Red mountain; and cobaltiferous arsenopyrite in the Deer Park vein southwest of Rossland.

21. Ymir

Arsenopyrite is said to occur sparingly in the Ymir gold camp. (Geol. Surv., Canada, Mem. 94, p. 56 (1917)).

22. Hughes Creek

(*See* Figure 13)

The Wisconsin group of claims is on the north side of Hughes creek, a stream flowing northeasterly into Midge creek, some 8 miles above its mouth on the west side of Kootenay lake, approximately 20 miles from Proctor and 10 miles from Kootenay Landing. The property is situated about 14 miles from the lake. A pack-trail leads along the north side of Midge creek to Hughes creek. It then follows the east bank of Hughes creek for 4 miles to the cabins, crosses the creek, and zigzags up and along the west slope of the valley for 2 miles to the claims. The workings lie at an elevation of 6,100 feet or about 4,300 feet above the level of Kootenay lake. The property is owned by interests represented by C. D. Muxen, of Spokane, Wash.

The deposit occurs within an area underlain by the Nelson granite batholith. In the vicinity of the workings inclusions of partly metamorphosed sediments lie in the granite. The vein or mineralized zone appears to follow a zone of shearing which traverses the granite and has been traced by open-cuts and trenches for 650 to 700 feet. This zone in places extends over a width of 15 to 20 feet, but in such instances consists largely of veins of milky quartz, altered country rock, and irregular bodies of partly oxidized pyrite and arsenopyrite. In most cases the mineralization appears to be confined to a width of from 1 to 4 feet.

At an elevation of 6,160 feet a crosscut adit (No. 1) was driven 75 feet to intersect the mineralized zone. At this point, a winze sunk for 60 feet is said to have been in ore all the way, but it was filled with water in 1924 and this could not be verified. A drift was then run on the mineralized zone which strikes north 10 to 20 degrees east and dips 60 degrees to the west, that is, into the hill. For 40 feet along this drift two sulphide bodies 6 to 36 inches wide and separated by 30 inches of gouge are exposed. Crosscuts were then run to the northwest for 20 feet into the hanging-wall and to the southeast for 35 feet into the foot-wall. Both of these workings pass through highly altered granite containing quartz veinlets, considerable siderite, and occasional patches of sulphides. The drift was continued in the foot-wall for 100 feet beyond the crosscuts. For most of this distance only one sulphide body, 8 to 36 inches wide, is present. The wall-rocks on either side contain an abundance of quartz, siderite, and disseminated sulphides.

The No. 2 adit, situated to the south of No. 1, and 40 feet below it, was driven westerly for 145 feet. In this distance it passes through altered granite, argillaceous schist, limestone, gouge, and ore. The vein was struck at a point about 100 feet from the portal. It is 2 to 6 feet wide, strikes north 15 degrees east, and consists mostly of arsenopyrite and pyrite. On the south side of the adit two sulphide bodies, 4 feet and 18 inches wide respectively, separated by 18 inches of white gouge, are exposed. For 10 feet or more on either side the mineralized zone is bordered by soft, brown schist, gouge, or altered rock.

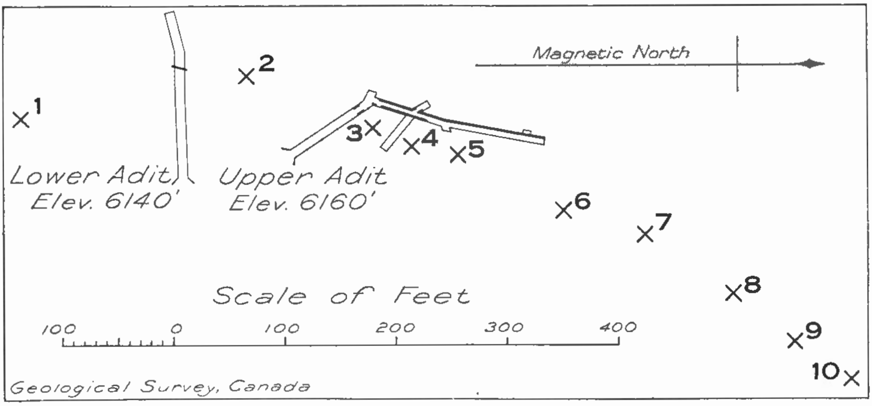


Figure 13. Plan of workings, Wisconsin property, Hughes creek, Kootenay district, B.C. Veins in adits shown by heavy black lines; open-cuts by crosses, numbered as in text.

A third adit to the northeast of, and 120 feet below, the No. 1 tunnel, was driven for about 970 feet. In this distance no mineral of value was found. It has been estimated that this adit would strike the vein if continued another 400 feet in a westerly direction.

The mineralization in the various workings consists of arsenopyrite, pyrite, and occasionally chalcopyrite in a gangue of quartz, siderite, altered wall-rock, and gouge. In open-cut No. 1, 4 feet of quartz is visible; in open-cut No. 2, quartz veinlets are present; in open-cut No. 3, there is exposed a width of 3·8 feet of pyrite and arsenopyrite, and 5·7 feet of quartz; open-cut No. 4 exposes an 8-foot oxidized zone; open-cut No. 5 was caved in at the time of examination; in open-cut No. 6 a 9-foot oxidized zone is exposed; in open-cut No. 7 there is an 18-inch oxidized zone; in open-cut No. 9, and again in open-cut No. 10, 18 inches of quartz is visible. The deposit has been considerably affected by oxidation. Some idea of the character and composition of the mineralized zone may be obtained from the following analyses made from composite samples taken by F. Keffer, first, from the surface showings, second, from the underground workings.

Composition	Surface cuts	Under-ground workings
	Per cent	Per cent
Silica	33·5	26·8
Iron	27·2	26·5
Lime	0·8	0·6
Sulphur	1·6	14·5
Alumina	11·5	10·7
Arsenic	12·8	11·1
Undetermined	12·6	9·8
	100·0	100·0

The principal values in the ore are gold, silver, and arsenic. The average value of fourteen samples taken along the drift in the No. 1 adit by H. Johns in 1914, yielded $7.08 in gold and $2.24 in silver a ton. Samples taken at the same time from eight open-cuts averaged $14.48 in gold and $2.36 in silver a ton. A sample across the vein in the No. 2 adit carried $4 in gold and $1.26 in silver a ton. The following samples were taken in 1914 by Chas. A. Banks, manager of the Jewel Mining and Milling Company, Greenwood, B.C. Their location is not given.

Sample number	Ounces per ton	
	Gold	Silver
1	0·06	0·9
2	0·24	1·1
3	0·24	2·2
4	1·22	4·85
5	0·38	7·4
6	0·52	3·7
7	0·66	9·0
8	0·28	4·0

Equal portions of samples No. 5 and No. 6 gave the following analysis:

	Per cent
Silica	27·0
Iron	27·0
Alumina	5·0
Lime	0·8
Magnesia	0·4
Sulphur	8·8
Arsenic	10·16
Copper	0·26
Zinc	0·50
Antimony	3·50
Undetermined	16·58
	100·00

Two samples of solid sulphides were taken by the writer from the drift in the No. 1 adit and submitted to the Mines Branch, Ottawa, for assay. One, containing considerably more pyrite than arsenopyrite, yielded 0·59 of an ounce gold and 29·92 ounces of silver a ton. The other, consisting of the two sulphides in approximately equal amounts, gave 0·97 of an ounce gold and 5·02 ounces of silver a ton.

Mill tests carried out on the ore show that it is amenable to cyanidation. In 1914 W. P. Alderson, of Sheep creek, B.C., tested a composite made of samples 5, 6, 7, 8, collected by Chas. A. Banks, and referred to above. These assayed 0·40 of an ounce in gold and 2·2 ounces of silver a ton. The ore was ground to pass a 100-mesh screen and cyanided. A total extraction of 92·5 per cent of the values was made. The tailings assayed $0.60 in gold. The consumption of cyanide amounted to 7 pounds a ton and of lime 29 pounds a ton.

Although no estimate of the tonnage present in the deposit can be made, the showings and the values in gold, silver, and arsenic seem to justify further development. There is an abundance of water for power purposes in Hughes and Midge creeks and plenty of timber is available in the vicinity of the claims.

23. Sullivan Mine

Arsenopyrite is said to occur with pyrite, pyrrhotite, and zinc blende in the ore of the Sullivan mine at Kimberley, B.C. (Geol. Surv., Canada, Mem. 76, 1915, p. 107.)

24. Silverton

Previous Descriptions

McConnell, R. G.: Geol. Surv., Canada, Ann. Rept., N.S., vol. VIII, pt. A, pp. 26-27 (1897).
Bancroft, M. F.: Geol. Surv., Canada, Sum. Rept. 1917, pt. B, pp. 33-35.
Ann. Rept., Minister of Mines, B.C.
Private report by F. Keffer of Spokane.

The L. H. group, consisting of eight Crown-granted mineral claims, is situated about 5½ miles by road southeast of Silverton on Slocan lake. The principal workings are at an elevation of about 5,530 feet or 3,770 feet above the lake. The property is owned by A. R. Fingland and Charles Brand of Silverton.

The area in the vicinity of the deposit is underlain, according to Bancroft, by igneous rocks representing a roof remnant now surrounded by granite. The mineralization occurs in a basic porphyritic rock resembling a kersantite in appearance. This rock has been cut by granitic and aplitic dykes and in places has been converted to biotite schist. The jointing and brecciation produced in the roof rocks by the invasion of granite provided channels for the mineralizing solutions. The basic rocks were silicified and partly impregnated with sulphides throughout a zone 20 to 40 feet in width which follows the master jointing. The ore-bodies vary from 8 to 30 feet in width and, as is in many places the case in such replacement deposits, are irregular in outline, their boundaries being determined almost entirely by assay values. The sulphides present are, in order of abundance, pyrrhotite, arsenopyrite, pyrite, and chalcopyrite. These minerals occur chiefly as particles disseminated throughout the country rock or, less commonly, in solid masses or veinlets associated with quartz and calcite. Narrow stringers of native arsenic with calcite are reported to have been found in one of the aplite dykes.

The L. H. property is essentially a low-grade gold deposit. The gold values are thought to be associated chiefly with the arsenopyrite. The average ore is said to consist of: insoluble matter 80·40 per cent; iron 8·10 per cent; sulphur 3·22 per cent; the balance being undetermined. According to F. Keffer the tonnage of ore so far developed on the property amounts to about 33,000 tons. The average value of this ore is said to be approximately $5.25 a ton in gold. Preliminary tests show that about one ton of concentrates may be expected from 10 tons of ore. Experiments conducted to determine the best method of ore treatment indicate that with amalgamation followed by table concentration and cyanidation 90 per cent of the gold values can be extracted. Although the percentage of arsenic in the ore has not been carefully determined it appears to be rather low.

25. Poplar Creek

Previous Descriptions

Brock, R. W.: Geol. Surv., Canada, Sum. Rept. 1904, pt. A, pp. 89, 90.
Ann. Rept., Minister of Mines, B.C., 1914, p. 323; 1920, pp. 123-124.

A number of quartz veins carrying arsenopyrite occur near Poplar, on the Lardeau branch of the Canadian Pacific railway, between the north end of Kootenay lake and the southeast extremity of Trout lake. The deposits are confined chiefly to a belt of metamorphic rocks consisting of schists and slates, which strikes roughly east and west (magnetic) and dips to the north. The veins both intersect and follow the schistosity of the enclosing formations; they vary in width from a fraction of an inch up to several feet; and consist largely of quartz with some arsenopyrite and minor amounts of pyrite, galena, chalcopyrite, pyrrhotite, and carbonates. The principal values are in gold. The arsenopyrite occurs as lenses or patches scattered irregularly through the quartz gangue or as crystals impregnating the wall-rocks, particularly where these consist of chloritic or calcareous schists. The best showings are on the Swede and Campobello groups of claims. Minor amounts of arsenopyrite also occur in the veins on the Bullock property.

The Swede group lies on the southeast slope of Poplar creek at an elevation of about 3,400 feet or 1,200 feet above the railway. A trail 3 miles long leads from Poplar past the Bullock property to the showings. A quartz vein, 6 to 12 inches wide, has been exposed by open-cuts at intervals for about 100 feet. This vein strikes parallel with the schistosity of the enclosing rocks, but dips in the opposite direction, that is, to the south. The vein-filling contains occasional patches of arsenopyrite.

The Campobello property lies on the north slope of Poplar creek about 1½ miles by trail from Poplar. The workings, consisting of several drift adits and open-cuts, are situated between elevations of 2,900 and 3,100 feet. A vein 6 to 8 inches wide, composed of milky quartz and occasional bunches of arsenopyrite, has been partly explored. It runs parallel to the trend of the schistose wall-rocks for a short distance and then appears to pinch out.

26. Ice River

Arsenopyrite occurs on the Waterloo claim located near the head of Moose creek in Ice River district. The ore-body appears to form a continuous bed about 6 feet thick in quartzitic limestone. The mineralization consists of sphalerite, galena, chalcopyrite, pyrrhotite, arsenopyrite, and pyrite in a gangue of calcite and quartz. (Geol. Surv., Canada, Sum. Rept. 1910, p. 141.)

On the Zinc Valley claim, located on the south side of Zinc valley in Ice River district, a lens-like deposit of sulphides occurs in a band of siliceous limestone enclosed in slates. The ore-body has a maximum width of 8 feet and consists of sphalerite, galena, pyrite, chalcopyrite, arsenopyrite, and native arsenic in a gangue of calcite, quartz, and unreplaced limestone. (Geol. Surv., Canada, Sum. Rept. 1910, p. 141.)

Pockets of almost pure pyrite, arsenopyrite, and some bornite occur in the limestone at the Shining Beauty mine situated about 3 miles north of the bridge over Ice river and at the head of the first large creek entering from the west. (Geol. Surv., Canada, Sum. Rept. 1910, p. 142.)

Other prospects on mounts Field, Stephen, and Dennis, and on Ottertail river, contain chalcopyrite, bornite, pyrite, pyrrhotite, and arsenopyrite. (Geol. Surv., Canada, Sum. Rept. 1910, p. 143.)

27. Carnes Creek

(*See* Figure 14)

Previous Description

O'Grady, B. T.: Ann. Rept., Minister of Mines, B.C., 1922, p. 215.

The J. and L. group consists of five unsurveyed claims on the south side of the east fork of Carnes creek about one-half mile above its intersection with the main creek. Carnes creek flows southwesterly into Columbia river at a point about 24 miles north of Revelstoke. Of this distance about 16 miles is by auto road and 8 miles by trail along the river. Just beyond the mouth of Carnes creek a trail branches off to the east. It follows along the north bank of the creek; crosses the east fork and leads to the mine cabin, about 8 miles from Columbia river. The workings lie on the south and west slopes of the spur separating the forks of Carnes creek and at elevations of 3,000 to 4,400 feet. The claims are owned by E. McBean, of Revelstoke, B.C.

The rocks in the vicinity of the J. and L. deposit are chiefly schist and limestone with occasional bands of quartzite. The vein or mineralized zone occurs at or near a schist-limestone contact which strikes north 65 to 75 degrees west (magnetic) and dips 30 to 55 degrees to the northeast (into the hill). This contact has been traced at intervals by open-cuts and trenches for several thousand feet up and across the hill-side (*See* Figure 14). The mineralized zone is not continuous throughout this distance. In places it reaches a width of 6 to 8 feet. The hanging-wall consists of schist and the foot-wall of limestone. Gouge is present in many places. The ore is a fine-grained mixture of zinc blende, galena, arseno-

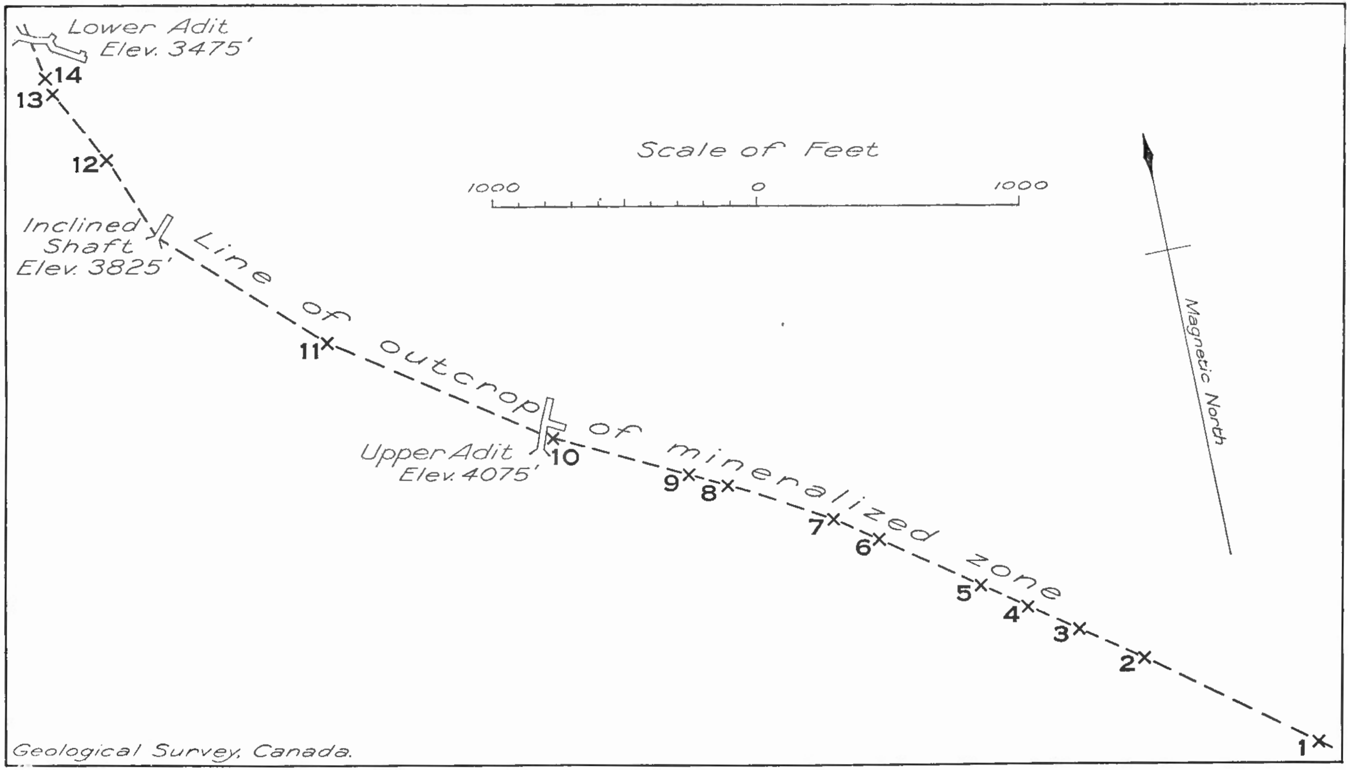


Figure 14. Plan of J. and L. property, Carnes creek, Kootenay district, B.C. Mineralized outcrops, open-cuts, etc., shown by crosses, numbered as in text.

pyrite, pyrite, and chalcopyrite, with minor amounts of quartz and calcite. The sulphides occur as veinlets, lenses, or bunches occasionally as much as 3 feet wide, but usually not more than 12 to 16 inches. The vein matter has been extensively altered and decomposed by oxidation.

The positions of various outcrops and workings along the mineralized zone are indicated on Figure 14. At locality No. 1 the zone, partly mineralized, has a width of 24 inches. At locality No. 2 it is 12 inches wide, and at locality No. 3 it is 24 inches wide. At locality No. 4 pyrite and arsenopyrite, with a width of 30 inches, are exposed for a length of 6 feet. At locality No. 5 the mineralized zone is 12 to 18 inches wide and is visible for a length of 4 feet. At locality No. 6 the width is 16 inches and the exposed length is 4 feet. At locality No. 7 an open-cut reveals two bands of sulphides each 12 inches wide, separated by 8 feet of partly mineralized schist. At locality No. 8 an open-cut has been made on the schist-limestone contact. At locality No. 9 the schist-limestone contact is exposed. At locality No. 10, 36 inches of oxidized vein matter appears in an open-cut. At locality No. 11 the schist-limestone contact is visible and there is present 24 to 36 inches of sulphides, mostly pyrite, with quartz and schist. At locality No. 12 the schist-limestone contact is exposed, but no sulphides are present, and the same condition holds at locality No. 13. At locality No. 14 a short adit exposes 30 inches of sulphides.

At an elevation of 4,075 feet an adit (upper) was driven 90 feet to crosscut the vein at a depth of 60 feet below the outcrop. At this point a winze was sunk at an angle of 37 degrees for 120 feet on the vein. This passed through soft, white to brown, decomposed schist and vein matter for about 40 feet. Stringers and streaks of sulphides varying from 1 to 30 inches in width were then followed downward for 80 feet farther. From the top of the winze a drift was run southeasterly for 80 feet in highly altered schist in which the vein matter appeared to be 6 to 12 inches wide.

At an elevation of 3,825 feet a shaft was sunk at an angle of 43 degrees for 125 feet on the vein. Stringers and bunches of the sulphide minerals, varying from almost nothing up to 30 inches in width, extend more or less continuously from the top to the bottom of the shaft. In places the schistose hanging-wall is impregnated with sulphides for a foot or more from the vein.

An adit was driven at an elevation of 3,475 feet for 225 feet in a southeasterly direction along the schist-limestone contact. For most of this distance it passes through the limestone on the foot-wall side of the vein. The contact is marked by 12 inches of rusty, decomposed material for about 65 feet from the adit. From this point lenses and patches of sulphides, 4 to 18 inches wide, occur at intervals on the northeast side of the adit up to the face. Two crosscuts driven into the quartz schist of the hanging-wall showed very little mineralization.

Other showings of arsenopyrite occur between the lower adit and the east fork of Carnes creek. It is likely that some of these do not mark the continuation of the main vein, but of veins lying to the northeast which have not been explored.

The principal values in the J. and L. deposit are in gold, silver, and, possibly, arsenic. The following assays were made from samples taken from the various showings by B. T. O'Grady in 1922 and are quoted in the Report of the Minister of Mines for that year.

Sample No.	Description	Ounces per ton		Per cent		Copper
		Gold	Silver	Zinc	Lead	
1	Open-cut. Elevation 4,350 feet. Sample across 8 inches	0·8	0·8	4·0	nil	nil
2	Open-cut. Elevation 4,250 feet. Sample across 2 feet	0·36	2·0	3·0	nil	nil
3	Open-cut. Elevation 4,200 feet. Sample across 8 feet	0·24	4·5	2·0	2·0	nil
4	Open-cut. Elevation 4,150 feet. Sample across 2½ feet on H.W. side	0·3	2·0	5·0	nil	nil
5	Same as 4. Sample across 1 foot on F.W. side	0·26	1·2	3·0	tr	nil
6	Bottom of winze from adit. Elevation 3,870 feet. Across 6 feet	0·32	3·0	2·5	3·0	nil
7	Drift on vein in adit. Elevation 3,870 feet. Across 4½ feet decomposed vein matter	0·60	6·0	2·0	8·0	nil
8	Open-cut. Elevation 3,750 feet. Sample across 2 feet	0·30	0·8	2·0	nil	nil
9	Incline shaft. Elevation 3,620 feet. Across 1½ feet at bottom	0·42	9·0	6·0	8·0	nil
10	Same as 9. Across 2 feet. Fifty feet from bottom	0·62	8·0	7·0	4·0	0·5
11	Short adit. Elevation 3,260 feet. Sample across 2½ feet	1·14	1·5	9·0	1·0	nil
12	Main adit. Elevation 3,160 feet. Across 2 feet at 160 feet	0·30	7·0	20·0	9·0	nil
13	Grab sample from ore dump at portal of main adit	0·62	8·0	14·0	8·0	0·7

The average value in the ore, as indicated by the assays quoted above, is in the neighbourhood of $10 a ton. W. E. Narkaus, a mining engineer who examined the property, took twenty samples from the various showings. The lowest assay for gold and silver combined was $4.15 and the highest $27.10 a ton. The average for the twenty samples was $12.04 a ton in gold and silver and 12·7 per cent of As_2O_3. The J. and L. is obviously not a high-grade deposit. It is, therefore, doubtful if the ore could be mined, hand-sorted, and shipped to a smelter at a profit, even if transportation facilities were vastly improved. The future of the property lies in the development of a sufficient tonnage of ore to warrant the erection of a mill capable of recovering all the values present.

28. Barrett Creek

A persistent quartz vein, 2 feet wide, carrying pyrite, pyrrhotite, chalcopyrite, and arsenopyrite occurs on the Porto-Rico claim located near the head of a branch of Barrett creek, west of the main Salmon river. (Geol. Surv., Canada, vol. X, pt. S, p. 61 (1899).)

29. Watson Bar Creek

Native arsenic and arsenopyrite associated with zinc blende, pyrrhotite, and chalcopyrite have been found in quartz veins near Watson Bar creek and about 4 miles west of Fraser river. (Geol. Surv., Canada, vol. XIII, pt. R, p. 45 (1903).)

30. Texas Creek

Arsenic is reported by J. B. Perkins of Lillooet, B.C., to occur on Texas creek, west of Fraser river.

31. Cayoosh Creek

Minor amounts of arsenopyrite and pyrite occur in quartz veinlets traversing calcareous and slaty schist at the Ample mine on the south slope of Cayoosh creek, west of Lillooet.

32. Bridge River District

32a. CADWALLADER CREEK

Previous Description

McCann, W. S.: Geol. Surv., Canada, Mem. 130, pp. 45-68, 79-96 (1922).

The most important ore deposits in Bridge River district are the gold-quartz veins. Most of these occur in a narrow belt of augite diorite which extends from Bridge river along Cadwallader creek. The deposits are fully described by W. S. McCann from whose report the following account has been derived. With the exception of a few properties, development has not gone beyond the prospect stage and in no case have the veins been explored to a depth of more than 300 feet. The principal mines in the area are the Lorne, Coronation, Pioneer, and Wayside. The veins, which vary from a few inches to 6 or 8 feet in width, consist chiefly of quartz with minor amounts of arsenopyrite, pyrite, chalcopyrite, tetrahedrite, sylvanite, and native gold. The bulk of the gold is in the free state and can be recovered by amalgamation, but at the Lorne and Pioneer mines gold is said to occur as a fine mechanical mixture with arsenopyrite. In many places the altered wall-rock adjoining the veins is highly impregnated with pyrite and arsenopyrite, but the gold values in this material are quite low.

At the Pioneer mine, two veins varying from 1 to 4 feet and averaging 2 feet in width, have been developed to a depth of 300 feet. Arsenopyrite and pyrite occur both in the vein-filling and in the wall-rock. The average tenor of the ore is estimated by the management to be $13.50 in gold a ton. Below the mill there is a tailings dump of about 100,000 tons estimated to contain $4 in gold a ton. The total production of the mine is about $1,350,000.

Several veins have been developed at the Lorne mine. Of these, the King vein, which consists of from 4 to 6 feet of solid quartz, has been the most productive. It is reported that an average of $17 in gold a ton was recovered from this vein by amalgamation. Concentrates from the arrastre beds assayed $90 to $380 a ton and the tailings from the arrastre and mill assayed from $3 to $6 in gold a ton. The average extraction from other veins is said to be $14 or about 60 per cent of the gold in the ore. Assays of altered diorite wall-rock yielded 0·04 of an ounce gold a ton.

Arsenopyrite also occurs sparingly disseminated throughout the quartz veins on the Alhambra and Ida May claims which lie between the Pioneer and Lorne mines. Small amounts of the sulphide are present in similar deposits on the Silver Basin group situated in the canyon of Cadwallader creek, on the Veritas claim near Little Gun lake, and at the Wayside mine on the north side of Bridge river, 3 miles above Gun creek.

32b. NATIVE SON

(*See* Figure 15)

This property lies near the head of Leckie creek, a small stream flowing northward into the middle fork of Gun creek. It is reached from the Bridge River road by taking the main Whitewater trail to the forks of Gun creek. From this point a pack-trail about 5 miles long leads to the claims. Altogether, this property is situated about 40 miles from Shalalth station on the Pacific Great Eastern railway, about 28 miles of this distance being by road. The claims were staked in 1923 by Henry Swartz and J. Russell, of Lillooet, and leased to the Trites, Woods Company, of Vancouver. Development work under the direction of J. E. Leckie was begun in August, 1924, and a temporary camp was erected at an elevation of 6,050 feet. The property was visited early in September at a time when exploration had not proceeded far enough to furnish any definite data as to the extent of the deposit or the values to be expected.

The area in the vicinity of the Native Son deposit is underlain by sedimentary rocks, chiefly argillaceous and feldspathic quartzites. These have been intruded by masses of biotite granite and granodiorite. The igneous contact strikes roughly north 60 to 75 degrees west and crosses the head of Leckie creek several hundred yards south of the deposit. The sediments strike north 30 degrees east and dip steeply to the west. The mineralization is confined to certain ill-defined, fractured, and jointed zones in the quartzites, along which patches, streaks, or veinlets of arsenopyrite occur. The gangue consists almost entirely of country rock. That replacement has been the dominant process of ore deposition is suggested by the irregularity of the sulphide bodies, and by the fact that distinct walls are lacking.

The showings occur on the banks and in the bed of Leckie creek between elevations of 6,100 and 6,300 feet. Several open-cuts have been made and short prospect adits have been driven below the most promising outcrops. These workings, particularly on the east side of the creek, indicate that at least some of the showings are not in place, but simply form a part of the slide rock covering the slope. The best showing on the east side of the creek is just east of adit "D" (Figure 15) where there is a mass of almost solid arsenopyrite about 10 feet wide which has been exposed for 25 feet on the surface. Beyond this distance the sulphide

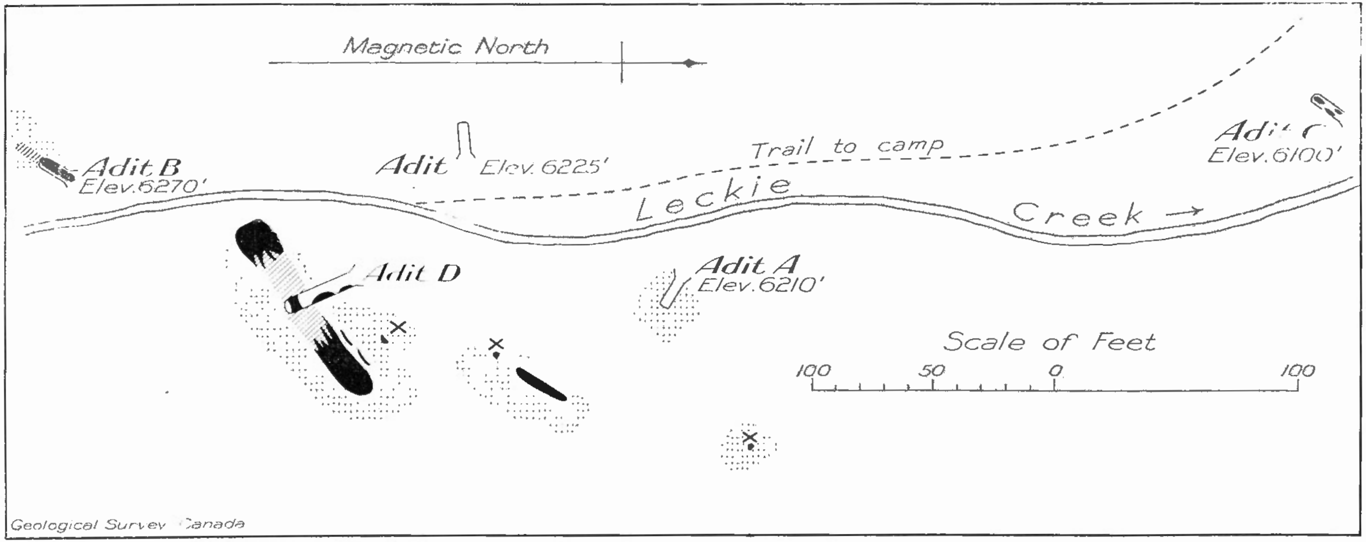


Figure 15. Plan of workings on the Native Son property, Bridge River district, B.C. Arsenopyrite shown by solid black; irregularly mineralized rock by diagonal ruling; slide rock by pattern of dots; and open-cuts by crosses.

body becomes narrower, splits up into stringers, and finally appears to pinch out. At the time the claim was visited an adit (A) had just been started on the east side of the creek to penetrate the slide rock and crosscut the surface showings at depth. In addition, other adits (B and C) were being driven on two veins exposed near the bed of the creek. At "B" a 4-foot zone containing streaks and bunches of arsenopyrite was being followed. A sample of solid arsenopyrite taken from this showing was found by the Mines Branch, Ottawa, to contain 0·03 of an ounce in gold and 0·07 of an ounce in silver a ton. At "C", several hundred feet downstream from "B", a drift has been started on the oxidized outcrop of another zone containing irregular patches and stringers of arsenopyrite. Small showings up to 18 inches wide are visible in each of the three open-cuts, and just northeast of the middle open-cut there is a showing at the surface, 36 inches wide.

32c. ELDORADO

The Eldorado group, consisting of seven claims, is situated in the basin at the head of Eldorado creek, a stream flowing southward into the north fork of Gun creek. The property is reached from the Bridge River wagon road by a trail about 10 miles long. The claims are owned by Grant White, a resident of the district.

The workings consist of two drifts and a number of strippings on the north slope of Eldorado basin between elevations 6,400 and 6,800 feet. There are several veins on the property. In one open-cut, a vein containing 3 to 18 inches of arsenopyrite, pyrite, and quartz is exposed for 10 feet. The No. 1 adit was driven for 35 feet in a northwesterly direction on an oxidized zone 12 to 36 inches wide containing streaks of arsenopyrite. The wall-rocks appear to be altered granite, although they are so soft and decomposed that they cannot be identified with certainty. The No. 2 drift follows, for 50 feet, a vein 12 to 24 inches wide, which strikes nearly north and south and dips at a low angle to the east. The vein matter consists of streaks of arsenopyrite and pyrite admixed with quartz, decomposed granite, and oxidation products. Good gold values are said to have been obtained from some of the surface workings, but this was not verified. The tonnage of sulphides developed is small.

32d. IRON RIDGE

Two claims, the Iron Ridge and Gordon, have been staked on Iron ridge, a spur at the head of Taylor basin, about 2 miles east of the Eldorado property. The trail from the Bridge River road to the Eldorado group passes within 100 yards of the showings. The outcrops occur on the east slope of the ridge and at an elevation of 6,600 feet. The claims are owned by Jas. Stables, of Vancouver.

The mineralization occurs in an aplitic dyke 2 to 12 feet wide which is exposed in a northwesterly direction for about 100 feet. The wall-rocks on either side appear to consist of sheared, altered, and partly silicified sediments. The minerals present, in order of abundance, are arsenopyrite, zinc blende, jamesonite, and pyrite. With the exception of the jamesonite these are all coarsely crystalline. The gangue consists of quartz in subordinate amounts. The sulphides occur in lenses and irregular masses at intervals along the walls and within the dyke. The largest body of sulphide exposed is 2 feet wide and 6 feet long, the other showings being much smaller. No development work has been done on the outcrops. Gold and silver values are said to be present.

32e. NEAR GUN CREEK

Veinlets of auriferous arsenopyrite are reported by A. W. A. Phair of Lillooet, B.C., to occur near the Bridge River road about one mile above Gun creek.

33. Bonaparte River

Argentiferous tennantite occurs in some abundance, with pyrite, galena, and chalcopyrite, on the Avoca claim, on the west side of Bonaparte river 2½ miles above Hat creek. (Geol. Surv., Canada, vol. IX, pt.R, p. 13 (1898)).

34. Barkerville

Gold-quartz veins, varying from 12 inches to 5 feet in width, and well mineralized with galena, pyrite, and arsenopyrite, occur in the neighbourhood of Barkerville. The sulphides in many cases carry high gold values. Selected samples of arsenopyrite assayed as much as 135 ounces of gold a ton of pure material. (Geol. Surv., Canada, Sum. Rept. 1922, pt. A, pp. 86-7.)

NORTH WEST TERRITORIES

A large amount of arsenopyrite is reported to occur in an altered diabase dyke, 75 feet wide, which intersects the chloritic schist outcropping on a high point north of Rabbit island on the west side of Hudson bay between Chesterfield and Rankin inlets. (Geol. Surv., Canada, N.S., vol. IX, pt. F, p. 82 (1898)).

Small veins of quartz and calcite, containing considerable pyrite, arsenopyrite, and chalcopyrite, occur in the altered diabase at the south point of Corbett inlet on the west shore of Hudson bay. (Geol. Surv., Canada, N.S., vol. IX, pt. F, p. 83 (1898)).

SASKATCHEWAN

Arsenopyrite, associated with jamesonite, stibnite, zinc blende, and chalcopyrite, was identified in a specimen from a small quartz vein traversing granite gneiss near Fond-du-lac, at the east end of lake Athabaska. (Alcock, F. J.: Geol. Surv., Canada, Sum. Rept. 1916, p. 156.)

Arsenical iron is reported to occur on the Little Nell group of claims at Beaver lake, Saskatchewan. (The Financial Post, Dec. 26, 1924, p. 8.)

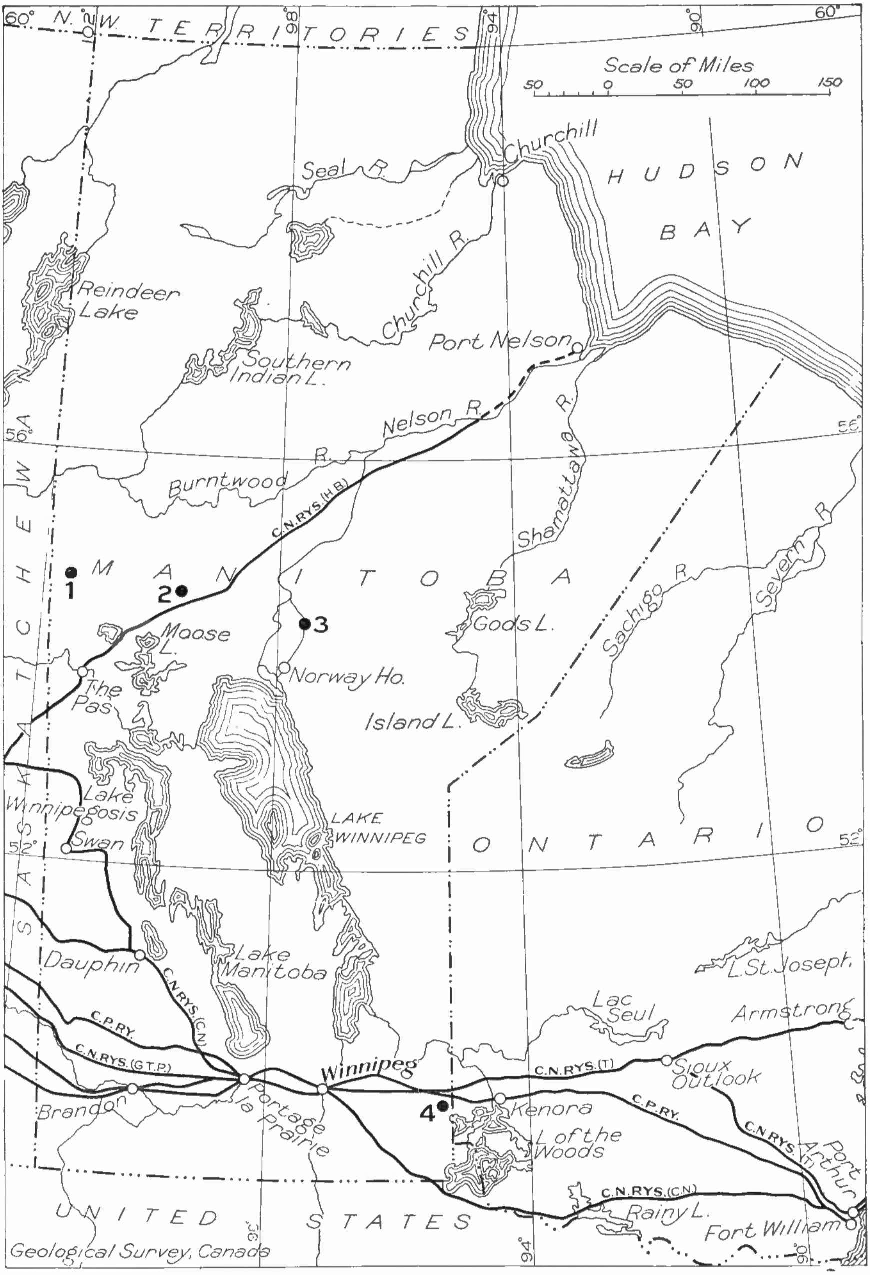


Figure 16. Index map of Manitoba showing location of arsenic-bearing occurrences. 1, Elbow lake; 2, Wekusko (or Herb) lake; 3, Pipestone Lake area; 4, Star and Long lakes.

MANITOBA

1. Elbow Lake

Crystals of arsenopyrite occur in the wall-rock adjoining gold-quartz veins in the greenstone area near Elbow lake, northeast of Athapapuskow lake. (Geol. Surv., Canada, Sum. Rept. 1922, pt. C, p. 41.)

2. Wekusko (Herb) Lake

Previous Description

Alcock, F. J.: Geol. Surv., Canada, Mem. 119, pp. 31-37 (1920).

A number of gold-quartz, arsenopyrite-bearing veins occur in the vicinity of Wekusko lake, Manitoba. They have been described by Alcock, and from his report the following account has been compiled. The area is underlain by a complex of Precambrian igneous and sedimentary rocks, intruded by granite and granite gneiss. Most of the veins are lenticular and are fissure veins, with sharply defined walls. The mineralization consists of quartz, tourmaline, arsenopyrite, both in the wall-rocks and vein filling, and occasionally pyrite, chalcopyrite, galena, sphalerite, and gold. Although arsenopyrite is of widespread occurrence in the veins it is nowhere present in sufficient abundance to be of economic importance. All evidence points to a genetic relationship between the quartz veins and the intrusions of granite.

3. Pipestone Lake Area

Arsenopyrite associated with diabase, schists, and granite has been reported to occur at an unspecified locality in Pipestone Lake area, on Nelson river. (Geol. Surv., Canada, N.S., vol. XIII, pt. FF, p. 16 (1903)).

Arsenopyrite and pyrite occur in the schist on the large island at the point where Nelson river enters Pipestone lake. A sample assayed for gold and silver gave negative results. (Geol. Surv., Canada, Sum. Rept. 1919, pt. D, p. 18).

4. Star and Long Lakes

Previous Description

Marshall, J. R.: Geol. Surv., Canada, Sum. Rept. 1917, pt. D, p. 22.

Star lake lies in southeastern Manitoba about 5 miles southwest of Ingolf station, on the main line of the Canadian Pacific railway. According to Marshall arsenopyrite with pyrite occurs in a gold-bearing quartz vein on the Gold Coin claim, about a mile south of Star lake. The vein occurs in a shear zone in granite. Its maximum width does not exceed 3 feet and it can be traced on the surface for 60 feet. Pyrite and arsenopyrite occur also in the wall-rock. A sample selected by J. R. Marshall gave the following assay: gold, 2·30 ounces; platinum, 0·10 ounce; silver, a trace.

Other amounts of arsenopyrite are present in a large mass of quartz situated about half a mile northwest of the west end of Long lake in southeastern Manitoba. (Geol. Surv., Canada, Sum. Rept. 1917, pt. D, p. 20).

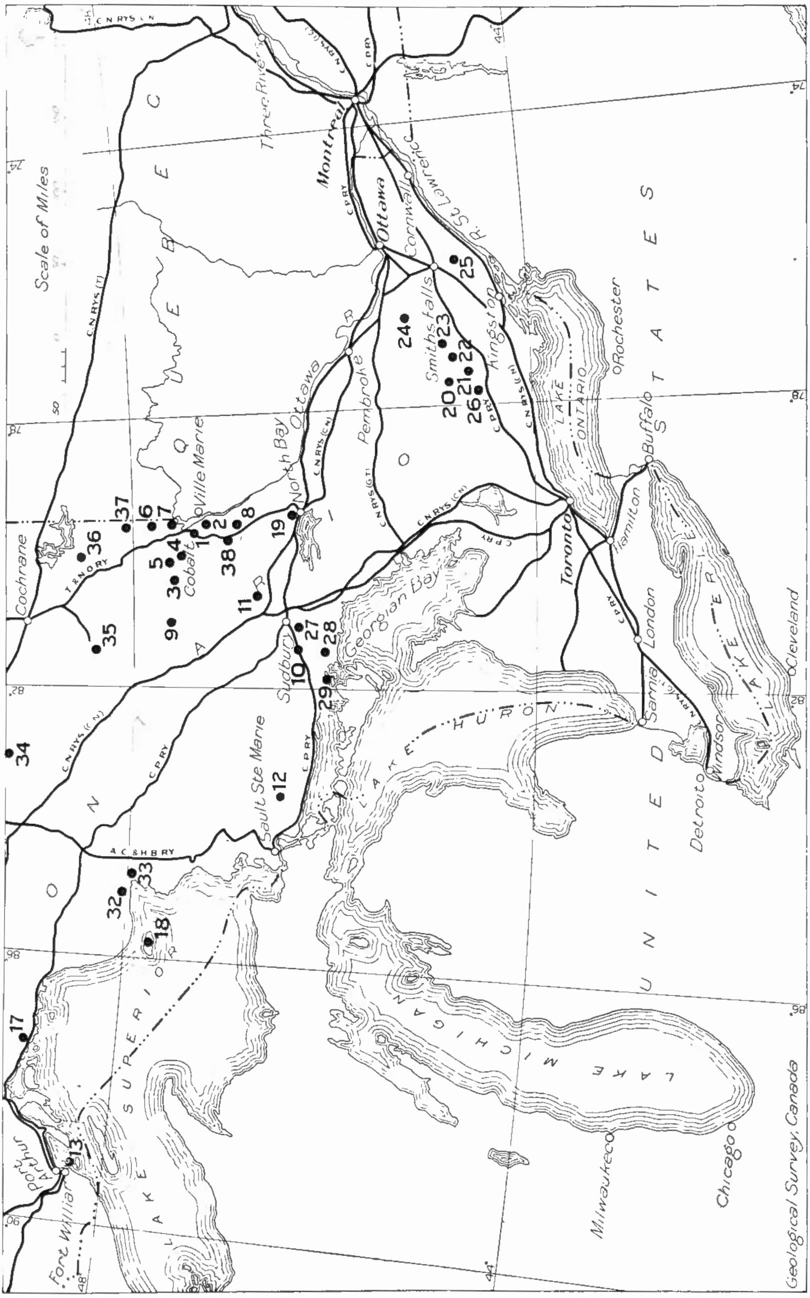
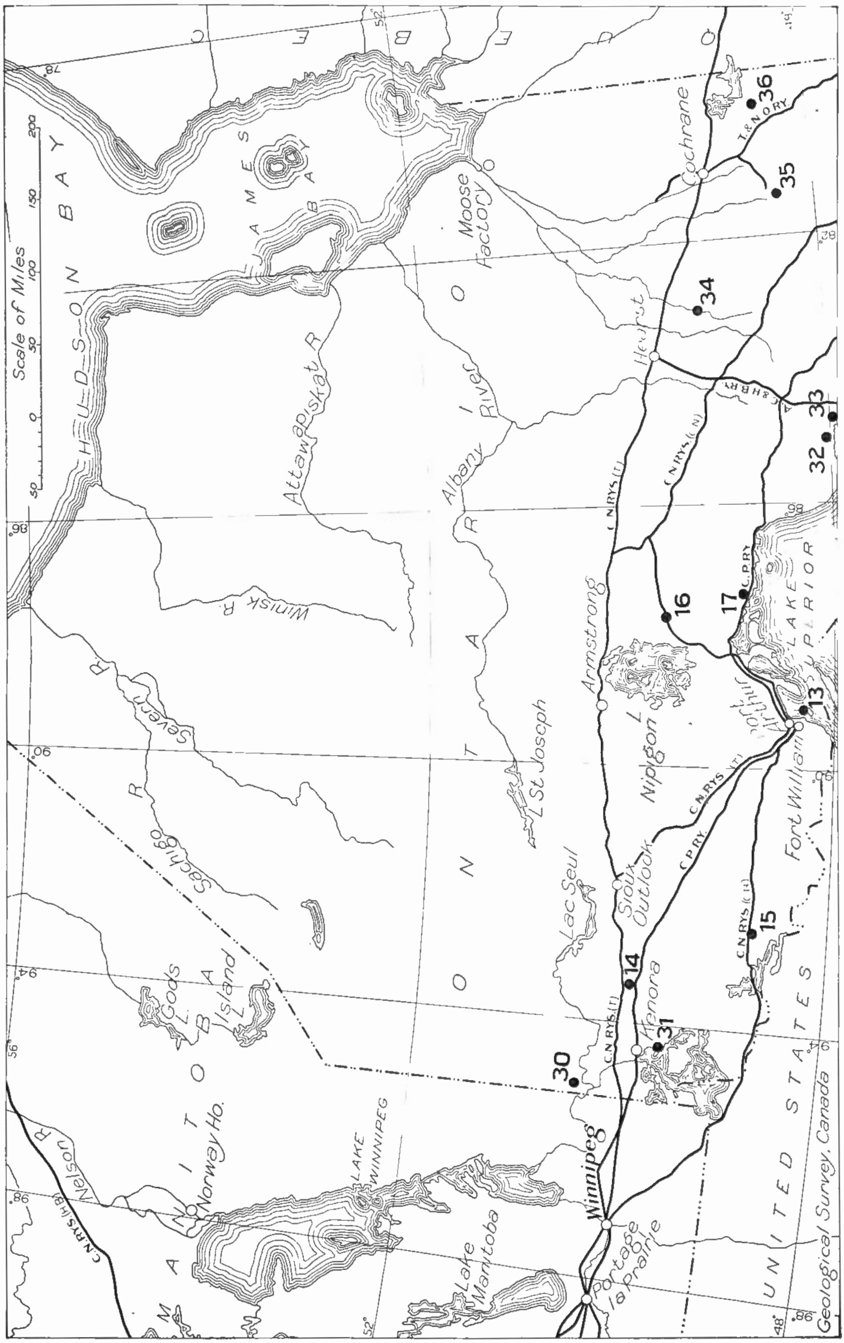


Figure 17. Index map of Ontario showing location of arsenic-bearing



occurrences. For explanation of figure, *See* page 90.

Explanation of Figure 17 (Pages 88 and 89)

The localities indicated by numbers on Figure 17 are as follows:

1. Cobalt silver area
2. South Lorrain township
3. Gowganda silver area
4. Auld township and Maple mountain
5. Elk Lake silver area
6. Blanche river
7. Casey township
8. Rabbit lake
9. Shiningtree lake and Rosie creek
10. Sudbury nickel area
11. Wanapitei and Timigami lakes
12. Otter township
13. Port Arthur and Fort William
14. Wabigoon Lake area
15. Mine Centre
16. Jellicoe
17. Schreiber
18. Michipicoten island
19. Widdifield township
20. Wollaston and Farady townships
21. Madoc, Marmora, Elzevir, Rawdon, and Tudor townships
22. Lennox and Addington county
23. Frontenac county
24. Lanark county
25. Leeds county
26. Peterborough county
27. Long Lake
28. Howry creek
29. Whitefish river
30. North of Deer lake
31. Lake of the Woods
32. Michibiju
33. Michipicoten
34. Opasatika river
35. Bristol township
36. Beatty township
37. Larder lake
38. Strathy township

ONTARIO

Most of the arsenic-bearing deposits in Ontario belong to one or other of two distinct geological groups. One of these, comprising the silver deposits of Cobalt, South Lorrain, Elk Lake, Gowganda, and Port Arthur mineral areas, is genetically related to diabase intrusions of late Precambrian (supposedly Keweenawan) age and consists of veins carrying sulphides, arsenides, and sulpharsenides of silver, cobalt, nickel, and copper, as well as native silver and bismuth in a gangue of calcite and quartz. The nickel-copper ore deposits of Sudbury mining district, which carry some arsenic, are probably of about the same age, though quite different in manner of deposition.

The other group comprises various auriferous deposits of arsenopyrite in eastern Ontario, apparently related to granitic intrusions. These granites are commonly believed to be early Precambrian, though some evidence in favour of a late Precambrian age has recently been adduced. If this latter opinion be correct the Long Lake and Howry Creek deposits, which may have a genetic relationship to the Killarney granite, belong, perhaps, in the same group.

Besides these two major groups are various other occurrences of undetermined or less well established geological relationships.

1. Cobalt

Previous Description

Knight, C. W.: "Cobalt and South Lorrain Silver Areas, Ont."; Ont. Dept. of Mines, vol. XXXI, pt. II (1924). This report contains a complete bibliography.

With the discovery in 1903 of the silver veins at Cobalt, a new impetus was given to the production of white arsenic which, hitherto, had been obtained from the gold-arsenopyrite ores of Hastings county in the south-eastern part of the province. The Cobalt silver area, about 5 miles in diameter, which is so widely known for the fabulous amount of silver it has yielded, constitutes the world's chief source of cobalt, and also contributes about 10 per cent of the total yearly production of white arsenic.

With the exception of a small tonnage of arsenical concentrates formerly shipped from the Richardson mine, Guysborough county, N.S., and within recent years from Hedley district, British Columbia, the whole arsenic production of Canada since 1906 has been derived from the nickel-cobalt-arsenic ores of Cobalt district, including Gowganda and South Lorrain. The following statistics, compiled from the reports of the Ontario Department of Mines, give an idea of the amount and value of the arsenic produced from the area since its discovery.

White Arsenic Production of Cobalt and Adjoining Districts[1]

Year	Tons	Value
		$
1904	72	903
1905	549	2,693
1906	1,440	15,858
1907	2,958	40,104
1908	3,672	40,373
1909	4,294	61,039
1910	4,897	70,709
1911	3,806	74,609
1912	4,166	80,546
1913	3,663	64,146
1914	2,030	116,624
1915	2,490	148,379
1916	2,160	200,103
1917	2,592	608,483
1918	2,545	566,332
1919	2,834	485,360
1920	1,883	431,527
1921	1,491	233,763
1922	2,059	299,940
1923	2,579	582,794

The chief producing companies in Cobalt district are: Nipissing Mines Company, Limited; The Mining Corporation of Canada, Limited; M. J. O'Brien, Limited; La Rose Mines, Limited; McKinley-Darragh-Savage Mines of Cobalt, Limited; Coniagas Mines, Limited; and Kerr Lake Mines, Limited.

Description of Deposits. Cobalt district is underlain by Precambrian rocks. The oldest formation in the region, known as the Keewatin complex, consists of highly folded and schistified volcanics, together with some intrusives and cherty or jaspery sediments. Large bodies of granite are intrusive in the Keewatin. On the greatly eroded surface of the Keewatin and granite are comparatively gently folded beds of conglomerate, greywacke, and quartzite called the Cobalt series. Following the deposition of these sediments sill-like bodies of diabase 600 to 1,100 feet thick were intruded into the Keewatin and Cobalt series. A few narrow dykes of aplite cutting the diabase represent an acid differentiate of the diabase magma. The veins, which were formed after the intrusion of the diabase, have been found chiefly in the Cobalt conglomerate and greywacke, but also in the Keewatin and in the diabase itself.

[1] Figures compiled from the reports of the Ont. Department of Mines.

Most of the productive veins occupy vertical or steeply-inclined fractures which are thought to have originated as a result of the tensional stresses set up during, or subsequent to, the intrusion of the diabase sill, and variously ascribed to the contraction which accompanied the cooling of the diabase or to the torsion produced when the rocks were folded. The joints show a varied behaviour in the different rocks traversed, being best defined in the Cobalt sediments, less regular in the diabase, and in many cases accompanied by gouge or brecciation in the more plastic Keewatin greenstones. The veins are characteristically narrow. Although most of them average about 4 inches in width they range from the thickness of a knife-blade to several feet, and in some cases where the wall-rocks have been impregnated with silver they have been mined for widths of 40 feet. As a general rule the ore-bodies do not extend more than several hundred feet along the strike and seldom to a depth greater than 200 feet below the surface. The majority of the productive veins in the area were found in the Cobalt sediments underlying the diabase sill, whereas in the outlying districts of South Lorrain and Gowganda the ore-bodies occur in the Keewatin or in the diabase.

The vein-filling consists largely of smaltite-chloanthite with niccolite and native silver in a gangue of calcite or dolomite. The less common arsenic-bearing minerals found are cobaltite, arsenopyrite, and proustite. It is generally believed that the arsenides and arsenosulphides were the first minerals deposited in the fractures, and that following a period of slight deformation native silver was introduced and deposited chiefly with or by replacement of the smaltite and niccolite. Outcrops or weathered parts of the veins mostly contain crusts or coatings of cobalt and nickel bloom, more rarely scorodite or arsenolite.

For the most part the ores are unusually rich in silver, cobalt, and arsenic. According to R. B. Watson,[1] a typical high-grade ore carries 10 per cent silver, 9 per cent cobalt, 6 per cent nickel, and 39 per cent arsenic; the rest is lime and silica and smaller amounts of antimony, iron, sulphur, bismuth, tellurium, etc. Some idea of the content of the ores and mill products may be obtained from the following analyses[2] of shipments received by the Deloro Smelting and Refining Company, Limited.

Analyses of Different Products at Deloro

—	Ore (hand-picked)	Jig product	Table concentrate	Slime concentrate
Silver.....oz. per ton	2,194	1,442	1,426	324
Cobalt.....per cent	7·90	10·40	8·20	2·10
Nickel..... "	4·30	5·80	3·80	0·50
Copper..... "	0·10	0·20	0·25	....
Iron..... "	5·00	6·50	11·60	6·80
Arsenic..... "	30·20	47·20	37·10	10·00
Sulphur..... "	1·70	3·70	8·25	2·98
Silica..... "	4·17	4·50	9·50	58·30
Lime..... "	15·00	5·20	....	2·50
Magnesia..... "	2·70	0·80	....	1·92

Origin of Deposits. There is still some divergence of opinion among those who have studied and worked in Cobalt district as to the origin of the veins. Since the vein-filling is mainly massive it offers little positive

[1]Watson, R. B.: Eng. and Min. Jour., vol. 104, p. 1077 (1912).
[2]Ont. Dept. of Mines, Ann. Rept., pt. III, p. 39 (1918).

evidence concerning the processes involved in the formation of the ore-bodies. Miller implies that the veins have resulted from the filling of pre-existing joints and fissures with mineral matter and he further remarks that there appears to have been no difference in the precipitation of the ores due to physical or chemical influences of the country rocks. Whitehead, on the other hand, points out that although filling may have been an important process of vein-formation, the behaviour of veins in traversing rocks differing in physical and chemical properties has led him to the belief that the various rocks have each had a definite effect upon the precipitation of the vein material. He, therefore, regards replacement as being the process of vein-formation which best accords with his observations. As a criterion of the metasomatic origin of the veins he cites instances where isolated blocks or angular fragments of wall-rock are enclosed in the ore-bodies. Spurr interprets this phenomenon to mean that the veins are, in reality, vein-dykes which were injected under an initial pressure and in such a state as to be capable of breaking off the rock fragments and holding them suspended until consolidation took place.

With regard to the origin of the mineralizing solutions it is generally agreed that the arsenides and most of the native silver are of hypogene origin, although the presence of preglacial weathering to a depth of at least 480 feet in the Keeley mine at Silver Centre, South Lorrain township, and the occurrence of phenomenal silver values at and below this level strongly suggest that downward enrichment has taken place. Miller believes that the ores were deposited from highly heated waters, probably associated with or following the irruption of the diabase. Whitman regards the diabase sill as the source of the mineralization, the various constituents being derived from it by diffusion or ionic transfer in relatively stagnant solutions containing sodium thiosulphate. From these solutions the vein minerals were deposited along joints and fissures, accompanied by extensive replacement of the wall-rocks. Whitehead would not connect the origin of the veins with hydrothermal activity from the diabase itself, but rather with later thermal solutions ascending from great depths along faults. More recently Lindgren has advanced the idea that the various constituents were introduced in the colloidal state and that the deposits originated largely as a result of hypogene gel replacement.

2. South Lorrain Township

Previous Descriptions

Burrows, A. G.: "South Lorrain Silver Area"; Ont. Dept. of Mines, Ann. Rept., vol. XIX, pt. II, pp. 134-144 (1913).

Bell, J. M.: "The Occurrence of Silver Ores in South Lorrain, Ontario, Canada"; Bull. Inst. of Min. and Met., Feb., 1922.

Whitman, A. R.: "Genesis of the Ores of the Cobalt District of Ontario"; Univ. of California, Pub. vol. 13, No. 7, pp. 253-310 (1922).

Knight, C. W.: "The South Lorrain Silver Area"; Ont. Dept. of Mines, Bull. 48 (1923).
"Cobalt and South Lorrain Silver Areas"; Ont. Dept. of Mines, vol. XXXI, pt. II (1924).

Bell, J. M.: "Deep-seated Oxidation and Secondary Enrichment at the Keeley Silver Mine"; Econ. Geol., vol. 18, pp. 684-694 (1923).

Bastin, E. S.: "Silver Ores of South Lorrain and Cobalt"; Econ. Geol., vol. 20, pp. 1-24 (1925).

This small but highly productive area lies 16 miles southeast of Cobalt and about 3 miles by road from lake Timiskaming. Silver was first discovered in the district in 1907 and for several years considerable amounts of the metal were produced from the Wettlaufer property. After a period of quiescence lasting from 1914 to 1920 attention was once more attracted to South Lorrain by the discovery of phenomenal silver values on the holdings of the Keeley Silver Mines, Limited, and later, on the adjoining Crompton and Frontier properties, developed by the Mining Corporation of Canada. Since 1921 the output of silver bullion from the district has increased enormously.

The formations which occur in this area are essentially the same as those found in the vicinity of Cobalt. In South Lorrain the Nipissing diabase forms an elongated, dome-shaped body intruded into the Keewatin greenstones and the sediments of the Cobalt series. The productive veins have been found only in the greenstone and diabase and not as yet in the conglomerate and greywacke, which carried the richest ore-bodies in Cobalt district. In addition to native silver the veins contain cobaltite, niccolite, arsenopyrite, smaltite, argentite, and ruby silver in a gangue of calcite and dolomite. According to E. S. Bastin, the smaltite, commonly thought to be the most plentiful arsenide in the district, is really a mixture of cobaltite and arsenopyrite. The Woods vein, which is the chief source of the silver values, occupies a reverse fault which passes from the Keewatin into the diabase sill. In places, vein matter is almost absent, whereas in other places as much as 4 feet of solid ore have been found. A number of other veins have been opened up by the mining companies, but the ore-shoots are on the whole less continuous along the strike than those of Cobalt district. Unmistakable evidence of preglacial weathering has been found at a depth of at least 500 feet in the Keeley property and it is not improbable that some of the silver was deposited by supergene enrichment. E. S. Bastin, in reporting on the Frontier mine for the Mining Corporation of Canada, expressed the opinion that the silver was largely of hypogene origin and emphasized the fact that the persistence of the veins in depth will depend primarily on the extent of the facturing in the diabase.

At the present time the concentrates from the Keeley mine are shipped to the Deloro smelter, where the silver, cobalt, and arsenic values are recovered. The Mining Corporation, after extracting the silver values, sends its cobalt-arsenic slimes to Perth Amboy, N.J., for treatment. It is not known exactly what proportion of the total arsenic production comes from South Lorrain, since its output is included in that from Cobalt district.

Veins containing smaltite have been found in the area south of Bay lake and west of Montreal river, in the township of Lorrain. These veins, which occur in diabase, consist chiefly of calcite with minor amounts of cobalt bloom, pyrite, and chalcopyrite. In depth they are said to carry small quantities of smaltite and niccolite. (Rept. Ont. Dept. of Mines, vol. XIX, pt. 2, p. 154 (1913)).

3. Gowganda

Previous Descriptions

Collins, W. H.: "Geology of Gowganda Mining Division"; Geol. Surv., Canada, Mem. 33 (1913).
Burrows, A. G.: "Gowganda and Other Silver Areas"; Ont. Dept. of Mines, Ann. Rept., vol. XXXI, pt. III (1921).

Gowganda silver area is situated 56 miles northwest of Cobalt. The deposits lie chiefly in Haultain, Nicol, and Milner townships. Ore has been shipped from this area since 1910 and at the present time it is next in importance to South Lorrain among the silver districts outside of Cobalt.

The rocks in Gowganda area are in general similar to those at Cobalt. The oldest are the Keewatin greenstones and schists which are overlain by gently-dipping conglomerate and greywacke of the Cobalt series. Both formations have been intruded by a sill-like body of quartz diabase which, from an economic point of view, is the most important rock in the district, since the majority of the silver-bearing veins occur in it, although a few have been found in the Keewatin and in the Cobalt series above the sill, but not below it. At Cobalt most of the ore was obtained from deposits in the conglomerate and greywacke underlying the Nipissing diabase which had been removed by erosion.

Some of the veins, due to their aplitic composition, are regarded by Burrows as representing differentiation products from the diabase magma. Many carry irregularly distributed bunches of smaltite and niccolite with silver in a gangue of calcite and quartz. The majority of the veins in the area consist largely of calcite with some quartz mineralized with arsenides, and small amounts of chalcopyrite, galena, native bismuth, and silver.

Although several properties are being developed in the area, the only producing mines are the Miller Lake-O'Brien and the Castle-Trethewey. The ore and concentrates are shipped either to Cobalt or Deloro for treatment.

4. Auld Township and Maple Mountain

A number of narrow, aplitic veins in which native silver and some smaltite have been found, occur on the Hitchcock location on the south half of lot 3, con. VI, Auld tp., Timiskaming dist. (Ont. Dept. of Mines, Ann. Rept., vol. XIX, pt. 2, p. 162 (1913)).

Veins of the Cobalt type were found in 1907 in Speight and Van Nostrand townships, 30 miles northwest of Cobalt, and for the five years considerable underground development was done and trial shipments of a few tons of ore were made. No steady production followed, however. The deposits are situated on the eastern side of a high ridge, known as Maple mountain, which extends for 9 miles northward along the western side of Leo, Van Nostrand, and Speight townships. They are closely associated with a sill of diabase intrusive in quartzite of the Cobalt series. (Geol. Surv., Canada, Mem. 33, pp. 106-107.)

5. Elk Lake

Previous Descriptions

Knight, C. W.: Ont. Dept. of Mines, vol. XIX, pt. 2, pp. 155-163.
Collins, W. H.: Geol. Surv., Canada, Mem. 33, pp. 107-109.

Elk Lake area is, like Gowganda and South Lorrain, also a subsidiary of the main Cobalt mineral area. It is situated on Montreal river 40 miles northwest of Cobalt. The first discoveries were made in 1906 and since then veins of the Cobalt type have been found at numerous places in the townships of James, Tudhope, Mickle, and Willet. The geological conditions are closely similar to those at Gowganda (Geol. Surv., Canada, Map 155A). Nearly a dozen properties have been explored to depths up to about 300 feet, by means of underground workings, but the total amount of ore shipped has been small.

6. Blanche River

Small quartz veins carrying massive smaltite are reported to occur in the area south of lake Wendigo in the townships of Ingram and Pense, district of Timiskaming. (Ont. Dept. of Mines, Ann. Rept., vol. XIX, pt. 2, p. 149 (1913)).

7. Casey Township

Veins similar to those which occur in the vicinity of Cobalt have been worked in Casey township. The deposits in this area have been found chiefly in the conglomerate and greywacke of the Cobalt series underlying the Nipissing diabase. The principal mine is the Casey Cobalt, where the veins have a filling of smaltite, chloanthite, and niccolite in a calcite gangue. (Ont. Dept. of Mines, Ann. Rept., vol. XIX, pt. 2, pp. 145-8 (1913)).

8. Rabbit Lake

Cobalt-nickel arsenides occur sparingly on Rabbit lake, 27 miles south of Cobalt. (Ont. Dept. of Mines, vol. XVI, p. 2, pt. 30 (1907)).

9. Shiningtree Lake and Rosie Creek

In the western part of Leonard township, about 60 miles west of Cobalt, a few veins of the Cobalt type occur with a sill of diabase intrusive in conglomerate, greywacke, and quartzite of the Cobalt series. Similar veins were found in the adjoining township of North Williams. The discoveries were made in 1908 and in one case a shaft was sunk 92 feet deep, but no shipments of ore were made. (Geol. Surv., Canada, Mem. 33, pp. 112-113; Mem. 95, pp. 118-122.)

A few quartz-calcite veins of the Cobalt type, but only sparsely mineralized, were found in 1909 in Sudbury district, in the townships of Browning and Unwin (Geol. Surv., Canada, Map 155A), traversed by Rosie creek, a tributary of Wanapitei river. This area, which is nearly 70 miles west of Cobalt, is the most distant from Cobalt of all the subsidiary mineral areas of the Cobalt type. (Geol. Surv., Canada, Mem. 95, p. 118.)

10. Sudbury Nickel Region

The nickel-copper ore deposits of Sudbury mineral district are closely associated with a great laccolithic body of quartz-norite, at least a mile in thickness. This intrusive outcrops as an oval ring 37 miles by 17 miles in diameter and from 1¼ to 6 miles wide. (Geol. Surv., Canada, Map 155A.) It is believed to have a saucer or boat-shape underground, the lower contacts dipping towards the centre at angles ranging from 30 degrees to vertical. Some irregular, dyke-like apophyses of the norite extend from the main mass outward into the older rocks. The norite is intrusive toward all the neighbouring Precambrian rocks except certain bodies of granite (Killarnean) and occasional dykes of olivine diabase, both of which cut the norite. The norite is believed to be Keweenawan and of about the same age as the quartz diabase with which the silver-cobalt veins of Cobalt, Gowganda, etc., are associated. However, the nickel-copper ore deposits are not in veins, but are of the nature of magmatic segregations around the outer (lower) edge of the laccolith and along the apophyses.

Various occurrences of arsenical minerals in or nearby the Sudbury laccolith have probably some genetic relation with it.

Considerable gersdorffite and some niccolite have been taken from the Worthington mine in Drury township. (Ont. Dept. of Mines, Ann. Rept., vol. XI, p. 28 (1901)).

Gersdorffite and niccolite have been found at the Macdonell mine on lot 12, con. III, Denison tp. (Geol. Surv., Canada, Ann. Rept., vol. V, pt. R, p. 22 (1893)). On the same lot niccolite is found with chalcopyrite, pyrrhotite, and gersdorffite in a mixture of quartz and calcite associated with diabase and mica schist. (Geol. Surv., Canada, Ann. Rept., vol. V, pt. R, p. 45 (1893)).

Niccolite has been found on the northeast corner of the west half of lot 12, con. II, Denison tp. (Geol. Surv., Canada, Pub. 961, p. 100 (1908)).

Sperrylite occurs in the nickel-copper ores of Sudbury district. It was first found at the Vermilion mine on lot 6, con. IV, Denison tp. (Geol. Surv., Canada, Ann. Rept., vol. IV, pt. T, p. 59 (1891)).

Danaite, associated with nickeliferous pyrrhotite, is reported from lot 6, con. III, Graham tp. (Geol. Surv., Canada, Ann. Rept., vol. V, pt. R, p. 19 (1893)).

Considerable danaite is said to occur at the Century copper mine on the north half of lot 4, con. IV, Graham tp., where it is associated with pyrrhotite, chalcopyrite, and pyrite in hornblende schist. (Geol. Surv., Canada, Pub. 961, p. 103 (1908)).

Smaltite occurs with chalcopyrite in McKim township. (Geol. Surv., Canada, Ann. Rept., vol. II, pt. T, p. 11 (1887)).

11. Wanapitei and Timagami Lakes

The country around Wanapitei lake is underlain largely by Huronian strata of the Bruce and Cobalt series (conglomerates, greywacke, quartzite, and impure limestone) intruded by sill-shaped bodies of basic rock that bears resemblances both to the quartz diabase of Cobalt and the quartz norite of Sudbury district and is of the same or nearly the same age. Here, however, the intrusive has given rise to veins composed of quartz and a non-magnesium carbonate (brünnerite) mineralized with pyrite, chalcopyrite, some arsenopyrite, and some free gold. (Geol. Surv., Canada, Mem. 95, pp. 114-116.)

Arsenopyrite occurs in a quartz vein associated with jaspilite near the western point of Austin bay, which is the southern extremity of the south arm of lake Timagami. (Ont. Dept. of Mines, vol. X, p. 174 (1901)). Arsenopyrite is reported by J. F. Black, of Sudbury, to occur in Davis township, district of Sudbury. (Rept. Ont. Dept. of Mines, vol. XI, p. 106 (1901)). Arsenopyrite occurs in a small quartz vein on the point between the two deep bays on the south shore of lake Wanapitei. (Rept. of the Royal Commission on the Min. Res. of Ont., 1890, p. 27). Auriferous arsenopyrite is present in a quartz vein on the north shore of lake Wanapitei. (Rept. of the Royal Commission on the Min. Res. of Ont., 1890, p. 112).

12. Otter Township

On the Kerr claim, SE. $\frac{1}{4}$, south half of lot 1, con. IV, Otter township, southern Algoma, a quartz vein has been stripped over a length of 230 feet and at one place a pit has been sunk 13 feet. In the pit the vein is 7 feet wide and consists for the most part of quartz or quartz and diabase. Calcite occurs in lesser amounts and cobaltite and native bismuth have been found in small masses. To the east and west of the pit the vein is much narrower. On the adjoining claim to the east there is a quartz vein with a similar strike and with an average width of one foot. Calcite, and occasionally cobaltite and native bismuth, have been deposited between the quartz layers. The country rock is diabase. (Burrows, A. G.: Ont. Dept. of Mines, Ann. Rept., vol. XIX, pt. 2, p. 196).

13. Port Arthur and Fort William

Previous Descriptions

Ingall, E. D.: Geol. Surv., Canada, Ann. Rept., vol. III, pt. H (1889).
Miller, W. G.: Ont. Dept. of Mines, vol. XIX, pt. 2, pp. 197-208.
Bowen, N. L.: Ont. Bureau of Mines, vol. XX, pt. 1, pp. 119-132.

The silver-bearing veins of the district in the general vicinity of Port Arthur in some cases carry arsenic-bearing minerals. The veins occur for the most part in vertical fissures in gently dipping slates of the Animikie formation and almost invariably are adjacent to sills or dykes of diabase of Keweenawan age. Compared with the silver-bearing veins of Cobalt district, those of the Lake Superior area are distinguished by "a higher percentage of gangue material, the ore usually occurring in bunches or pockets, and the percentage of silver is always much higher than that of the associated nickel and cobalt which generally occur in small quantities or are entirely absent in some of the deposits"..........

Arsenopyrite is said to have been found at the Emmons' mine on lot A, McIntyre township, west of Port Arthur. (Rept. Ont. Dept. of Mines, vol. XVI, pt. II, p. 155 (1907)).

Niccolite with native silver in a gangue of calcite and quartz was found at the 3 A mine on lot 3 A, McGregor township. (Geol. Surv., Canada, Ann. Rept., pt. H, vol. XIV, p. 149 (1906)).

Niccolite, arsenopyrite, and copper arsenides were found at the Silver Islet mine off Thunder cape. (Ont. Dept. of Mines, Ann. Rept., vol. XIX, pt. II, p. 205 (1912)).

Arsenic is said to have been found with argentite and native silver in the Jarvis Island mine, Thunder bay. (Rept. of the Royal Commission on the Min. Res. of Ont., 1890, p. 198).

Native arsenic is reported from Edward island, 9 miles east of Silver islet, at the entrance to Black bay. (Ont. Dept. of Mines, Ann. Rept., vol. V, p. 86 (1895)).

14. Wabigoon

Arsenopyrite is said to have been found at the Northern Queen mine near Wabigoon, Kenora district. (Ont. Dept. of Mines, Ann. Rept., vol. VII, p. 124 (1898)).

15. Mine Centre

Arsenopyrite has been reported to occur in the vicinity of Mine Centre, Rainy River district. (Ont. Dept. of Mines, Ann. Rept., vol. XI, p. 106 (1902)).

16. Jellicoe

Minor amounts of arsenopyrite and tourmaline occur in veinlets of quartz contained in a narrow albite porphyry dyke 1 mile west of Jellicoe station on the Canadian National railway. (Ont. Dept. of Mines, Ann. Rept., vol. XXVI, p. 242 (1917)).

17. Schreiber

A deposit of arsenopyrite and pyrite is reported to occur on locations 776X and 777X near Schreiber on the Canadian Pacific railway. (Ont. Dept. of Mines, Ann. Rept., vol. XI, p. 106 (1902)).

18. Michipicoten Island

Nickel and copper arsenides are reported to occur in a vein cutting a bed of amygdaloid on Michipicoten island. (Geol. Surv., Canada, Rept. of Prog. 1863, p. 506).

19. Widdifield Township

Niccolite has been reported from Widdifield township, Nipissing district. (Geol. Surv., Canada, Pub. 958, p. 14 (1906)).

20. Wollaston and Faraday Townships

The Rollins property is located near the north end of lot 16, con. XIV, Wollaston tp., Hastings co. It lies about 3½ miles north of Coehill, the terminus of the Coehill branch of the Central Ontario railway. The prospect is owned by D. W. Rollins of Coehill and D. E. K. Stewart of Madoc.

The workings lie about 100 yards west of the road that skirts the property and consist of a shaft 25 feet deep in metamorphosed sediments, and a small pit in sandstone adjoining a body of pegmatite.

The area is underlain by amphibolite and metamorphosed sediments of Precambrian (Grenville series) age. These rocks have been cut by bodies of pegmatite and quartz which may be genetically connected with an intrusive mass of granite gneiss about a mile west of the deposit.

In the shaft there are exposed several vertical bands of, respectively, coarsely crystalline limestone, impure quartzite, and biotite schist which strike north 30 degrees west. The more schistose bands have been partly replaced by arsenopyrite which occurs on the north side of the shaft in widths varying from 4 to 20 inches. The extent of the deposit along the strike could not be determined. Judging by the small amount of sulphide to be seen on the opposite wall of the shaft, the sulphide content is variable. About 25 feet northwest of the shaft, arsenopyrite replaces sandstone for several inches near the margin of a stringer of pegmatite. A body of pegmatite, varying from 15 to 36 inches in width and exposed for about 50 feet, outcrops southwest of the shaft, but is unaccompanied by mineralization.

Over twenty years ago two carloads of ore were shipped to the smelter at Deloro by Mr. Stewart, who states that they averaged 27·2 per cent in arsenic. The gold values were insufficient to pay for extraction.

Arsenopyrite occurs on the Jeffrey prospect in concession IX, Faraday township, about 7 miles directly west of L'Amable station on the Central Ontario railway. A pit 10 feet deep has been sunk on a vein said to be 4 feet wide and to consist of quartz and arsenopyrite. A sample of the ore taken by J. W. Wells and assayed gave: gold, 0·06 ounce, silver, 3·01 ounces a ton; arsenic, 27·54 per cent. (Ont. Dept. of Mines, Ann. Rept., vol. XI, p. 102 (1902)).

21a. Marmora Township

(Abridged from manuscript report by M. E. Wilson)

The southeast part of Marmora township and adjoining southwest part of Madoc township are underlain by a body of granite which with its surrounding offshoots occupies an area 6 to 8 miles in diameter. The granite intrudes volcanic rocks of the Grenville series, crystalline limestone and greywacke of the Hastings series, and a body of gabbro intruding the Hastings strata. The gabbro occupies an area 2 miles long by ½ mile wide in the locality where the most important, known, gold-bearing mispickel-quartz veins of the district are found. Dykes and small masses of granite occur in the strata surrounding the granite body. Along the north and south margins, these offshoots of the main body are mainly confined to a narrow zone, but along the west margin they occur throughout a belt from ½ to 2 miles wide. The gabbro mass is almost everywhere cut by a network of granite dykes.

Throughout the zone characterized by the presence of dykes and small bodies of granite, are numerous veins of quartz carrying 10 per cent or less of mispickel. The longest known vein measures 1,100 feet; the average width of the broadest vein is 7 feet. The veins parallel the margin of the granite body and dip westerly from the granite at angles varying from almost horizontal to 55 degrees. Besides quartz and mispickel, the veins carry ankerite, biotite, tourmaline, feldspar, fluorspar, chalcopyrite, pyrite, and magnetite. They occur in the limestone, greywacke, gabbro, and granite. Since they are confined to the contact zone of the granite batholith, it is concluded that they are derived from this intrusive. The gold is entirely, or almost entirely, associated with the mispickel.

DELORO PROPERTY

The veins on the Deloro property are in the east half of lots 9 and 10, con. VIII, Marmora tp., near Deloro and about 2 miles east of Marmora station on the Trenton-Bancroft branch of the Canadian National railway; a siding connects the property with the railway. The deposit has long been known, and mining had commenced prior to 1871. The property was acquired in 1880 by the Canadian Consolidated Gold Mining Company who constructed a mill for concentrating the mispickel, a roasting plant for recovering the arsenic, and a chlorinator for extracting the gold from the roasted ore. This company discontinued operations in 1884. From 1892 to 1894 the Hastings Mining and Reduction Company operated the mine in a small way and constructed an experimental mill having a capacity of 7 to 10 tons a day. In 1896 Canadian Goldfields, Limited, purchased the property and re-opened the mine. A mill was built and gold and the arsenic were produced. The mine was again closed in 1903. Later, in 1907, the property was bought by the Deloro Mining and Reduction Company and the mill was converted into a refinery for treating cobalt-nickel-arsenic ores from Cobalt.

The production of arsenic from the property during the years 1899 to 1903, the period during which the mine was most extensively operated, was as follows.[1]

Year	Tons
1899	57
1900	303
1901	695
1902	800
1903	257
Total	2,112

On the Deloro property are two north-south trending rock areas, separated by a drift-covered depression 150 to 500 feet wide. The western rocky area is underlain by flat-lying, Palæozoic limestone. The eastern area has an irregular surface and is underlain chiefly by Precambrian

[1]Ont. Dept. of Mines, Ann. Rept., vol. XII, p. 18 (1903).

gabbro, granite, and syenite. It is in this area that the mispickel-bearing quartz veins occur. The gabbro is medium to coarse grained. The granite and syenite form masses and dykes invading the gabbro. The veins strike from north to northeast and occur within an area about 400 feet wide and 440 yards long. They range in length from a few hundred to over 1,000 feet and have an average width of 1 to 5 feet. They dip westerly at angles of 20 to 55 degrees. They consist chiefly of quartz, rusty weathering ankerite, and mispickel in amounts up to 10 per cent. The less abundant constituents are biotite, muscovite, pyrite, chalcopyrite, gold, fluorite, and zircon. The order of deposition was, mispickel, quartz, and ankerite latest of all.

The most important vein is the Gatling. The two shafts (Gatling and Tuttle) in the vein were sunk on what appeared at the surface to be separate ore-bodies, but these united between the third and fourth levels. On the Deloro property the vein has a length of 900 feet, but it continues for at least 100 feet farther to a shaft on the adjoining Atlas property and may extend several hundred feet farther. The vein strikes north 5 degrees east (magnetic) and dips westerly at an angle averaging 40 degrees in the Gatling shaft and 55 degrees in the Tuttle shaft. The vein is not now visible at the surface except on the Atlas property where it is 3 feet wide. According to the mine plans, the average width between the Tuttle and Gatling shafts was about 4 feet on the second level, 6 feet on the third, and 3 feet on the fourth. On the fifth level, the width is said to have averaged 5 feet.

Assay plans show a gradual decrease in the gold content of the vein from about $9 a ton on the second level, to $3.50 on the fourth, and less than $2 on the fifth. The gold was chiefly associated with the mispickel.

West of the Gatling vein, a nearly parallel vein occurs in the Red shaft, and another in a crosscut from the Gatling shaft. These are apparently continuations of one another and lie 250 feet west of the Gatling-Tuttle vein. They dip 70 degrees west and when worked the vein is said to have been 3 to 4 feet wide on the first level and 2½ feet wide on the second level.

On the second level from the Gatling shaft, a crosscut was run west and drifts run north and south from it on a vein said to be 1½ to 4 feet wide and to carry considerable mispickel in places; assay records show an average gold content of less than $2 a ton.

About 330 feet west of the Gatling shaft there is a vein striking north 40 degrees east (magnetic) and dipping at 70 degrees northwest. This was worked from the air-shaft and from the west crosscut at the 200-foot level on the Gatling shaft. This vein is the southwestern continuation of the West vein on the Atlas property in which ore was obtained said to have been equal in grade to that found in the Gatling-Tuttle vein.

Another vein, the Hawkeye, is on lot 10. It strikes north 25 degrees east (magnetic) and dips westerly with an average angle of 35 degrees. At the head of the main shaft the deposit consists of masses and veins of quartz up to 3 feet in width mingled with fragments of gabbro. To the north of the main shaft, 50 feet away, a vein 3 to 4 feet wide is exposed at the top of another shaft. The vein at these and other openings carries mispickel, but in small amounts only. According to assay plans, the

Hawkeye vein on the first level had an average gold content of $3.72 a ton and an average width of 3 feet 9 inches; on the second level, the average gold content was $1.64 a ton and the average width, 2 feet 3 inches.

About 80 feet east of the main Hawkeye shaft, there is an opening exposing a quartz vein 2 feet wide. There is some mispickel in the quartz on the dump. Two hundred feet southwest of this shaft, on the strike of this vein, several openings show a quartz vein 2 to 3 feet wide.

One hundred and fifty feet east of the Hawkeye shaft, there is a shaft in the north face of which is exposed a mass of quartz 4 feet wide. The vein is said to be 5 to 8 feet wide and to carry gold up to $1.20 per ton.

ATLAS OR FIVE ACRES

This property consists of 5 acres in the east half of lot 10, concession IX. The first work in the area was performed in 1895. In 1899 the property was purchased by the Atlas Arsenic Company, Limited, who built a 10-stamp mill and carried on mining and milling operations until 1904. Since that time the mine and mill have been idle.

There are two veins on the property. They extend from the Deloro property, one being the continuation of the Gatling vein, and the other of the Air vein. The western or Air vein was worked from a shaft inclined at about 60 degrees northwest and with levels at depths of 78, 100, and 190 feet. The vein on the 100-foot level was, in places, 5 feet wide; on the 190-foot level, the vein in one place was 15 feet wide and consisted of quartz carrying mispickel and pyrite. The ore from the vein in general is said to have averaged $8 in gold a ton. On the 100-foot level, a crosscut was driven 20 feet east to a second vein 3 to 8 feet wide.

On the eastern or Gatling vein, there is a shaft inclined 55 degrees to the west. So far as known no drifting was done.

PEARCE OR SEVERN

This property consists of 20 acres in the east half of lot 8, concession VIII. Gold was discovered about 1869. Prospecting and development work commenced shortly thereafter. In 1901 the property was purchased by the Atlas Mining Company and was operated until 1904. In 1907 some work was done, but since then the property has remained idle.

The deposit is a quartz vein cutting granite or quartz syenite. The vein strikes northwest, has an average dip of 25 degrees southwest, and where now visible at the top of a shaft has a width of 1 to 1½ feet, increasing downwards to 4½ feet, and in the underground workings to (it is said) 8 feet. Considerable mispickel is reported to have been present and the average gold content is stated to have been from $6.50 to $10 a ton.

The vein was mined from an inclined shaft and from levels at various depths down to 150 feet. The maximum length of the workings is said to have been 125 feet to the south, and 105 feet to the north.

COOK

This property adjoins the Deloro on the east and lies in lot 9, concession IX. It is owned by the Cook Land Company of Toronto. All the mining was performed between 1901 and 1903, and was done on two veins about 800 feet apart.

The western vein is in granite containing greywacke inclusions, and dips south or southeast at angles of about 20 degrees. The principal opening is a shaft inclined at 20 degrees, from which drifts were run underground. At the mouth of the shaft a vein of quartz 6 to 18 inches wide is visible. The vein is said to carry mispickel, pyrite, and chalcopyrite. Seventy feet northeast an adit has been driven 50 feet southeast. Near its entrance a vein 8 to 12 inches wide is visible and farther in, there is a fractured zone in which are lenses of quartz up to 6 inches wide. About 80 feet west of the main shaft there is a shaft inclined 60 degrees westerly. This is said to have penetrated a quartz vein at a depth of 25 feet.

The eastern of the two main veins cuts greywacke, strikes about north, and was worked from a shaft inclined 45 degrees to the west. The vein was reported to vary in width from 1½ to 6 feet. It consisted of quartz with some mispickel, carbonate, and other constituents in minor quantities.

DEAN AND WILLIAMS

This property, owned by the Cook Land Company, is in the southeast corner of lot 7, concession IX. Mining operations were conducted prior to 1873 on a vein consisting of a succession of lenses striking north 25 degrees west (magnetic) and dipping 45 degrees east. The vein cuts granite and consists of quartz, carrying mispickel, rusty carbonate, biotite, pyrite, chalcopyrite, etc. A series of openings have been made along the outcrop over a length of 350 feet. No quartz is now visible at the most southerly opening, but at the next pit north there is a zone 2 to 3 feet wide in which are quartz veins, the widest being 1 foot. The quartz contains aggregates of mispickel, some of which are several inches wide. In the same pit there is visible: a mass of quartz 3 to 4 feet wide, but narrowing upwardly; an irregular vein, in places 6 inches wide, of quartz-bearing mispickel; and a branch vein 1 foot wide. A shaft extends from the bottom of this pit, is said to be 100 feet deep with drifts to the north and south, and to have been sunk on a vein whose breadth averaged 3½ feet with a maximum of 5 feet, and which at the bottom of the shaft consisted largely of mispickel.

CAMPBELL-BLOOMFIELD OR GILLEN

This property lies in the northeast corner of lot 6, concession VIII. It was first prospected in 1868. Various openings on the deposit occur over a length of 200 feet, but the vein is now visible in only one pit where it dips about 30 degrees southwest, has a width of 1 to 4 feet averaging about 3 feet, and cuts granite. In the dump is considerable quartz, a large proportion of carbonate, and a few masses of mispickel up to 3 or 4 inches in diameter.

TORONTO OR RANKIN

This property is in the northeast corner of lot 6, concession IX. A shaft and a pit have been sunk in granite, but the vein is no longer exposed. On the dump occurs quartz, mispickel, carbonate, etc.

CONCESSION VIII, LOT 8

In the east end of this lot there is a shallow pit exposing a 5-foot zone of quartz veins dipping 60 degrees southwest. The widest vein measures 2½ feet. The wall-rock is granite. The vein material is quartz, with a small proportion of mispickel and biotite.

CONCESSION IX, LOT 5

On the west half of this lot a shallow pit has been sunk in syenite. The material on the dump includes quartz, carbonate, mispickel, and hematite.

CONCESSION IX, LOT 4

On the west half of this lot, a shaft has been sunk in granite and on a vein said to be 6 to 24 inches wide. The vein dips 70 degrees southwest. On the dump quartz with mispickel, carbonate, etc., is visible. Fifty feet west of the shaft there is an outcrop of quartz, 5 feet wide, cutting greywacke.

CONCESSION X, LOT 1

A mineralized zone along the contact of siliceous greywacke and limestone is exposed in two pits a few hundred feet north of the Marmora road. The maximum exposed width of the zone is 2 feet. The principal minerals present are pyrrhotite and pyrite, but chalcopyrite and mispickel also occur. A sample assayed by the Mines Branch contained no gold and 0·4 per cent arsenic.

CAMERON-FEIGLE GROUP

This group includes several properties in lots 16 and 17, concession IX, Marmora township. A property on the west half of lot 17 has been known at various times as the Powell, the Cameron, and the Crescent. The east half of lot 17 was first called the Feigle, then the Crescent, finally the Sovereign. The west half of lot 17 is the Gladstone. These properties were worked at an early date for their gold content and mining intermittently continued until 1903. This group of properties occurs in an area of crystalline limestone and greywacke intruded by numerous, irregular masses of granite.

On the Cameron property there is a succession of shafts and pits over a length of 540 feet and in which at intervals is visible a quartz vein dipping about 70 degrees westerly. The country rock is greywacke. The form of many of the openings indicates that the vein consists of a succession of lenses up to 6 feet wide, but probably averaging not more than 3 feet. The vein material piled near the openings consists largely of quartz containing some mispickel, feldspar, and tourmaline. Where the vein is exposed no mispickel is visible. A sample of the quartz assayed by the Mines Branch contained a trace of silver and no gold.

On the Feigle property the deposit consists of an horizontal zone of quartz veins lying 5 to 15 feet below the surface and cutting granite. The maximum width of the zone is said to be 20 feet. The individual veins range in width from a fraction of an inch to 2 feet and, on an average, form one-third of the zone. The veins are now visible only in two pits situated, respectively, at the north and the south ends of the workings which occur over an area at least 350 feet long from north to south and 50 to 100 feet wide, corresponding to the area occupied by the body of granite. In the north pit the veins are of quartz containing a small proportion of mispickel, some black tourmaline, and aggregates of magnetite.

On the Gladstone property which adjoins the Feigle on the north, are various pits sunk in greywacke. No veins are now visible in the pits and only a few fragments of quartz or other vein material occur in the dump.

CONCESSION IX, LOT 13

On the west half of this lot, two pits, 40 feet apart, have been sunk in a brecciated felsite with a limestone matrix lying along the contact of felsite and limestone. The westerly of the two pits is probably 30 feet deep; the deposit as exposed in the face of the pit consists of mispickel scattered through limestone. At one point, on the north face of the pit, there is a zone more than 1 foot wide, in which mispickel forms nearly half the rock. In the dump, the mispickel occurs in masses and in aggregates of crystals in limestone and in felsite. A selected sample of the mispickel assayed by the Mines Branch, carried: silver, 0·07 ounce; and gold, 0·01 ounce a ton.

GAWLEY

This deposit occurs on the east half of lot 19, con. IX, Marmora tp. It was opened about 1901, by the Atlas Mining Company. The wall-rock consists of thinly-bedded limestone and greywacke dipping 80 degrees north. The deposit is a vein a few inches to 3 feet wide, exposed in a shaft and pits over a length of about 900 feet. The vein is composed of quartz, carbonate, mispickel, and chalcopyrite. The mispickel occurs partly massive, partly in crystals, and is embedded in the other three principal constituents of the vein. An average sample from the ore in the dump assayed by the Mines Branch, contained: arsenic, 14·53 per cent; copper, 1·43 per cent; silver, 0·16 ounce; and gold, 0·09 ounce a ton.

NOBBS

This property is in lot 24, con. V, Marmora tp. On this property, limestone is cut by a northwesterly granite dyke about 20 feet wide. Several prospect pits have been sunk in the dyke. In the west half of the lot there is such an opening, 20 feet long, 8 feet wide, and 12 feet deep, from which 14 tons of mispickel ore were shipped in 1890. At present, a zone of quartz and mispickel, up to 2½ feet wide, is visible in the east face and bottom of the pit. In the west face there remain only two small masses of mispickel, a few inches in diameter. It is evident that a quartz body carrying some mispickel and striking north 75 degrees west (magnetic) was once present, but the deposit probably was only a small lens, for no trace of the lead can be seen in either direction along the strike.

21b. Madoc and Elzevir Townships

By M. E. Wilson

The township of Elzevir, with the exception of a belt along its south and southeastern margin, is underlain by granite gneiss, part of a huge batholith that continues northeastward for many miles. This is adjoined on the south and west by a belt of lava flows, 1 to 6 miles wide, belonging to the Grenville series. The lava flows are followed in turn to the westward by sediments—conglomerate, greywacke, dolomite, and limestone—which rest unconformably on the volcanics and form what has been known as the Hastings series. In these zones of volcanics and sediments, veins and lenses of quartz or of quartz and ankerite are very common. Some of these carry gold and a few mispickel or other sulphides, but the proportion known to be present is not large. The following descriptions include all those deposits that are known to carry mispickel.

SOPHIE PROPERTY

There are two veins in this property which is in con. X, lot 14, Madoc tp. Only one of these veins, the north, situated about 400 feet northwest of the shaft-house, carries mispickel. All that can be seen of the deposit at the surface, at present, is a vein-zone trending about north 30 degrees east, magnetic, exposed for 45 feet along its strike. The total width of quartz in the zone ranges from 1 to 3 feet; the average is 18 inches to 2 feet. About 100 feet north of the outcrop of the vein there is a timbered shaft 15 feet by 5 feet, inclined 70 degrees to the west. The dump adjoining this shaft includes fragments of vein material consisting of quartz, ankerite, muscovite, biotite, feldspar, pyrite, pyrrhotite, and mispickel. The proportion of the sulphides is very small. The rock exposed in the Sophie property is chiefly the volcanic member of the Grenville series, but at the point where the vein occurs there is a parallel zone of laminated, dolomitic, biotite-hornblende schist over 10 feet wide. This is probably a zone of sedimentary material lying between two flows.

JAMES GROUP, ELZEVIR TOWNSHIP

Previous Descriptions

Wells, J. Walter: Ont. Dept. of Mines, Ann. Rept., vol. II, p. 102 (1902).
Miller, W. G.: Ont. Dept. of Mines, Ann. Rept., vol. II, p. 200 (1902).

Most of the development work in this locality has been performed in lot 3, con. IV, Elzevir tp., on property owned by Joseph James of Actinolite, but two openings have been made across the Madoc-Actinolite road in lot 2 (Clapp property). The development work consists of numerous pits or shafts up to 40 feet deep, all of which, with the exception of 10 feet at the bottom of shaft No. 2, put down by Mr. James, were sunk by a United States Senator named Flint about the year 1872. Mr. James also owns the waterpowers on the Skootamatta river, which crosses the property.

The rocks exposed in the mineralized belt consist of hornblende schist, the volcanic member of the Grenville series, and hornblende-mica schist, forming a transition zone between the volcanic and conglomerate of the Hastings series. The mineral deposits consist of numerous, irregular aggregates and veins of quartz up to 3½ feet wide occurring either in the hornblende-mica schist or in the hornblende schist near its contact with the hornblende-mica schist. The area throughout which the quartz occurs is about 400 feet wide and ½ mile long. Locally in the zone the quartz forms up to one-quarter of the total rock, but throughout considerable areas it usually forms less than one-tenth. The quartz in places, especially along its contact with the schist, carries some mispickel and the schist adjoining the quartz is impregnated with mispickel, but the proportion of this mineral in any of the openings seen by the writer is small.

In the easternmost pit (No. 7) which lies east of Skootamatta river, quartz lenses are visible in mica-hornblende schist. No. 1 pit is 700 feet east of Actinolite station and on the west side of the river, 800 feet away from No. 7 pit. No. 1 pit is a cutting in a hill-side, is 30 feet long, 20 feet wide, and 25 feet high at the face. The northeast face of the pit is of alternating zones of white quartz and hornblende-mica schist. The schist contains a very small proportion of fine-grained sulphide. On the dump there is a pile of about 100 pounds of mispickel that probably was obtained from a deeper part of the opening now filled with water. A sample of the quartz from the face of the pit, assayed by the Mines Branch, Ottawa, carried no gold and only a trace of silver. A sample of the mispickel on the dump carried 0·01 ounce silver and 0·04 ounce gold a ton. A shaft (No. 2 working) lies across the road, 250 feet west of No. 1 pit. The shaft opens from the bottom of a pit 25 feet long and 15 feet wide in hornblende schist exposed in spots on two faces of the pit. Quartz veins occur on the southwest face where three areas, each 2½ feet wide, consist largely of quartz. Some mispickel is visible in schist masses on the dump. The shaft is said to be 40 feet deep and it is reported that samples from the shaft contained as high as $20 a ton in gold. It seems certain, however, that these were selected samples.

Quartz lenses in hornblende schist are visible in a pit 150 feet south of the shaft, but no mispickel was observed. Eight hundred feet farther west, just north of the Madoc-Actinolite road, is pit No. 4, 25 feet long by 15 feet wide. Only the west rock face is visible. It is of mica-hornblende schist with aggregates and lenses of quartz forming about one-tenth of the rock over a width of 10 feet. A small proportion of mispickel occurs in the wall-rock. South of the road at this point are two pits showing quartz lenses and irregular quartz aggregates, but with no visible mispickel.

Two hundred and forty feet west of working No. 4, is pit No. 3, where in a width of 10 feet, aggregates and veins of quartz from a fraction of an inch to 3½ feet wide form one-quarter of the rock face. The country rock (hornblende schist) between the veins is impregnated with a small amount of mispickel, which also occurs in the quartz. A sample of the quartz assayed by the Mines Branch, Ottawa, held no gold and only a trace of silver. On a stripped area, nearby, quartz aggregates and veinlets form crumpled zones in hornblende schist which in places carries a little mispickel. Three hundred feet west, close to and on the north side of the road, is pit No. 5 sunk in hornblende schist. A zone of nearly pure quartz, 3 feet wide, is visible on the west face and lenses of quartz occur in the east face.

21c. Rawdon and Tudor Townships

Arsenopyrite has been found at the Emily mine, Rawdon township, Hastings county. (Ont. Dept. of Mines, Ann. Rept., vol. XI, p. 105 (1902)).

Arsenopyrite is reported from the Golding mine in Tudor township, Hastings county. (Ont. Dept. of Mines, Ann. Rept., vol. XI, p. 105 (1902)).

22. Lennox and Addington County

22a. REBSTOCK PROPERTY

This property is located on the east half of lot 23, con. V, Kaladar tp. It is owned by Albert Woodman, of Flinton, Ont.

The workings consist of a shaft 35 feet deep and a minor amount of stripping. The shaft has been sunk on a mass of quartz enclosed in green chloritic schist which strikes north 25 degrees east. The schist immediately adjoining this body of quartz has been largely replaced by hornblende and in places by tourmaline, biotite, and arsenopyrite. These minerals have been shattered and are traversed by veinlets of carbonate or of quartz. Arsenopyrite, although present in relatively small amounts, is the dominant sulphide and occurs as crystals in the chlorite and hornblende schists; as irregular patches associated with tourmaline, and in dense, fine-grained masses. Pyrite was the only other sulphide observed and is disseminated throughout the chlorite schist. The mineralization could not be traced on the surface far from the shaft, the sinking of which appears to have removed most of the mineralized outcrop. According to Mr. Woodman the gold values in the deposit are low and did not average 0·05 ounce a ton in the assays made by him.

The order of deposition of the minerals is interesting. Hornblende and biotite were formed by replacement and recrystallization of the chlorite schist, and tourmaline and arsenopyrite replaced these early silicates and in part filled open spaces. Movement took place which shattered the tourmaline crystals, the interstices and openings were then filled with quartz and calcite.

22b. KENNEFIC PROPERTY

This property lies on Tim Hunt's farm on lot 7, con. V, Anglesea tp., Addington co. It can be easily reached by a branch road which leads to Mr. Hunt's house from the Cloyne-Kaladar highway. From this point the shaft can be reached by a few minutes walk. D. E. K. Stewart, of Madoc, is said to be the owner of the property.

The work done on this property consists of a shaft 20 feet deep and now full of water. A number of narrow quartz veins within a zone 7 feet wide are enclosed in green schist and strike north 20 degrees east. On the north side of the shaft about one-half of this zone consists of white quartz, with a little arsenopyrite, in veinlets which branch, widen, and pinch between lenses of green schist. About 15 feet north of the shaft the veins are further exposed. The vicinity appears to be underlain by massive greenstone, probably gabbro, which has, in places, been rendered schistose. Into such a zone quartz veinlets carrying minor amounts of arsenopyrite have been introduced in a direction paralleling the schistosity. The wall-rock adjoining the veins occasionally contains minute scales of biotite and large crystals of garnet formed by recrystallization of the green schist. The only sulphide noticed was arsenopyrite, which appears to occur as small, irregularly distributed masses in the veinlets of quartz. The gold values are said to be low.

22c. O'DONNELL'S PROSPECT

This property is located on lots 6 and 7, con. III, Anglesea tp., Addington co. It can be reached by trail from a road which passes within a quarter of a mile of the workings. The prospect is owned by Hugh O'Donnell, a resident in the vicinity.

A shaft 15 feet deep has been sunk on a wide vein of white quartz. Several small pits have also been dug to the south of the shaft along the strike of the vein. The vein occurs along a shear zone in gabbro which has been rendered schistose by the movement. The green schist occupying this zone has been altered, in part, to mica schist, especially near the walls of the vein.

The vein exposed in the shaft strikes north 10 degrees east (magnetic) and appears to be vertical. On the north side of the shaft it consists of 6 feet of white quartz with occasional patches of arsenopyrite, galena, sphalerite, and pyrite; on the south side it narrows to 5 feet and on the bottom of the shaft it widens to about 8 feet. Though, due to the overburden present, the vein cannot be traced beyond a few yards on either side of the shaft, it has been uncovered at several points along the strike. At a distance of 325 feet south 10 degrees west from the shaft, trenching exposed a quartz vein one foot wide carrying some arsenopyrite and 40 feet farther south the same vein is again exposed. These showings appear to lie on the continuation of the main vein.

In addition to quartz the vein matter contains a sprinkling of sulphides, chiefly arsenopyrite, with some galena and a little zinc blende, pyrite, and chalcopyrite. A chip sample from the patches of sulphides exposed in the shaft was submitted to the Mines Branch, Ottawa, for assay. The results are as follows:

Gold	0·14 ounce a ton
Silver	0·56 "
Arsenic	8·40 per cent
Zinc	4·60 "
Lead	Not det.

22d. EFFINGHAM TOWNSHIP

Danaite is reported to occur on lot 14, con. XII, Effingham tp., Addington co. (Geol. Surv., Canada, Mem. 74, p. 32 (1915) .)

23. Frontenac County

Arsenic occurs in the Boerth mine, on lot 28, con. VII, Clarendon tp., about 2 miles southeast of Plevna and 12 miles west of Clarendon station, on the Kingston and Pembroke railway. It is more than twenty years since operations ceased. The deposit, which occurs near the contact of diorite and crystalline limestone, consists of auriferous arsenopyrite associated with quartz and tourmaline. Although two shafts, 120 feet and 35 feet deep, were sunk on the property, most of the ore extracted came from surface strippings or open-cut work. (Ont. Dept. of Mines, Ann. Rept., vol. IX, pp. 93-4 (1900); vol. XI, p. 203 (1902) .)

Arsenopyrite was found on the Cook, or Babcock, property, 5 miles southeast of Plevna and 2 miles south of the Boerth mine. A shaft 40 feet deep was sunk on the deposit, which consists of quartz and schistose diorite containing arsenopyrite. There is no well-defined vein on the property. Samples of ore taken from the dump and assayed by J. W. Wells carried $4 to $18 a ton in gold and an average of 14 per cent arsenic. (Ont. Dept. of Mines, vol. XI, p. 105 (1902) .)

Arsenopyrite occurs near Plevna in an area underlain by a greenstone schist which contains patches of the sulphide. It has been found in a number of pits lying to the west of the main road and on both sides of the swamp or valley adjoining the southern edge of the village. (Ont. Dept. of Mines, vol. XI, p. 203 (1902) .)

Tennantite is reported to occur on lots 6-9, con. IX, Barrie tp. (Geol. Surv., Canada, Ann. Rept., vol. VI, pt. R, p. 28 (1895) .)

24. Lanark County

Arsenopyrite was found at the Joe Lake mine in con. IV, Lavant tp. (Ont. Dept. of Mines, Ann. Rept., vol. XI, p. 105 (1902) .)

Arsenopyrite is said to occur on lot 5, con. IV, Ramsay tp. (Rept. of the Royal Commission on the Min. Res. of Ont., 1890, p. 146.)

25. Leeds County

Arsenopyrite is reported to occur on Harvey hill. (Geol. Surv., Canada, "Geology of Canada, 1863," p. 505.)

26. Peterborough County

Cobaltiferous löllingite associated with pyrrhotite and quartz occurs on lot 16, con. XIV, Galway tp. (Geol. Surv., Canada, Ann. Rept., vol. VI, pt. R, pp. 19, 43 (1895) .)

27. Long Lake

Previous Descriptions

Coleman, A. P.: Ont. Dept. of Mines, Ann. Rept., vol. XXIII, pp. 217-9 (1914).
Baker, M. B.: Ont. Dept. of Mines, Ann. Rept., vol. XXVI, pp. 157-162 (1917).
Hopkins, P. E.: Ont. Dept. of Mines, vol. XXX, pt. 2, p. 18 (1921).
Collins, W. H.: Geol. Surv., Canada, Mem. 143, pp. 120-122 (1925).

The Long Lake gold mine is situated one mile south of the foot of Long lake and is best reached by road from Naughton station 11 miles west of Sudbury on the "Soo" line of the Canadian Pacific railway. The property was purchased by the Canadian Exploration Company, which mined, from 1909 to 1916, about 200,000 tons of ore averaging $8 a ton in gold. After the removal of the known ore-body the management abandoned the workings and dismantled the mill.

The ore was taken from a large glory hole and from a shaft and underground workings reaching to a depth of 345 feet, at which point efforts to pick up the faulted part of the ore-body proved futile. The gold values were recovered by cyanidation and the arsenic content of the ores was allowed to escape with the tailings.

As described by various geologists, the gold deposit was confined to a block of feldspathic quartzite caught up and surrounded by diorite. The quartzite, which strikes northeast and southwest, belongs to the lower part of the Bruce series and has been intruded by large bodies of Killarney granite to the south of the mine. The diorite is also cut by or enclosed in apophyses of this pink granite. Later dykes of diabase traverse both the sediments and the intrusives. Subsequent faulting has affected all the rocks in the area. The ore consisted of feldspathic quartzite impregnated with gold-bearing arsenopyrite and pyrite, together with pyrrhotite, chalcopyrite, a little galena, and occasional nests of native arsenic in beautiful crystals. These sulphides were typically fine grained, although pyrite, and in fewer cases arsenopyrite, were conspicuously crystalline in places. In thin section the quartzite shows evidence of recrystallization and the grains of feldspar are particularly fresh and unaltered.

It has been suggested by Dr. Coleman and later by M. B. Baker that the diorite was the source of the ore. This conception was based largely on the fact that the quartzite ore-body was surrounded by the diorite intrusive, although of the other, similarly located masses of quartzite in the area, none was found to be auriferous. Although direct evidence is lacking in the case of the Long Lake deposit, it is known that arsenopyrite is typically associated with granites, and the proximity of the Killarney granite suggests that it was the source of the emanations which permeated and partly replaced the mass of quartzite engulfed in the diorite. However, the data available at the present time still leave the origin of the deposit a matter of surmise.

28. Howry Creek

Previous Descriptions

Collins, W. H.: Geol. Surv., Canada, Sum. Rept. 1917, pt. E, pp. 10-13.
Geol. Surv., Cănada, Mem. 143, pp. 122-124 (1925).

Since 1911 a number of claims have been staked for gold along the north side of Howry creek, a small stream flowing into Charlton lake, which lies a few miles north of lake Huron in Sudbury district. The claims are located about 6 miles east of Willisville (milepost 66), on the Algoma Eastern railway, and can be reached in two hours by canoe. Considerable work has been done on the claims (mining locations 3673, 2782, 2783) originally staked by James Bousquet and now held by the Howry Creek Mining Corporation, Limited.

Development work has been confined to a shaft 65 feet deep, a cross-cut tunnel 450 feet long, and several hundred feet of trenching and stripping.

The entrance to the tunnel lies about 400 feet south 6 degrees west of the shaft, which has been sunk on the vein. The tunnel runs almost due north for 400 feet, where it branches, one branch running north 15 degrees west, the other north 65 degrees east. For 325 feet it passes through quartzite, beyond which it continues in green schist up to the point where the tunnel divides. Both branches are in quartzite. Beyond a small amount of pyrite in the green schist no mineralization was noticed throughout the length of the tunnel. At its north end a depth of about 60 feet below the surface had been reached.

The shaft has been sunk in quartzite at a point where the vein branches. In sinking, it was seen to further subdivide into small stringers of quartz running in various directions and in some cases reuniting lower down to form larger veinlets. At a depth of 16 feet there is 3 feet of white quartz on the east side of the shaft. Irregular stringers of quartz continue downward, but distinct walls are lacking. In the shaft the quartzite is much jointed and fractured, so that bedding planes have been obliterated. At a depth of 56 feet the vein, consisting largely of arsenopyrite and pyrite, was 18 to 20 inches wide on the southeast side and 6 inches wide on the southwest side of the shaft. At the bottom of the shaft the vein appeared to widen to about 3 feet, but the proportion of quartz had greatly increased.

The stripping and trenching which has been done along the vein for several hundred feet west and 100 feet east of the shaft, has uncovered lenses or pockets of arsenopyrite and served to expose the irregular and variable character of the vein along the strike. Shallow pits have been sunk on the most promising sulphide bodies, which have been largely removed. These bodies do not appear to have been more than a few feet in length and perhaps a foot in width. Trial shipments of arsenopyrite were made from the property for testing purposes. Plans were laid at one time to install an arsenic-recovery plant on the property and this may still be done if the results of further development work prove encouraging.

The regional geology of the vicinity of the claims has been concisely described by Mr. Collins as follows:

The mineralized area is underlain by quartzite, greywacke, and conglomerate belonging to the upper part of the Gowganda formation and the lower part of the Lorrain quartzite (Cobalt series). These formations lie on edge, strike east and west and are intersected by a few dykes and larger bodies of diabase (Keweenawan).

Subsequent shearing movements have affected all the rocks, so that the quartzites are locally fractured and brecciated, the larger bodies of diabase have been rendered schistose along their margins, and the smaller ones converted and drawn out into lens-shaped masses of green schist. The vein occupies such a shear zone passing through quartzite and green schist and paralleling the general strike of the sedimentary formations. The behaviour of the vein, which branches and pinches along its course, appears to be directly dependent on the structural deformation mentioned above.

The vein consists largely of white quartz, together with ankerite, arsenopyrite, and pyrite. For the most part it lies between indefinite walls and in many cases encloses fragments of quartzite or schist, the latter in some places being replaced by the sulphides. Hydrothermal alteration has not been extensive, but in places the feldspathic quartzite and green schist adjoining or caught up in the vein have been converted to sericite and secondary silica. Arsenopyrite is more abundant than pyrite, but the two minerals occur intimately mixed and were probably deposited contemporaneously. Examination of the ore shows that both sulphides were shattered and brecciated, either prior to or at the time of the introduction of quartz and ankerite. Quartz, especially, traverses and fills fractures in the sulphides. The gold and silver values in the ore are said to be associated with arsenopyrite and pyrite rather than with the quartz gangue. In 1916 the vein was sampled systematically. "Some very high values in gold were obtained, but the average from all the samples taken indicates a gold content considerably under $10 a ton." A chip sample taken across 18 inches of vein matter, largely arsenopyrite, at a depth of 56 feet in the shaft, was assayed by A. Sadler of the Mines Branch and found to contain:

Silver	0·08 ounce per ton
Gold	0·51 "
Iridium	0·04 "
Arsenic	32·34 per cent

It is not known in what form the iridium occurs, except that it is probably contained in the arsenopyrite. It may possibly be present as an arsenide analogous to sperrylite.

The age and source of the ore in the Howry Creek deposits are at present matters of conjecture. The fact that veins occur in or along the contact of the diabase shows that the mineralization must have taken place after the intrusion of that rock. No other important igneous bodies are known to be present in the vicinity, but a large body of Killarney granite is intrusive in the Huronian sediments some miles to the southeast (*See* Geol. Surv., Canada, Map 155A) and may underlie them, at considerable depth, at the locality where the ore deposit occurs. At the Long Lake gold mine, which lies about 25 miles northeast of Howry Creek area, a block of feldspathic quartzite impregnated with pyrrhotite, arsenopyrite, and pyrite, and enclosed in diorite, was discovered in close proximity to the Killarney granite. The contact of this rock with the older Huronian sediments has been traced southward to Georgian bay and passes about 12 miles to the southeast of Howry creek. It is not improbable, as pointed out by W. H. Collins, that a genetic relationship exists between this granitic intrusion and the deposits at Howry creek and Long lake. If so, other gold-arsenic deposits may occur in the area of sediments lying west of the Killarney granite.

28a. Bousquet Extension

This property lies about 1½ miles west of the Howry Creek Mining Corporation's holdings. The main vein occurs on mining location 766, which is owned by James Bousquet, of Willisville.

The vein has been exposed by trenching or stripping for 100 feet along its strike, and a shaft 18 feet deep has been sunk near the middle of the outcrop.

The vein consists almost entirely of white quartz and varies from 12 to 32 inches in width. It strikes east and west and lies along the contact between quartzite and diabase. This latter rock, which forms the north wall of the vein, has been altered and rendered schistose for several feet from the contact. Although arsenopyrite is reported to have been found in the shaft in some quantity, only minor amounts of the sulphide were seen on the surface.

29. Whitefish River

Arsenopyrite with chalcopyrite and pyrrhotite were reported to occur at the Wallace mine, one mile west of the mouth of Whitefish river, on the north shore of lake Huron. (Geol. Surv., Canada, vol. XIV, pt. H, pp. 147-8 (1906).)

Arsenopyrite is said to occur in the area north of the bay of Islands, in the north channel of lake Huron. (Rept. of the Royal Commission on the Min. Res. of Ont., 1890, p. 59.)

Arsenopyrite occurs with pyrite and chalcopyrite in quartz veinlets on Edgewood island, Manitoulin district. (Rept. of the Royal Commission on the Min. Res. of Ont., 1890, p. 109.)

30. North of Deer Lake

Previous Description

Wright, J. F.: Geol. Surv., Canada, Sum. Rept. 1922, pt. C, pp. 74-76.

In the spring of 1921 cobaltite was discovered about 15 miles north of Deer lake, on English river, Patricia district. The deposits, as described by Wright, occur at intervals in a band of garnetiferous schist, about 8 feet wide, that forms the margin of a zone of biotite and hornblende schists at their contact with pink granite. In the prospect pits the zone of black garnet schist is impregnated with small lenses and thin bands of cobaltite and chalcopyrite, with minor amounts of pyrite, pyrrhotite, magnetite, and covellite. The cobaltite also occurs as small crystals scattered throughout the gangue. Assays and partial analyses by the Mines Branch, Ottawa, of two average samples taken across 8 feet of the mineralized zone, gave the following results:

No.	Per cent			Ounces
	Cobalt	Nickel	Copper	Gold and silver
340 A	2·16	trace	0·10	nil
340 B	trace	trace	0·87	nil

340 A. From pit near camp and about half-way up hill.
340 B. From pit one-quarter mile west of camp.

31. Lake of the Woods

Previous Descriptions

Geol. Surv., Canada, Rept. of Prog. 1882-3-4, pt. K, p. 11.
Rept. of the Royal Commission on the Min. Res. of Ontario, 1890, p. 117.

About 1880 a number of auriferous quartz veins were found and to some extent mined in the vicinity of Hay island and Bigstone bay, along the northeastern shore of lake of the Woods. These veins, which occur in amphibolites or slates in close proximity to granite, vary greatly in width and continuity. In some cases they appear to occupy shear zones in the amphibolites which have been rendered schistose and occasionally impregnated with sulphides. The vein-filling consists almost wholly of quartz, included fragments of schist, and minor amounts of arsenopyrite, chalcopyrite, pyrite, galena, zinc blende, and calcite. Although some of the veins are reported to carry high gold values, mining did not prove successful and operations ceased in 1884. The chief localities at which arsenopyrite was found in the district are as follows:

Winnipeg Consolidated mine	East shore of Bigstone bay
Lake of the Woods mine	" "
Hay Island mine (Keewatin)	Hay island
Heenan mine	"
Pipestone point	South of Hay island
Pine Portage mine	Pine Portage bay

A deposit of arsenopyrite and pyrrhotite was reported by E. Coste[1] to occur on the southwest point of an island just east of Scotty island. He says the vein, which cuts mica slates, consists largely of the sulphides with a minor amount of quartz, and although its width could not be determined it appeared to be about 11 feet thick. The arsenopyrite is said to carry 5 to 9 per cent of cobalt and the pyrrhotite at times 4 to 5 per cent of nickel. Coste states that the average arsenic content must be 35 to 40 per cent.

[1]Geol. Surv., Canada, Rept. of Prog. 1882-3-4, pt. K, pp. 17-18.

32. Michibiju

In 1913 a gold-arsenopyrite deposit was found in township 34, range 24, near the southeast corner of Thunder Bay district. The discovery is located about 55 miles south of White River station on the Canadian Pacific railway and 10 miles north of lake Superior. The main outcrop consists of a silicified zone 3 feet wide contained in a well-mineralized green schist and cut by numerous small stringers of quartz. Considerable arsenopyrite occurs in patches on the hanging-wall and probably in the quartz stringers which follow the trend of the zone. A sample of the sulphide was assayed by the Provincial Assayer and showed a high gold content. (Ont. Dept. of Mines, Ann. Rept., pt. 1, pp. 11-12 (1913).)

33. Michipicoten Area

The Keewatin iron formations of Michipicoten area, which consist of a banded silica member, a pyrite member, and a carbonate (siderite) member in stratiform arrangement, regularly contain a trace of arsenic in the pyrite member and in one range, the Brooks, crystals of arsenopyrite half an inch long have been found. These iron formations are of Keewatin (early Precambrian) age and are believed to have originated from heated mineralized waters given off by some of the volcanic flows, of which the Keewatin is mainly composed. (Collins and Quirke: Geol. Surv., Canada, Mem. 147, "The Michipicoten Iron Ranges.")

Minor amounts of arsenopyrite associated with pyrite and chalcopyrite occur in a quartz vein on claims 480 and 634, located between Wawa creek and Michipicoten river. (Ont. Dept. of Mines, Ann. Rept., vol. IX, p. 114 (1900).)

Some arsenopyrite has also been found in the auriferous quartz veins of the Goudreau Gold Mines, Limited, property in township 28, range 26. (Geol. Surv., Canada, Mem. 147, "The Michipicoten Iron Ranges.")

34. Opazatika River

Arsenopyrite is reported to occur near the foot of Split Rock rapids on Opazatika river. (Ont. Dept. of Mines, Ann. Rept., vol. V, p. 256 (1895).

35. Bristol Township

Arsenopyrite is abundant in quartz veinlets on the McAuley-Brydges claim in Bristol township. (Ont. Dept. of Mines, Ann. Rept., vol. XXI, pt. 1, p. 223 (1912).)

36. Beatty and Munro Townships

Arsenopyrite has been found in several localities in Beatty township, Cochrane district. Arsenopyrite and pyrite occur in a quartz vein on the Dunlop location on lot 8, concession V. A 20-foot shaft sunk on the vein shows it to be 7 feet wide. It carries a little gold. Arsenopyrite occurs in quantity on the Mayot or Treadwell location situated on lot 9, concession

VI. According to P. E. Hopkins, both deposits contain much arsenopyrite, pyrite, and quartz, and low values in gold, silver, and copper. They are said to resemble the gold-arsenopyrite bodies near Timagami. (Hopkins, P. E.: Ont. Dept. of Mines, Ann. Rept., vol. XXIV, pt. 1, p. 180 (1915); vol. XXX, pt. 2, p. 28 (1921). Also, Ont. Dept. of Mines, Ann. Rept., pt. 2, p. 58 (1919).)

Arsenopyrite occurs in crystals in a quartz vein on the Dobie-Leyson claim on lot 10, con. I, Munro tp. (Ont. Dept. of Mines, Ann. Rept., vol. XXIV, pt. 1, p. 180 (1915).)

37. Larder Lake

Arsenopyrite occurs in the ores found on several claims in Larder Lake area and particularly near Pancake lake, McVittie township, on those owned by the Associated Goldfields Limited and the Crown Reserve Mining Company. The latter deposits have been described by H. C. Cooke,[1] from whose report the following statements are derived. The ore-bodies are replacement lenses developed in Keewatin lavas and tuffs. The principal lens has a maximum known width of 40 feet and a proved length of over 900 feet. Smaller lenses have also been discovered. The ore consists of Keewatin lavas replaced by calcite, quartz, hematite, pyrite, arsenopyrite, and some feldspar. The source of the mineralizing solutions is tentatively ascribed to a mass of diorite porphyry found in the vicinity. Gold values in the ore-body average fairly well but are extremely variable, between $2 and $20 a ton. Neither free gold nor telluride has been found in the ores, although both the pyrite and arsenopyrite carry gold values. Mill tests conducted with ores show that the gold is associated to a greater extent with the arsenopyrite than with the pyrite. The arsenic content of the ores is probably in the neighbourhood of 1 per cent.

38. Strathy Township

38a. BIG DAN

(*See* Figure 18)

Previous Descriptions

Coleman, A. P.: Ont. Dept. of Mines, Ann. Rept., vol. IX, p. 173 (1900).
Knight, C. W.: Ont. Dept. of Mines, Ann. Rept., vol. XXIX, pp. 214-7 (1920).

The Big Dan deposit is on claim W.D. 271, Strathy township, Nipissing district. The property lies about 200 yards west of milepost 74 on the Temiskaming and Northern Ontario railway, about 2 miles north of Timagami station. A spur, formerly known as Greys siding, was laid into the property, but the rails have since been removed. The Big Dan is held by the Timagami Mining and Milling Company.

The workings consist of two shafts, an adit, an open-cut, and a number of small trenches or pits. The shafts lie 120 yards apart on a line running north 20 degrees east (magnetic). The more northerly shaft appears to

[1] Cooke, H. C.: Geol. Surv., Canada, Sum. Rept. 1923, pt. C I, pp. 61-73.

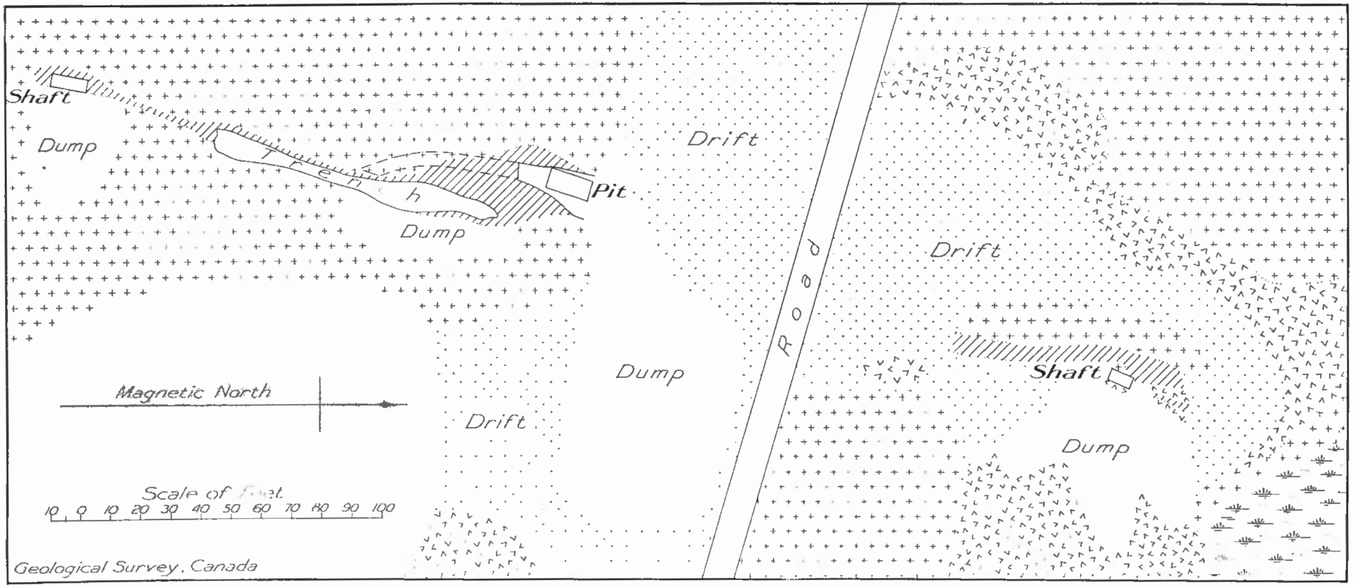


Figure 18. Big Dan property, Strathy township, Timiskaming district, Ontario. Zone carrying sulphides shown by diagonal ruling; basalt by pattern of crosses; quartz porphyry and diorite by pattern of arrows.

be inclined at about 70 degrees to the west, the other is vertical, and both were full of water at the time the property was visited. The adit lies between the two shafts, its entrance being at the south end of the open-cut. The tunnel runs southerly for about 50 feet, where it ends in a stope extending to the surface about 20 feet above. The open-cut is 25 feet long, 6 to 16 feet wide, and about 25 feet high. The largest trench is south of the open-cut, extends south for almost 100 feet, and varies from 3 to 10 feet in width and averages 5 feet in depth. Minor trenches occur at intervals for a distance of 700 feet south and 200 feet north of the main workings. All buildings, including the mill erected to concentrate the ore, have been destroyed by fire.

The mineralization occurs in a zone of variable width, lying chiefly in Keewatin basalt and along which shearing and brecciation have taken place. This zone strikes north 20 degrees east, dips steeply to the west, and can be traced on the surface for about 1,000 feet, but only at wide intervals is there any evidence of mineralization. At the north shaft the shearing has taken place between basalt and quartz porphyry; elsewhere on the property it is confined to the basalt. The mineralized or gossan-stained zone attains a width of 25 to 30 feet near the open-cut, but it is usually very much narrower. There is no distinct vein and the sulphides, arsenopyrite, pyrrhotite, pyrite, and chalcopyrite, occur as disseminated particles or veinlets impregnating and replacing the schistose basalt, and in fine-grained, solid masses enclosing angular fragments of country rock. Arsenopyrite and pyrrhotite are more plentiful than the other sulphides, but both pyrite and pyrrhotite appear to become more prevalent relatively to arsenopyrite, as the intensity of mineralization decreases. Quartz and calcite are only sparingly present, which is not surprising in a deposit where hydrothermal alteration also appears to be quite limited in extent.

Several intrusive bodies occur on the property. The one most closely associated with the deposit is at least 100 feet in width and consists of quartz porphyry near its contact with the basalt, although changing to more dioritic phases farther away. At the north shaft, which has been sunk on this contact, the basalt contains a small quantity of sulphides, whereas the dyke consists of quartz and sericite, the latter mineral giving way to chlorite and calcite where alteration has been less intense. The presence of hydrothermal alteration at this point suggests that the mineralizing solutions followed the intrusion of the porphyry dyke. This intrusion was probably the cause of the local brecciation and shearing in the basalt which provided channels along which the emanations bearing sulphur, arsenic, and iron were able to penetrate. The minerals deposited filled open spaces and replaced the basalt in preference to the quartz porphyry.

Due to the irregular nature of this deposit extensive sampling would be necessary before a reliable estimate of its arsenic and previous metal content could be arrived at. According to A. P. Coleman,[1] who reported on the property in 1900, assays made on the ores ran from less than $1 up to $31·20 in gold and silver, averaging $5.75.

At the present time very little ore can be seen outcropping anywhere along the shear zone. The solid lens or body of arsenopyrite encountered in the open-cut and adjoining trench was said to average a foot in width

[1]Ont. Dept. of Mines, vol. IX, p. 173 (1900).

for a length of about 50 feet before it was removed. Other smaller bodies of sulphide were also found, but they proved to be discontinuous, as may be expected in a deposit due largely to replacement.

38b. LITTLE DAN

Previous Description

Knight, C. W.: Ont. Dept. of Mines, Ann. Rept., vol. XXIX, pp. 217-8 (1920).

This property is located on claims WS 14 and WS 13 at the east end of Arsenic lake, Strathy township. It is best reached by a trail, about 1½ miles in length, which begins at the Big Dan mine.

The workings consist of a shaft and a small open-cut near and south of the east end of the lake. The shaft was flooded at the time the property was visited in 1923 and the open-cut, which is about 40 feet long, 4 to 10 feet wide, and 20 feet deep, was also inaccessible. Considerable diamond drilling has been done on the claims.

The mineralization lies along a shear zone in Keewatin basalt which has been rendered schistose by the movement. This zone, which is exposed for a few feet near the south end of the open-cut, strikes north 15 degrees west, but appears to swing toward the east near the mouth of the cut. The mineralized part, where visible, is about 12 inches in width and consists of bleached or altered schist in which are contained lenses, stringers, and irregular masses of arsenopyrite, pyrite, and chalcopyrite, with a minor amount of quartz. The schist is grey to buff and partly silicified where the sulphides are most plentiful, but changes to pale green and finally dark green on passing outward from the altered zone. The buff-coloured or grey schist has been impregnated and cut by veinlets of arsenopyrite and pyrite, and also by quartz stringers carrying chalcopyrite. The sulphides diminish rapidly in the less altered schist and within a few feet of the vein disappear entirely except for a little pyrite in the basalt.

A chip sample taken across the 12-inch mineralized zone exposed in the south end of the open-cut gave, when assayed by Mr. A. Sadler of the Mines Branch, Ottawa, the following values:

	Oz. per ton
Gold	0·22
Silver	2·19

Selected particles of arsenopyrite from a sample taken at the Little Dan claim gave on assay, according to W. G. Miller,[1] $4 in gold and 59 cents in silver a ton, and contained 36·24 per cent arsenic. W. E. H. Carter [2] reported that the best ore ran $16·63 a ton in gold and silver, from 0·5 to 1·5 per cent in copper, and about 30 per cent in arsenic. It is reported that about 270 tons of arsenopyrite were shipped from the property.

38c. FAIRVIEW CLAIM

A little arsenopyrite occurs associated with pyrite, pyrrhotite, and chalcopyrite, on the Fairview claim on the east side of Net lake about 1½ miles north of the Big Dan workings. (Ont. Dept. of Mines, Ann. Rept., vol. IX, p. 173 (1900).)

[1] Ont. Dept. of Mines, Ann. Rept., vol. XVI, pt. 2, p. 9 (1907).
[2] Ont. Dept. of Mines, Ann. Rept., pt. I, pp. 73-4 (1905).

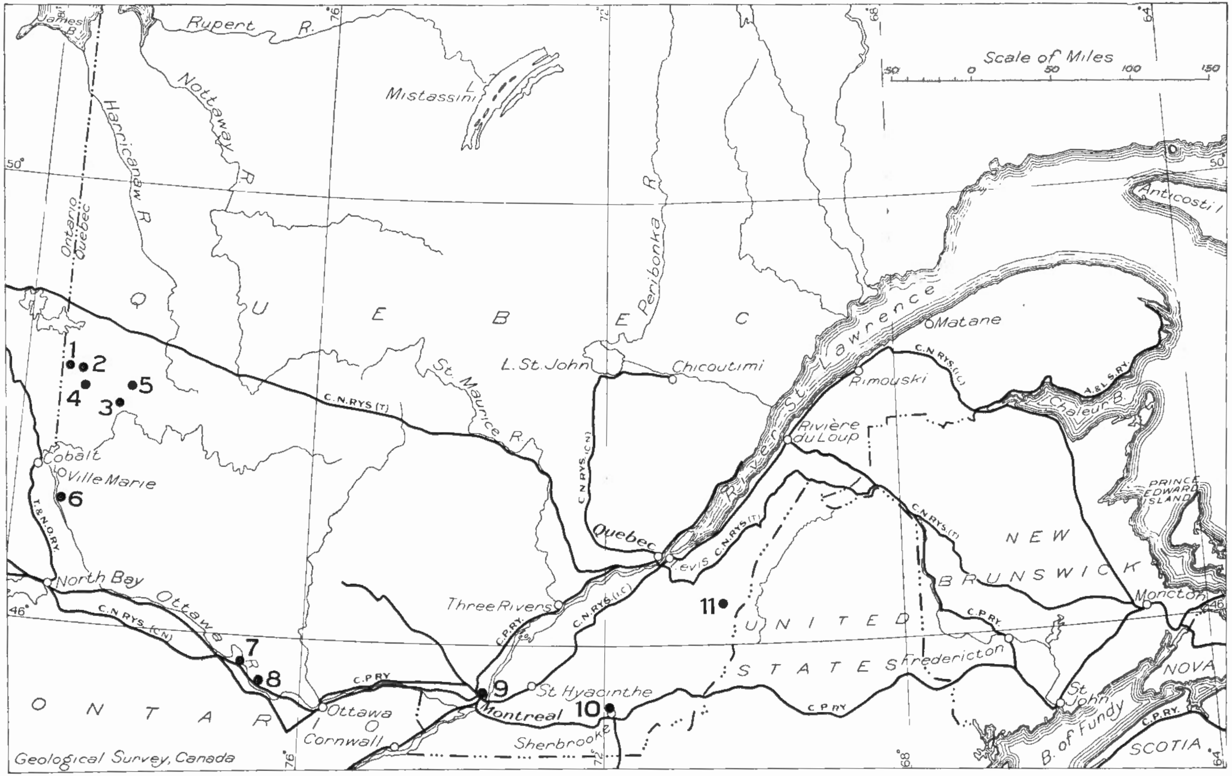


Figure 19. Index map of Quebec showing location of arsenic-bearing occurrences. 1, Montbray township; 2, Dufresnoy township; 3, Kinojevis river; 4, Rouyn township; 5, Cadillac township; 6, Fabre township; 7, Calumet township; 8, Shawville; 9, Outremont; 10, Sherbrooke county; 11, St. Francis.

QUEBEC

Arsenic has been reported from a number of localities in Quebec, but nowhere do the occurrences appear to be of more than mineralogical interest.

Arsenic-bearing minerals have been observed, according to Theo. Denis, Superintendent of Mines for Quebec, at several localities in Témiscamingue district.

(1) In Montbray township, on Kanasuta river.

(2) In Dufresnoy township, on the lake of the same name.

(3) On Kinojevis river, west of lake Kewagama.

Other occurrences are as follows:

(4) In the Timiskaming conglomerate south of Pelletier lake, Rouyn township, Témiscamingue district, quartz veins carrying free gold, pyrite, and arsenopyrite have been discovered on the Bathurst claims, optioned to McIntyre Porcupine Mines, Limited. The veins strike east and west, and consist of a complex of veins and stringers of quartz in the sheared conglomerate over a zone averaging 5 or 6 feet in width. Development work in 1924 consisted of stripping and trenching only, and gold is the only metal of importance. (Cooke, H.C.: Bull. Can. Inst. Min. Met., April, 1925, p. 348.)

(5) In the northwest corner of Cadillac township, Témiscamingue district, M. J. O'Brien, Limited, were in 1924 developing one group of claims at the extreme south end of Kewagama lake, and another group 4 miles from the north boundary of the township and 1 mile from its western boundary. On the first group a large body of pyrite and arsenopyrite was found close to the lake; on the second group three veins are said to have been found, but most of the development had been concentrated on one. This vein is a shear zone in Timiskaming conglomerate filled with lenses of quartz carrying free gold, pyrite, and arsenopyrite. It is about 12 feet wide, strikes about east and west, and dips steeply. It is said to have been traced for 2,000 feet and at the end of 1924 a shaft had been sunk 45 feet. (Cooke, H. C.: Bull. Can. Inst. Min. Met., April, 1925, p. 348.)

(6) Small veins of smaltite have been reported in Fabre township, Témiscamigue district. These are of the same character and age as the Cobalt deposits in Ontario. (Rept. Dept. of Mines, Quebec, 1907, p. 57.)

(7) Danaite has been found with pyrrhotite on lot 12, range IX, Calumet tp., Pontiac district. (Geol. Surv., Canada, Ann. Rept., vol. XII, pt. R, pp. 19-20 (1902).)

(8) A vein carrying arsenic and low values in gold and silver is reported to occur near Shawville, Pontiac district. The property is owned by W. H. Buddle of Espanola, Ontario.

(9) Native arsenic was found in a narrow vein in nepheline syenite at Outremont, Jacques Cartier district. (Geol. Surv., Canada, Ann. Rept., vol. XIV, p. 23 (1906).)

(10) Tennantite occurs with chalcopyrite, pyrite, and quartz at the Crown mine on lot 2, range IX, Ascot tp., Sherbrooke district (Trans. Roy. Soc. of Canada, vol. I, sce. 3, p. 80.)

(10a) Arsenopyrite occurs in a quartz vein carrying galena at Moulton hill, Sherbrooke district. (Geol. Surv., Canada, Ann. Rept., vol. IV, pt. T, p. 21 (1891).)

(10b) Arsenopyrite is reported from lot 4, range VIII, Ascot tp., Sherbrooke district. (Geol. Surv., Canada, Mem. 74, p. 33 (1915).)

(11) Arsenopyrite occurs with argentiferous galena in a quartz vein on Chaudière river, near St. Francis, Beauce district. (Geol. Surv., Canada, Ann. Rept., vol. IV, pt. T, p. 21 (1891).)

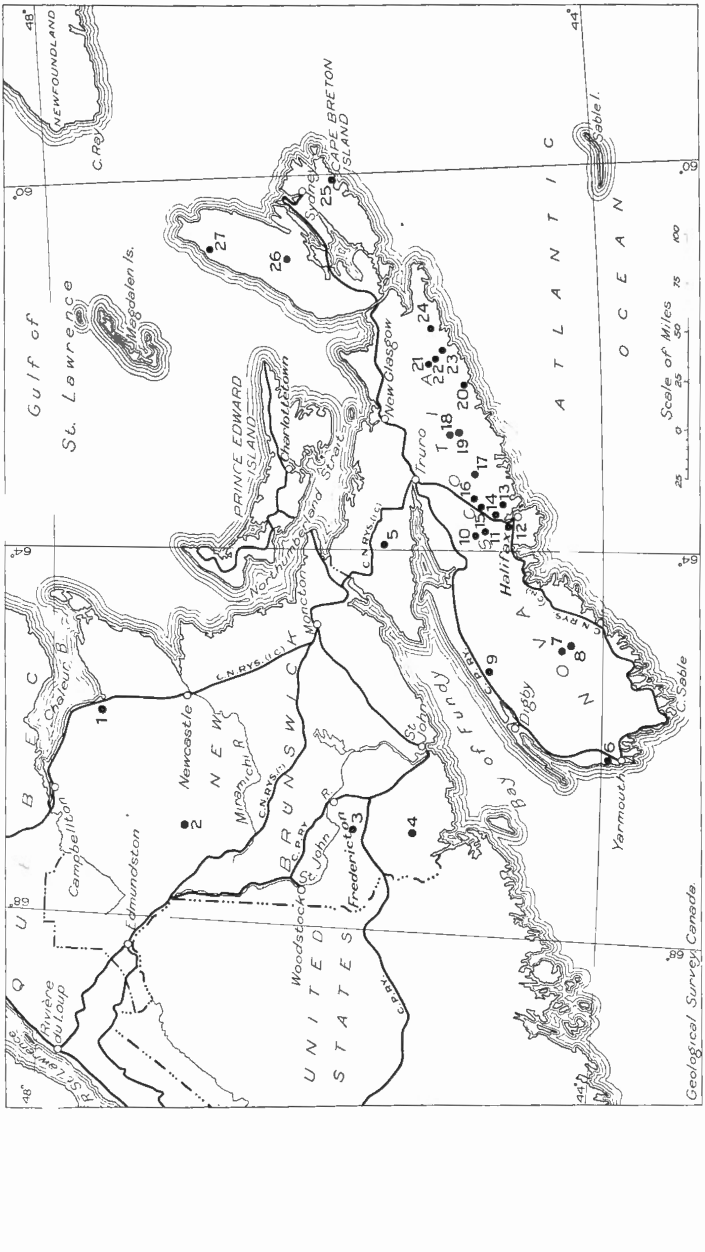


Figure 20. Index map of New Brunswick and Nova Scotia showing location of arsenic-bearing occurrences. For explanation of figure, *See* page 125.

Explanation of Figure 20

The localities indicated by numbers on Figure 20 are as follows:

New Brunswick

1. Stevens brook
2. Serpentine river
3. Lake George
4. Charlotte county

Nova Scotia

5. Williamsdale
6. Cream Pot mine
7. Brookfield
8. Malaga
9. Bartiaux brook
10. Mount Uniacke
11. South Uniacke
12. Lower Sackville
13. Montague
14. Waverley
15. Wellington
16. Oldham
17. Meagher Grant
18. Caribou
19. Moose River
20. Salmon River
21. Cochrane hill
22. Stillwater
23. Goldenville
24. Goldboro
25. Gabarus bay
26. Wagamatkook
27. Cheticamp

NEW BRUNSWICK

Arsenopyrite has been found in several localities in New Brunswick. With the possible exception of the deposit at Stevens brook, Gloucester county, the occurrences are, so far as is known, only of mineralogical interest.

1. Stevens Brook

This property lies about 12 miles northwest of Bathurst, Gloucester county. The workings are located on the east bank of Stevens brook, a tributary flowing southerly into Millstream river, which empties into Chaleur bay. The claims are held by Dr. F. Sexton, of Halifax, N.S.; Dr. L. D. Densmore, of Bathurst, N.B.; and M. McGrath, of Wine Harbour, N.S.

A number of small open-cuts, of which the largest is about 15 feet wide, have been made on the eastern bank 20 to 30 feet above the brook. These excavations have, in most cases, been just deep enough to penetrate the surface material and expose the highly altered and iron-stained rocks below. Practically all the work done on the property lies within a length of 200 feet paralleling the brook. The deposit has since been explored, under option, by M. J. O'Brien, Limited.

The vicinity is underlain by metamorphosed sediments, green tuffs, and volcanic breccia of Ordovician age. Mineralization occurs in silicified or cherty slates showing rhombohedral jointing, which strike almost east and west, and are either vertical or dip steeply to the north. The metamorphosed sediments vary somewhat in composition across the strike, but their altered condition renders identification difficult. The volcanic tuffs and breccia which outcrop about 100 yards to the south of the workings appear to strike in the same direction as the slates.

At intervals for a length of 200 feet small bodies of sulphides, chiefly arsenopyrite, pyrite, pyrrhotite, and chalcopyrite, have been exposed by trenching. Although these outcrops lie on a line running north 20 degrees east, the mineralized zones appear to be in no way connected, but to consist of separate replacements along different slaty bands. In the largest open-cuts the zones carrying the sulphides did not appear to exceed 2 to 3 feet in width and occasional solid masses of arsenopyrite 6 to 8 inches wide could be seen. In most cases the sulphides occur as tiny veinlets or fine-grained patches disseminated through the altered and silicified country rock. Since deposits of this kind are characterized by indefinite and irregular boundaries further development will be necessary in order to determine the extent of the mineralization along those bands which have been most favourable for replacement.

Assays made of the mineralized rock from this property vary from about 80 cents to $7 a ton in gold, and from 22 to 28 per cent of arsenic. These values were no doubt obtained from selected samples containing considerable arsenopyrite and cannot be considered as representative of the deposit. A chip sample taken at random in the mineralized part of the largest open-cut gave the following values when assayed by A. Sadler of the Mines Branch, Ottawa: gold, 0·06 ounce, and silver, 1·48 ounces a ton.

2. Serpentine River

Arsenopyrite occurs on Serpentine river, Northumberland county. (Geol. Surv., Canada, Ann. Rept., vol. X, pt. M, pp. 39-40 (1899).)

3. Lake George

The antimony deposit owned by the North America Smelting Company, Limited, at Lake George, York county, contains some arsenic. A sample of the ore from this property assayed at the Mines Branch, Ottawa, gave 11·65 per cent antimony and 0·37 per cent arsenic. (Parsons, C. S.: Mines Branch, Dept. of Mines, Canada, Sum. Rept. 1922, p. 136.)

4. Charlotte County

Arsenopyrite is reported from several points in Charlotte county: (*a*) On Waewig river (Geol. Surv., Canada, Rept. of Prog. 1870-71, p. 223); (*b*) On Sand brook, flowing northwest into the southwest branch of Oromocto river (Geol. Surv., Canada, Rept. of Prog. 1870-71, p. 223); (*c*) near Moore lake (Geol. Surv., Canada, Rept. of Prog. 1876-77, p. 329).

NOVA SCOTIA

It is well known that arsenopyrite is widely distributed throughout the gold districts of Nova Scotia. In the past it was mined along with the gold-quartz veins and, being regarded as a nuisance, was allowed to go to waste. Within recent years there has been a considerable demand for arsenic and efforts have been made to recover it in Nova Scotia. Since 1901, however, the gold-mining industry of the province has declined. In that year the gold production was 30,539 ounces, or 0·35 of an ounce per ton of ore milled. By 1923 the output had fallen to 535 ounces and the average recovery to 0·23 of an ounce per ton. As the production of arsenic will depend, to some extent at least, on the revival of the gold-mining industry it is essential that a general survey be made of the conditions which have led to its decline in order that the handicaps likely to be encountered in starting or attempting to maintain a steady production of arsenic may be apparent.

The gold districts of Nova Scotia, some forty or more in number, are widely scattered throughout an area 250 miles long and 10 to 75 miles wide, comprising the seaward half of the peninsula (*See* Map 39A). This area is underlain by a vast thickness of folded quartzites and slates into which the many granitic masses, now exposed, were intruded. The sediments, which are commonly regarded as Precambrian in age, were invaded by the granite intrusions before the close of the Devonian. The Gold-bearing series is known to attain a thickness of 30,500 feet, of which the upper or Halifax slate formation comprises 14,500 feet and overlies conformably the Goldenville group consisting of at least 16,000 feet of interbanded quartzites and slates. It is from the quartz veins associated with this lower series that the great bulk of the gold has been recovered. Arsenopyrite is also widely distributed throughout the gold-bearing area, in close association with the gold, and it is thought by some operators to be present in sufficient quantities in many of the veins to warrant the establishing of an arsenic industry within the province.

One of the most remarkable features of the Nova Scotia gold veins is the extent to which structural deformation of the rocks has determined the size, shape, and location of the quartz masses. The quartzites and slates of the Gold-bearing formation have been folded into a series of east-west anticlines which are, on the average, about 3 miles apart, and which vary from 5 to 100 miles in linear extent. As might be expected, the folding has not been uniform throughout the course of many of the anticlines, with the result that a series of dome-like structures, seldom more than one-half mile in length and pitching east and west, recur at intervals of 10 to 25 miles along the anticlinal axes. Erosion has so removed the crests of the domes that the bedding as seen on the present land surface appears to be elliptical in form. Much attention was paid in the past to these domes, for it was early realized how dependent the veins were for their shape, location, and continuity on the structural peculiarities of the enclosing rocks. The arching of the strata was accompanied by differential movement between the beds, with the result that open spaces, largest at the crests and pinching on the limbs, were formed at favourable horizons within the anticlines. The filling of such openings with quartz gave rise to the so-called "saddle reefs". Where soft, shaly bands were involved in the movement a flowage of material took place from the tightly squeezed parts on the limbs towards the crests of the folds. At the same time drag-folding developed so that subsequent separation between the beds left "s"-shaped openings in which saddle reefs, known locally as "serpent" and "barrel" leads, were deposited. For the most part the veins are of the "interbedded" type, that is, they form sheet-like bodies intercalated between bedding planes in the strata, and simply represent the limbs or remnants of arched structures long since eroded. These veins vary in width from a fraction of an inch up to 24 inches, an 8-inch lead being considered a good size. They have a limited persistence along the strike and, in the majority of cases, extend to relatively shallow depths, although ore-shoots have been mined in a number of interstratified veins to a vertical depth of 400 feet or more. In the case of veins, such as the Libbey at Brookfield and the Lake lode at Caribou, which occupy fractures intersecting the strata at an angle of about 45 degrees to the anticlinal axes, mining was continued to a depth of 1,000 feet.

The vein filling throughout the whole gold-bearing area consists largely of quartz. Arsenopyrite is the dominant sulphide and is present to some extent in every gold district, although it varies greatly in amount from one district to another, from one vein to another, and in different parts of the same vein. It occurs either in seams and narrow zones near the walls of the veins, or as irregular bunches scattered haphazardly throughout the quartz matrix. The wall-rocks adjoining the veins are in many places impregnated and replaced by crystals of arsenopyrite for distances varying from a few inches in the case of quartzites to a foot or more in slates and schists. Other minerals occasionally present in minor amounts are: pyrite, pyrrhotite, galena, zinc blende, chalcopyrite, calcite, and, in some cases, scheelite and tourmaline. Arsenopyrite and scheelite were the first minerals deposited. The former appears to have both preceded and accompanied the introduction of silica and gold. With regard to the origin of the deposits all the available evidence points to a close genetic relationship between the quartz veins and the intrusions of granite occurring within the gold-bearing area.

Of the forty gold districts in Nova Scotia twenty-eight have been closed down for years; of the remaining twelve, half were entirely idle during 1923, and the others carried on operations of a desultory nature. The reasons for the depression, which commenced in 1902 and has continued to the present time, may be briefly summarized as follows:

(1) Some veins have been worked out; many others due to their narrowness, spotty gold values, or failure to continue in depth, have been abandoned.
(2) In some cases the reopening of workable veins has been rendered impracticable due to the mining methods formerly adopted.
(3) Due to the lack of authentic underground maps and assay plans of the great majority of the workings it is difficult to interest capital in reopening almost inaccessible properties, no matter how justified such action might be.
(4) Increased costs of production, especially the items of fuel and labour, have caused suspension of operations in some districts.
(5) Unsound business methods that in some cases were employed in managing and raising funds for development, together with the past history of the gold mining industry, have unduly shaken the confidence of investors.
(6) Some mines were undoubtedly closed down because of a lack of knowledge of the true nature of the ore-shoots; in other cases, the inability to treat refractory ores at a profit discouraged operators.

Other factors which must be taken into consideration, and which apply more specifically to the recovery of arsenic, may be mentioned:

(1) The deposits are small and widely scattered. This prohibits large-scale operations, requires duplication of milling machinery, and necessitates the transportation of concentrates.
(2) The recovery of arsenic will be largely as a by-product from gold mining operations. In no deposit examined was it seen to be present in sufficient quantities to warrant mining for itself even if the price were to increase considerably.
(3) Even where arsenopyrite is present in the gold-quartz veins, the percentage is usually so low that the installation of concentrating machinery would be of doubtful economic value, especially to the small operator.
(4) The successful operation of an arsenic-recovery plant would require not only a steady and assured supply of arsenical concentrates or ores at a low cost, but also a uniform price and stable market for the output.

Before an arsenic industry can be built up within the province there must be more assurance that an ample supply of raw material will be available at a reasonable cost. The sources from which such a supply must be obtained are as follows:

(1) Stocks of arsenical concentrates stored at various mills.
(2) Arsenopyrite in old dumps of tailings and rock.
(3) Arsenical concentrates now being recovered, or which can be obtained from the operation of the gold mines in the province.
(4) The discovery of new arsenopyrite-gold-quartz veins.
(5) Belts or bands of slate mineralized with arsenopyrite.
(6) The discovery, development, or operation of arsenic deposits outside of the gold districts.

These various sources of supply are discussed separately in the following paragraphs.

(1) A number of the mills throughout the province were equipped in the past with machinery to recover the arsenopyrite in the gold-quartz ores. Due to high transportation charges, lack of market, or low gold values, these concentrates were allowed, in some cases, to accumulate at the mills. Small shipments were made in the past to Wales, Germany, and Belgium. In order to recover the gold values in the concentrates, and to obviate shipping them to a smelter, some of the larger mills adopted cyanidation. Scattered throughout the province there are now available about 1,000 tons of arsenical concentrates carrying from 15 to 25 per cent arsenic and $3 to $30 in gold. About half this tonnage has been cyanided. The largest accumulations occur at the Dufferin mines in Salmon River district, Halifax county, and at Goldboro in Guysborough county.

(2) With regard to the arsenic content of the old tailings, and hence of the gold-quartz veins in general, reference need be made only to the results obtained by C. S. Parsons[1] of the Mines Branch, Ottawa, who sampled the dumps in twenty of the gold districts. He found that the gold values in the tailings varied from a few cents to $3 a ton, the average content being 60 cents. The following figures relating to the percentage of arsenic in the dumps examined by him have been compiled from his report:

Arsenic, per cent	Approximate tonnage	Per cent of total tonnage
0·25 or less	366,700	67·5
0·25—0·50	76,200	14·0
0·50—1·00	90,000	16·6
1·00 or more	10,000	1·9
	542,900	100·0

These figures, substantiated by mill tests, indicate that the tailings throughout the country will not average 0·5 per cent arsenic. Providing that concentrates containing 25 per cent of arsenic could be made, this would mean that approximately 50 tons of tailings would have to be treated,

[1] Mines Branch, Dept. of Mines, Canada, Sum. Rept. 1922, pp. 162-170.

or an equivalent tonnage of ore crushed, in order to obtain one ton of concentrates. In certain cases the ratio of tons of concentrates recovered, to tons of ore or tailings milled, may be, cf course, higher, but rarely, if at all, does it exceed 1 to 20. Though no pretence at accuracy can be made in estimating the amount of tailings distributed over the province, it is probable that the available tonnage is not greatly in excess of 1,000,000 tons. Even if the retreatment of this tonnage were found to be feasible, then, with a concentration ratio of 1 to 50, only 20,000 tons of concentrates carrying 25 per cent arsenic could be expected.

(3) The quantity of ore crushed by the mills in Nova Scotia between 1913 and 1923 averaged 7,500 tons a year and from 1918 to 1923 only 2,100 tons. Taking the average figure of 7,500 tons of rock milled yearly it will be readily seen that a total saving of 150 tons (7,500 ÷ a concentration ratio of 50) of concentrates could be made if each mill were suitably equipped for the purpose. It is, therefore, evident that neither the gold-quartz veins at their present rate of production nor the old tailings can be relied upon to furnish an adequate supply of arsenical concentrates over a period of years. A limited production may be expected, however, from those districts in which the arsenopyrite content of the veins is said to be above the average (Goldboro, Brookfield), or in which the treatment of tailings is to be carried on in conjunction with regular milling operations (Montague, Goldenville).

(4) It is reasonable to expect that new arsenopyrite-gold-quartz veins will be found from time to time within the gold-bearing areas and it may be expected that their arsenic content will, on the average, be like that of the veins already mined. New deposits of this character have been found near Wellington, Halifax county, and in Salmon River, South Uniacke, and Malaga districts.

(5) The bands or belts of contorted slate which adjoin the quartz veins in some areas are in many cases impregnated with crystals of arsenopyrite. Although the mineralization varies greatly in intensity it is in many places quite extensive. Deposits of this nature occur at the Richardson and Dolliver mines at Goldboro, at Cochrane Hill, at the Dufferin mines in Salmon River district, and at Moose River. Although the arsenopyrite present in such slate belts contains as a rule negligible gold values, yet it may be sufficiently abundant in some instances to justify mining solely for its arsenic content. A deposit of this type is being developed by the Maritime Gold Mines, Limited, at Moose River, and needless to say the progress of the venture will be watched with a good deal of interest. In some districts the rock dumps contain considerable tonnages of slate mineralized with arsenopyrite. These might form a profitable source of arsenic if they could be worked in connexion with regular mining operations, although it is doubtful whether they would pay to handle otherwise.

(6) Occurrences of arsenic are known in several localities outside of the gold districts proper. The most promising of these is the deposit near Williamsdale, Cumberland county. Unlike the typical gold veins of Nova Scotia this deposit is associated with a body of basalt or diabase and the vein-filling consists largely of an intimate mixture of auriferous arsenopyrite and pyrite. As yet the other occurrences are chiefly of mineralogical interest.

During the field season of 1923 the following localities in Nova Scotia were visited. Guysborough county: Cochrane hill, Country Harbour, Forest hill, Goldboro (Isaac Harbour), Goldenville, Stillwater, Upper Seal harbour, Wine Harbour; Halifax county: Caribou, Ecum-Secum, Harrigan Cove, lake Catcha, Meagher Grant, Montague, Moose River, Oldham, Salmon River (Dufferin, Maple Leaf), Scheelite, Tangier, Waverley, Wellington; Hants county: Central Rawdon, East Rawdon, Mount Uniacke, Renfrew, South Uniacke; Lunenburg county: Gold River, Leipsigate; Queens county: Brookfield, Malaga; Yarmouth county: Carleton, Kemptville; Cumberland county: Williamsdale.

At the time these districts were visited mining was at a standstill. At Cochrane hill, Goldenville, Montague, Moose River, Salmon River, and Tangier the workings were being kept in readiness, or preparations were being made to resume active mining. From lack of capital or other causes a few properties were temporarily dormant at Caribou, Oldham, Mount Uniacke, Brookfield, and Malaga. Prospecting was being carried on in several localities such as Malaga, Oldham, Central Rawdon, and Beaver dam. Due to the inaccessibility of the workings partial underground examinations could be undertaken only at Tangier, Montague, and Cochrane hill.

Arsenopyrite is to be found in nearly every gold district of Nova Scotia, but reference has been made in the following pages only to those properties which at the present time appear most likely to become producers of arsenical concentrates. In addition, short descriptions of the known arsenic-bearing occurrences outside of the gold districts have been included.

5. Williamsdale

Previous Description

Geol. Surv., Canada, Sum. Rept. 1909, p. 227.

This deposit, which was discovered in 1906, is located on Clifford Taylor's farm near Williamsdale, Cumberland county. It is best reached by road from Oxford Junction on the Canadian National railway. The workings lie just east of Peleg brook and about a quarter of a mile south of Williamsdale along the Farmington road, which passes within 200 yards of the shaft. In 1909 the Nova Scotia Arsenic Mining and Prospecting Company took an option on the property and mined about 100 tons of ore, of which 20 or 30 tons were shipped to Germany. The claims were later staked for gold by F. W. Nelson, of Springhill. During 1924 Ernest Chisholm, of Truro, took over the property and development has since been actively carried on.

When the property was visited in 1923 the exploratory work consisted of a shaft 35 feet deep, and a small amount of trenching along the vein. This work was done largely by the N.S. Arsenic Mining and Prospecting Company. It is reported that the shaft has been continued to a depth of 100 feet and that considerable ore has been blocked out. The shaft was sunk on a 12-inch vein of white quartz carrying arsenopyrite and pyrite. The vein appears to strike north 10 degrees east (magnetic) and to dip steeply to the west. The hanging-wall consists of fractured, slickensided, and chloritized basalt or diabase, containing in places patches of arsenopyrite up to 6 inches in width. According to Mr. Taylor, a former owner, the vein varies in its downward course from a width of a few inches up to 3 feet. It is reported that recent development has shown the vein to attain a width of 6 feet. The vein occupies a shear zone in the diabase, but owing to the overburden present and to the lack of exposures it could not be traced for more than a few feet from the shaft.

It is reported that a bore-hole put down by A. E. Gayton between Peleg brook and the Farmington road, at a point about 200 yards north of the shaft, passed through nearly 30 feet of clay and shale before striking rock from which drillings were said to assay $27 in gold and 38 per cent in arsenic.

The vein-filling consists of arsenopyrite and pyrite in a quartz gangue. The sulphides were deposited and fractured prior to the introduction of the quartz which occurs as veinlets cutting them. The gold values are almost entirely in the arsenopyrite. The following assays have been made of samples from this property:

No.	Ounces Troy to the ton of 2,000 lbs.		Arsenic	Remarks
	Silver	Gold		
			%	
1	1·92	1·60	Not det.	Chip sample from ore dump
2	0·19	0·17	9·13	Selected sample from ore dump, mostly pyrite
3	2·43	2·28	35·84	Selected sample from ore dump, mostly arsenopyrite
4	Not det.	0·62	36·8	Ore

Samples 1, 2, and 3 were assayed by the Division of Chemistry, Mines Branch, Ottawa.
4. Nova Scotia Dept. of Public Works and Mines, Ann. Rept., 1923, p. 110.

6. Cream Pot Gold Mine

Previous Description

Faribault, E. R.: Geol. Surv., Canada, Sum. Rept. 1919, pt. F, pp. 18-20; Geol. Surv., Canada, Map No. 1815.

The Cream Pot mine is situated in Cranberry Head gold district, 6 miles north of Yarmouth, and on a bluff overlooking the sea. It is reported that this property, which has lain idle since 1903, will be reopened for examination. The workings were inaccessible when the property was visited in 1923 and the following account has been derived from the report by E. R. Faribault.

The vein has been opened up on the surface for 1,235 feet and worked for a length of 358 feet and to a depth of 220 feet, with apparently no change in its character, strike, or dip. It consists of a series of quartz lenses, mostly 4 to 8 inches wide and 1 to 3 feet long, which occur in the olive-green slates near the base of the Halifax formation. These lenses intersect the stratification of the slates at a small angle and dip steeply to the southeast. The vein filling contains free gold, auriferous arsenopyrite, and a little galena. A band of talcose rock heavily impregnated with crystals of arsenopyrite adjoins the foot-wall of the vein. The mine has produced $30,000 in gold; the ore contained from 10 pennyweights to 3 ounces of gold a ton and yielded a large proportion of concentrates which are said to have carried as much as 6 ounces of gold a ton.

7. King Fissure Mine

Previous Description

Geol. Surv., Canada, Mem. 20 E, 1912.
Plan of Brookfield district, Geol. Surv., Canada, No. 1012.

This mine lies in Brookfield gold district, in the northeastern corner of Queens county. The workings are situated about one-half mile south of Brookfield Mines Station on the Canadian National railway. In 1922 a ten-stamp mill and a bromo-cyanide plant were erected on the property under the direction of H. S. Badger of Bridgewater. In the following year, after a small tonnage of ore had been treated, operations were discontinued pending readjustment of the financial control of the property.

The principal vein on the property, known as the King lead, has been opened up by a 150-foot shaft and about 500 feet of drifting. These workings were full of water when the property was visited in 1923. The King lead occupies an east-west fracture on the east limb of the anticlinal fold in the Goldenville quartzites and slates which underlie the district. Its course is almost at right angles to that of the strata which strike north and south and dip gently to the east. On the surface, the vein varies from a few inches to 3 feet in width and consists largely of quartz. According to Mr. Badger a belt 5 feet wide and carrying about 15 per cent of arsenopyrite can be mined on the 150-foot level. Samples of the tailings taken by C. S. Parsons[1] averaged 0·5 per cent in arsenic.

8. Malaga

Previous Description

Geol. Surv., Canada, Mem. 20 E, pp. 177-180 (1912).
Plan of Malaga district, Geol. Surv., Canada, No. 995.

Gold was discovered in Malaga district, Queens county, in 1886. Since then a number of gold-quartz veins have been exploited. In some cases the deposits have been worked out, in others operations have been suspended owing to high mining costs, financial difficulties, etc. No active mining was being carried on in this district during 1923, although some prospecting was being done, particularly by S. A. Hiseler, of Halifax. According to an estimate made by C. S..Parsons[2] there are in the district about 35,000 tons of tailings carrying 0·025 ounce gold a ton and 0·42 per cent arsenic.

[1] Parsons, C. S.: Mines Branch, Dept. of Mines, Canada, Sum. Rept. 1922, p. 169.
[2] Parsons, C. S.: Mines Branch, Dept. of Mines, Canada, Sum. Rept. 1922, p. 169.

9. Bartiaux Brook

A prospect in which arsenopyrite occurs is located, according to Mr. E. R. Faribault, on the east side of Bartiaux brook about one mile south of the West Inglisville road, Annapolis county. The deposit lies near the contact between granite and altered sediments. The arsenopyrite is associated with irregular stringers of quartz carrying large flakes of muscovite. The sulphide also replaces the wall-rocks to some extent. Practically no work has been done on the property.

10. Mount Uniacke

Previous Description

Geol. Surv., Canada, Mem. 20 E, pp. 197-204 (1912).
Plan of Mount Uniacke district, Geol. Surv., Canada, No. 709.

Gold-quartz veins were first discovered in Mount Uniacke district, Hants county, in 1865. In succeeding years a number of leads or mineralized slate belts were opened up and the production of gold continued to increase until 1896, when it reached 3,732 ounces. Since that time many of the deposits have been worked out, others abandoned, and some temporarily closed down owing to lack of power, increased costs, or financial difficulties. During 1923 no active mining was carried on in this district, although plans were under way to re-open the Montreal and West Lake mines. The mill dumps[1] contain about 17,000 tons of tailings, carrying 0·02 ounce gold a ton and 0·29 per cent arsenic.

11. South Uniacke

Previous Description

Geol. Surv., Canada, Mem. 20 E, pp. 237-9 (1912).
Plan of South Uniacke district, Geol. Surv., Canada, No. 768.

Gold-quartz veins have been known to occur in this section of Hants county for a number of years. Recently several veins containing arsenopyrite have been located or leased by the Dunbrack brothers. These properties lie about one-half mile southwest of South Uniacke station, on the Dominion Atlantic railway. The claims can be reached by a trail which runs east from the Halifax road at a point about a quarter of a mile from the station.

About 50 feet of trenching has been done along a quartz vein 8 to 16 inches in width, which carries irregularly distributed bunches of arsenopyrite. Another pit has been sunk on a large body of white quartz which, however, contains very little of the sulphide.

The veins on the property are of the "interbedded" type and occur between walls of ferruginous slate forming a part of the north limb of the anticlinal fold in the Goldenville formation which underlies the area. The sporadic occurrence of arsenopyrite in the quartz filling and in the adjoining wall-rocks is here similar to, and characteristic of, the vast majority of gold veins in Nova Scotia.

[1] Parsons, C. S.: Mines Branch, Dept. of Mines, Canada, Sum. Rept. 1922, p. 168.

Just west of the Halifax road several "iron leads" 2 to 4 inches in width, consisting almost wholly of arsenopyrite, have been found, but they are too small to mine profitably.

12. Lower Sackville

Arsenopyrite is reported to occur on F. W. Dixon's property at the junction of the Windsor and Cobequid roads, Lower Sackville, Halifax county.

13. Montague

Previous Description

Geol. Surv., Canada, Mem. 20 E, pp. 182-186 (1912).
Plan of Montague district, Geol. Surv., Canada, No. 740.

This district lies about 5 miles northeast of Dartmouth, Halifax county. The Clark Gold Mines Corporation, capitalized at $2,000,000, was organized in 1923 to continue mining and development work on the Skerry and other leads in the district and to undertake the recovery of the gold and arsenic values in the old tailings. Electric power has been brought in from Dartmouth and should aid greatly in making these operations a success. If the venture turn out profitably, the company plans to extend its activities to Mount Uniacke and Waverley districts.

A number of shafts have been sunk at intervals along the Skerry lead, to which the company is devoting its attention at the present time. The main shaft now in use is 300 feet deep and lies a short distance to the west of a new four-compartment shaft which is partly completed, and which the management expects to continue down to a depth of 500 feet. Over 1,000 feet of drifting, and considerable stoping, have been done on the vein both east and west of the main shaft.

The veins which the company proposes to mine are of the "inter-bedded" type and occur on the south limb of the anticlinal fold in the Goldenville quartzites and slates, which passes through the district. In addition to gold, these leads carry a small amount of arsenopyrite, which will be recovered by concentration. Some idea of the values to be expected in the tailings and concentrates may be obtained from the following assays made by A. Sadler of the Mines Branch.

No.	Ounces Troy to the ton of 2,000 lbs.		Arsenic
	Silver	Gold	%
1	0·05	0·01	0·32
2	0·12	0·06	0·28
3	0·36	1·54	24·50

1. Tailings from the Salisbury dump.
2. " Boyd's dump.
3. Concentrates from Boyd's mill.

If the tailings contain 0·3 per cent arsenic, about 80 tons of the material must be treated in order to obtain a ton of concentrates running 24·0 per cent in arsenic.

14. Waverley

Previous Description

Geol. Surv., Canada, Mem. 20 E, pp. 250-257 (1912).
Plan of Waverley district, Geol. Surv., Canada, No. 721.

One of the first gold districts discovered in Nova Scotia was that near Waverley, Halifax county. Mining was carried on most actively during the sixties, the early seventies, the nineties, and the first few years of the present century. It is thought by some that with the introduction of cheap electric power some of the former workings can be re-opened and the old tailings treated at a profit. The mill dumps[1] are said to contain about 60,000 tons of tailings which carry 0·02 ounce gold a ton and 0·50 per cent arsenic.

15. Wellington

During the summer of 1923 Messrs. Cope and McDonald, of Enfield, found some arsenopyrite in a quartz vein lying about 2 miles east of Wellington station on the main line of the Canadian National railway and one-half mile south of the John Kelly farm. This vein, together with others in the vicinity, had been mapped (Geol. Surv., Canada, Waverley sheet, No. 1025) by E. R. Faribault years previously, but nothing had been done in the way of development work. In 1924 the Wellington Arsenic Company was organized to explore and develop the deposit.

In 1923, when the property was visited, a vein of milky quartz 15 to 18 inches wide had been uncovered, by trenching, for 15 feet. The vein strikes north 55 degrees west (magnetic) and cuts across slaty schists of the Halifax formation, which here strike east and west. Irregular lenses of arsenopyrite 6 to 8 inches wide occur at intervals in the quartz, or along its contact with the slates. A little pyrite is also present. It is reported that nine veins have since been uncovered in the vicinity and that a shaft sunk to a depth of 50 feet on one of the veins has disclosed enough arsenopyrite to warrant the erection of a concentrator.

16. Oldham

Previous Description

Geol. Surv., Canada, Mem. 20 E, pp. 204-210 (1912).
Plan of Oldham district, Geol. Surv., Canada, No. 642.

Gold-quartz veins were first discovered in Oldham district, Halifax county, in 1861, and since then mining has been carried on almost continuously. The gold production from this area has been remarkably uniform, reaching a maximum of about 3,200 ounces in 1893 and showing a marked decline only within the last few years. When the district was visited in 1923, operations, except for a little prospecting, were virtually at a standstill. This condition of affairs is ascribed to the depletion of ore reserves, high power, and mining costs, and lack of capital. The tailings in this district, estimated[2] at 17,000 tons, contain roughly 0·02 ounce gold a ton and from 0·02 to 0·57 per cent arsenic.

[1] Parsons, C. S.: Mines Branch, Dept. of Mines, Canada, Sum. Rept. 1922, p. 168.
[2] Parsons, C. S.: Mines Branch, Dept. of Mines, Canada, Sum. Rept. 1922, p. 158.

17. Meagher Grant

(*See* Figure 21)

The occurrence of arsenic in the vicinity of Meagher Grant, Halifax county, has been known for a number of years, but not until the spring of 1923 was any serious attention paid to the deposit. The property is located about 2 miles, by road, southeast of Meagher station on the Canadian National railway or a mile directly east of the tracks. The workings lie on a low hill 200 yards south of Anderson Dickie's house. Dr. F. P. Temple, of Halifax, and his associates, control the property.

The vein is exposed at intervals for about 90 feet along its strike by two shallow trenches and a pit sunk between them. The deposit lies in a shear zone between beds of slaty quartzite of the Goldenville formation, exposed on the westerly continuation of the Moose River anticline. At this point the beds strike north 85 degrees west (magnetic) and appear to be almost vertical. A band of slate 4 to 5 feet in width occupies the shear zone and has been crumpled and rendered schistose by the move-

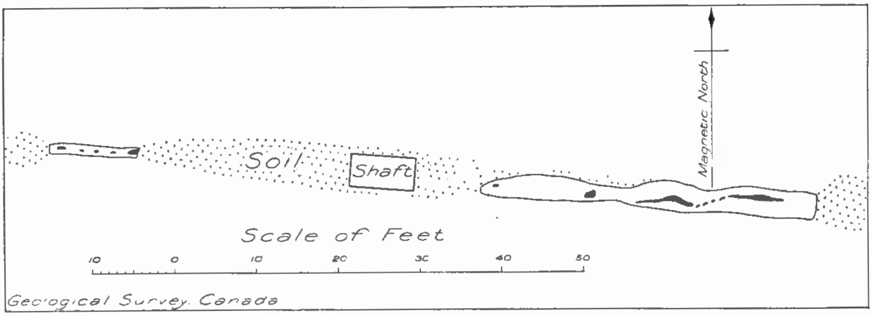


Figure 21. Meagher Grant property, Halifax county, Nova Scotia. Masses of arsenopyrite shown by solid black.

ment between the more resistant beds of quartzite. The openings formed in this way have been filled and the schist adjoining them replaced by a series of narrow lenses of arsenopyrite. The visible masses of sulphide vary in width from 1 to 8 inches, and occasionally extend as much as 8 feet along the strike before pinching out. The slaty schist surrounding these lenses has been impregnated with striated crystals of arsenopyrite for distances varying from a few inches to 2 feet on either side of the sulphide bodies. Quartz is only sparingly present along the shear zone.

Grab samples of arsenopyrite from this deposit have yielded the following results on assay and analysis:

No.	Ounces Troy per ton of 2,000 lbs.		Arsenic
	Silver	Gold	%
1	Not det.	trace	33·11
2	0·07	0·01	Not det.
3	....	0·06	28·8
4	0·02	Nil	33·08

1 and 2. By A. Sadler, Mines Branch, Dept. of Mines, Canada.
3. By G. F. Murphy, Nova Scotia Technical College, Halifax.
4. By L. R. Sidell, New York Testing Laboratories, New York.

18. Caribou

Previous Description

Geol. Surv., Canada, Mem. 20 E, pp. 124-129 (1912).
Plan of Caribou district, Geol. Surv., Canada, No. 643.

Gold mining began in Caribou district, Halifax county, in 1867. Operations were carried on almost continuously and a uniform production of gold was maintained until recent years when the largest mills were closed down. When this district was visited in 1923 the properties were still lying idle, presumably on account of high mining or power costs, depletion of the ore-bodies, or lack of capital. Some prospecting was being done at that time by H. Hall. The principal accumulations of tailings in this area are at the Lake and Caffrey mines. The dumps[1] at the former contain about 20,000 tons, carring 0·02 ounce gold a ton and 0·20 per cent arsenic, and those at the latter about 6,000 tons, carrying 0·02 ounce gold a ton and 0·50 per cent arsenic.

19. Moose River Mine

(Abridged from manuscript report by F. A. Kerr)

Previous Descriptions

Woodman, J. E.: Proc. and Trans. of the N.S. Inst. of Science, vol. XI.
Geol. Surv., Canada, Mem. 20 E, pp. 189-196 (1912).
Kerr, F. A.: Geol. Surv., Canada, unpublished report, Dec. 24, 1924.
Plan of Moose River district, Geol. Surv., Canada, No. 646.

Moose River mine is in block 1, lot 65, at Moose River, Halifax county. It lies immediately west of the well-known Touquoy property which was successfully operated for a number of years. The Maritime Gold Mines, Limited, under the management of R. E. G. Burroughs, began exploratory work during the winter of 1923-24 in the area just west of Moose river. By November, 1924, a shaft had been sunk through the glacial drift and into the bedrock to a depth of 88 feet below the surface. From this level, crosscuts were run 15 feet north and 195 feet south. During the winter of 1924[2] the south crosscut was continued an additional 250 feet, or about 450 feet in all from the shaft before development was suspended at this point and transferred to another section of the property.

The general geology of the area is fully described in Memoir 20 and illustrated by Map 624, Geological Survey, Canada. The main structural features are two major anticlines (Beaver Dam to the south, Moose River to the north), with a general trend east and west, but diverging to the east at an angle of 5 degrees and converging at a slightly smaller angle to the west. At Moose River these are 450 to 550 feet apart. The southern

[1] Parsons, C. S.: Mines Branch, Dept. of Mines, Canada, Sum. Rept. 1922, p. 158.
[2] Dept. of Public Works and Mines, N.S., Ann. Rept., 1925, pp. 159-160.

anticline (or anticlinorium) plunges to the east at an angle of 10 to 15 degrees and the northern plunges west at about the same angle. They are cut by a series of north-south faults of no very great magnitude. The strata involved consist of interbedded slates and quartzites belonging to the lower quartzite group of the Gold-bearing or Goldenville formation. The converging of the anticlines, with opposite plunge, and the presence of a band of slate in a quartzite series, have given rise to unusual structural features in the vicinity of the mine workings. The strata involved, being less competent than the overlying and probably the underlying beds, have suffered severe crumpling and in them have developed minor overturned folds which spread out in a fan-like arrangement to the east and upward and plunge irregularly at different angles.

The shaft sunk by the Maritime Gold Mines, Limited, passes through 24 feet of glacial drift and into the shale forming the north limb of the Beaver Dam anticline. At a depth of 88 feet a crosscut was run in a southerly direction for 450 feet toward the assumed axis of the fold. The rocks cut by the tunnel are mainly slate that varies from soft, black, highly cleaved, or schistose material to massive quartzite. The structure is difficult to interpret owing to the destruction of bedding planes, the intense crumpling of the rocks, and the injection of large quantities of quartz.

The main mineralization is by arsenopyrite and is very irregular in extent, richness, and character. This mineral occurs as bands of small prismatic crystals along bedding planes in the softer slates; as bands and small crystal impregnations in the harder quartzitic slates; and, in fewer cases, as large, lenticular crystals in still more quartzitic beds. In addition to the arsenopyrite mineralization there are numerous quartz and calcite veins; lenticular masses of scheelite, quartz, and ferruginous calcite; gold-bearing quartz-pyrite and quartz-pyrite-arsenopyrite veins; and pyritic impregnations in the slates. The mineralization is confined almost entirely to zones of crumpling and folding in the slates. The beds of quartzite are quite lean or barren and appear to have been much less susceptible to replacement by arsenopyrite or pyrite than the slaty members. The sparsely mineralized areas are usually lacking in quartz veins. The extent and character of the mineralization have been influenced by the amount of fracturing and disturbance; the susceptibility to replacement and permeability of the strata; and the distribution and abundance of quartz veins. It is thought that, during the later stages of folding, after fracturing had proceeded to such an extent as to permit circulation, ascending hydrothermal solutions began depositing minerals. This deposition continued for some time even after the completion of folding. During this period changing solutions deposited different groups of minerals. The introduction of quartz, calcite, scheelite, and pyrite is thought to have preceded the main arsenopyrite mineralization which took place during and after the final stages of folding. The earlier mineralization was almost entirely by fracture filling and the later mainly deposition by replacement.

Twenty-three channel samples were taken from the mineralized zones exposed in the crosscut driven south from the bottom of the shaft. The following analyses, made by A. Sadler of the Department of Mines, give some idea of the arsenic content in these zones.

Zone No.	Length of section		Arsenic	Remarks
	Feet	Inches	Per cent	
1........	3	6	2·56	West side
2........	7	5	0·26	"
3........	5	11	1·23	"
4........	5	7	0·19	"
5........	5	0	0·67	"
6........	5	8	0·24	"
7........	1	5	1·20	"
8........	3	8	0·12	East side
....	25	3	....	No samples taken, appears barren
9........	6	3	0·69	East side
10........	4	8½	2·63	East side, 12 inches of quartz and scheelite not sampled
11........	10	6	4·32	East side, 4 feet 2 inches of dull quartz omitted
12........	11	8	1·74	East side
13........	18	6	3·27	East side, 1 foot 11 inches of quartz omitted
14........	3	3	1·40	East side, "whin" belt
15........	4	0	2·87	East side
16........	6	8	3·37	East side
17........	4	3½	1·40	West side, "whin"
18........	9	6	3·03	West side, Fashion Plate
19........	3	8	2·95	West side
20........	7	9	2·90	West side, 3 feet 6 inches of quartz not sampled
21........	5	4	2·70	West side, Brown Skirt
22........	5	5	1·40	West side, "whin"
23........	5	7½	2·05	West side, 11 inches of quartz not included

All the above samples were assayed for gold. No. 21 gave 0·05 ounce to the ton. All the others gave only a trace. Samples 14, 17, and 22 were grouped for arsenic analysis.

For the most part sampling is unsatisfactory in a deposit of this kind. The only reliable method of ascertaining the true arsenic content is by means of mill tests on large quantities. The analyses of samples 22 and 23 are regarded as the best criteria of the values to be expected. In view of the fact that development was not far advanced when the property was examined any estimate of the quantity of ore would be hazardous. The width of the mineralized zone, as exposed in the tunnel, appears to be about 75 feet, but this will probably vary with depth and along the strike of the deposit. From the trend of the anticlinal structure and because the rock dumps near earlier workings show the presence of well-mineralized slate, it seems possible that the mineralized zone may extend several hundred feet east from the tunnel. The extension of the deposit to the west of the tunnel can only be conjectured as the surface is covered with drift and no exploratory work has been done in that direction. Development thus far has indicated that a considerable tonnage of mineralized slate carrying as much as 3 per cent of arsenic could be mined. Quarrying would be hardly practicable in view of the thick covering of drift overlying the deposit. Waterpower is being used to operate the mill and for underground development. The arsenopyrite is recovered by crushing the mineralized slate with stamps, followed by concentration on Wilfley tables.

20. Maple Leaf Mine

This property lies $1\frac{1}{2}$ miles by road and trail northeast of the Dufferin mines in Salmon River district, Halifax county. The claims, originally located by Geo. and S. McClennan, are being developed by the Maple Leaf Gold Mining Company, Limited, of Amherst.

A shaft and several pits have been sunk on a gold-bearing quartz vein reported to be 12 inches in width. The company has erected a 5-stamp mill with the intention of amalgamating the gold and later concentrating the small percentage of arsenopyrite in the ore.

The vein strikes north 75 degrees west (magnetic) and dips 65 degrees to the south. The walls are of impure quartzite and greenish slate, the latter rock, which forms the foot-wall, is impregnated in places with crystals of arsenopyrite. The sulphide also occurs in isolated patches in the vein-filling. The covering of glacial drift, in many places 9 or 10 feet thick, renders prospecting difficult and expensive.

21. Cochrane Hill Gold Mine

Previous Description

Geol. Surv., Canada, Mem. 20, pp. 133-4 (1912).
Plan of Cochrane Hill district, Geol. Surv., Canada, No. 843.

This property is in Cochrane Hill gold mining district, Guysborough county, about 10 miles north of Sherbrooke. As soon as sufficient funds are available the Cochrane Hill Gold Mining Company, which controls the property, proposes to undertake extensive development work under the direction of Mr. Hugh McDonald.

Up to the present time development work has been confined to the Mitchell and South belts, which have been opened up by a shaft 180 feet deep; by over 500 feet of crosscutting and drifting on the 165-foot and 175-foot levels; and by stoping which in places reaches nearly to the surface. Smaller shafts and open-cuts have been put down at intervals along the Mitchell belt which has been worked intermittently since 1868, but with very little financial success.

The district is underlain by sharply folded quartzites and slates of the Goldenville formation. In places these rocks, particularly the slates, have been penetrated along certain zones by numerous quartz veinlets in places carrying free gold and sulphides. Two such zones, each about 8 feet wide and separated by 22 feet of slate, occur on this property and have been referred to as the Mitchell and South belts. In addition to the intimate mixture of quartz and slate which comprise the belts there are also streaks, lenses, and disseminated particles of sulphides scattered throughout these zones. Arsenopyrite appears to be most plentiful, pyrrhotite and pyrite not quite as abundant, and only small amounts of galena, zinc blende, and chalcopyrite are to be found. The presence of feldspar in some of the quartz veins suggests their affinity to pegmatitic facies, and the development of staurolite, andalusite, garnet, and biotite in the adjoining slates is evidence of the elevated temperature prevailing at the time the veins were formed. The mineral association points strongly to the masses of granite outcropping in the vicinity as being the cause of the metamorphism and the source of the mineralization.

Since milling has not been carried on for a number of years no figures are available to show the proportion of concentrates to be expected in mining the two belts. Although arsenopyrite is the most abundant sulphide, sufficient pyrite and pyrrhotite are also present to appreciably lower the arsenic content of the concentrates. A sample of old tailings collected by C. S. Parsons of the Mines Branch carried 0·72 per cent of arsenic.

22. Stillwater Prospect

For a number of years arsenopyrite has been known to occur in a quartz vein, locally called a mundic lead, which lies nearly 2 miles west of Stillwater, Guysborough county. A trail about 1½ miles long leads from Gordon McIntosh's house on the west side of St. Mary river to the outcrop which lies on a swampy ridge.

A pit 15 feet long and several feet wide has been excavated in impure quartzite adjoining a vein of white quartz 2 feet wide. The quartzite enclosing the vein, which belongs to the "interbedded" type, is part of the Goldenville formation which here lies on edge and strikes east and west. Arsenopyrite occurs sparingly as patches in the quartz, as a replacement of the schistcse wall-rock, and in lenses of schist caught up in the vein. The lead can be traced for about 30 feet on the surface, but does not appear to contain much sulphide except at the pit. The gold values contained in the depcsit are reported to be quite low.

23. Goldenville

Previous Description

Geol. Surv., Canada, Mem. 20 E, pp. 224-236 (1912).
Plan of Goldenville district, Geol. Surv., Canada, No. 645.

Goldenville gold district, which is the most important in the province, lies 2 miles west of Sherbrooke, Guysborough county. Since gold was first discovered in 1861 mining has been carried on almost continuously. For some years the Sherbrooke Mines and Power Company, now known as the Consolidated Mines and Power Company, has been the chief producer in the district.

In this area the Goldenville formation is exposed as an anticline which strikes north 75 degrees west (magnetic) and pitches to the west. All the veins which have been worked are of the interbedded type and usually occur in slate belts between walls of quartzite. In most cases the veins are so narrow that the whole slate belts must be mined.

In 1923 the mill belonging to the Sherbrooke Mines and Power Company was destroyed by fire and in rebuilding it equipment was installed to save the arsencpyrite in the ores. Hitherto this mineral had been allowed to escape with the tailings. During that year 1,999 tons of $3 ore was milled, with an average recovery of $2.35 in gold a ton. Table[1] tests carried out at the Mines Branch, Ottawa, on the tailings from the battery plates, showed that 1 ton of concentrates containing 0·67 ounce in gold and 13·25 per cent arsenic may be expected from 50 tons of ore. According to C. S. Parsons[2] the principal dumps in the district contain about 200,000 tons cf tailings, carrying 0·02 ounce gold a ton and 0·19 per cent arsenic.

[1] Parsons, C. S., and Carnochan, R. K.: Mines Branch, Dept. of Mines, Canada, Sum. Rept. 1922, p. 172.
[2] Parsons, C. S.: Mines Branch, Dept. of Mines, Canada, Sum. Rept. 1922, p. 168.

24. Upper Seal Harbour (Goldboro)

Previous Description

Geol. Surv., Canada, Mem. 20 E, pp. 245-250 (1912).
Plan of Upper Seal Harbour district, Geol. Surv., Canada, No. 656.

Upper Seal Harbour district, situated at the head of Isaac Harbour, Guysborough county, was formerly one of the principal gold-producing areas in the province. Here the Goldenville quartzites and slates are exposed in a closely folded anticline which strikes north 60 degrees west (magnetic) and pitches to the east. The chief mines located on this structure were known as the Richardson and the Dolliver.

The Richardson property was operated almost continuously from the time of its discovery in 1892 until 1910 when, following subsidence and increased flow of water into the workings, the mine was abandoned. During this period the production amounted to $1,022,965 in gold from 395,731 tons of ore milled, or an average recovery of only $2.58 a ton. The ore-body, consisting of a belt of slate and quartz 20 feet thick at the apex and 6 feet thick on the limbs of the anticline, was mined to a depth of 700 feet and for 1,000 feet along the strike. Considerable arsenopyrite and some pyrite were found as masses in the quartz or as crystals disseminated through the slate. From 1907 to 1910 arsenical concentrates said to carry 40 per cent arsenic and $8 to $9 a ton in gold (after cyanidation) were shipped to Europe for treatment. During this time some of the former tailings were re-treated and their arsenic content recovered. In 1909, 1,171·5 tons of concentrates were obtained from 41,425 tons of ore milled, that is, 1 ton of concentrates from 35·6 tons of ore. Samples of the tailings taken by C. S. Parsons of the Mines Branch showed the No. 1 dump, of approximately 10,000 tons, to contain 0·137 ounce of gold a ton and 2·12 per cent arsenic. The No. 2 dump, of about 62,000 tons, carried 0·011 ounce of gold a ton and only 0·14 per cent arsenic. About 200 tons of cyanided concentrates are piled at the mill. Several small shipments of this material have been made within recent years.

The Dolliver property lies about a mile west along the anticlinal axis of the Richardson mine. In 1901 a vertical shaft was sunk near the axis of the fold and when the mine was abandoned in 1905 a depth of 488 feet had been reached. In this distance several large saddle reefs were intersected, but as the gold values recovered only amounted to about 0·026 ounce a ton of rock milled, operations were discontinued. Considerable arsenopyrite occurs in the black slate adjoining the veins, but the material did not pay to mill. About 50 tons of concentrates are stored at the mine.

Although the area between the Richardson and Dolliver mines is heavily covered with drift it is possible that further prospecting may result in the discovery of new leads or the continuation of the Richardson belt. This district probably contains more arsenic than any of the other gold-bearing areas.

25. Gabarus Bay

Arsenopyrite occurs at Eagle Head, Gabarus bay, Cape Breton county. (H. Piers, private communication.)

26. Wagamatkook

Previous Description

Geol. Surv., Canada, Mem. 20 E, pp. 279-281 (1912).

Arsenopyrite has been known to occur in the Wagamatkook gold district, for a number of years. The deposit, which lies in the valley of Second Gold brook about one-quarter of a mile south of Middle river, was discovered by W. C. Scranton and sold in 1906 to the Great Bras d'Or Gold Mining Company. Since 1911 the property has lain idle.

The Lizard vein, on which most of the work was done, has been opened by three adits and considerable crosscutting. An inclined shaft was sunk 140 feet below the brook level. Over 5,000 tons of ore were mined from stopes above the lowest adit before the company ceased operations.

The area is underlain by Precambrian slates and schists intruded by hornblende syenite and quartz porphyry. The Lizard vein lies between walls of schist in close proximity to the syenite and consists of a few inches to 6 feet of banded white quartz containing patches of sulphides scattered through it. These are chiefly arsenopyrite, chalcopyrite, and galena.

A sample of concentrates[1] from this property gave on analysis:

Arsenic	26·26 per cent
Iron	35·36 "
Sulphur	27·46 "
Silica, alumina, etc	8·68 "
Nickel	trace
Gold	2·14 ozs. per ton
Silver	2·46 "

27. Cheticamp

Previous Description

Geol. Surv., Canada, Mem. 20 E, pp. 276-278 (1912).

Several deposits which carry arsenopyrite are known to occur on L'Abime brook, a tributary of Cheticamp river in the northern part of Inverness county.

The ores are found in a belt of Precambrian chlorite, hornblende, and mica schists, lying between masses of granite. They consist of an intimate mixture of galena, zinc blende, chalcopyrite, arsenopyrite, pyrrhotite, and niccolite occurring in lenses or irregularly-shaped bodies in the schists. Attempts were made a number of years ago to mine the deposits for lead, gold, and silver, but without success.

GENERAL CONCLUSIONS

Arsenical minerals have been found in at least one hundred and twenty-five localities in Canada, occurrences being reported in all provinces with the exception of Alberta and Prince Edward Island. The principal sources of arsenic at the present time are:

(1) The silver-cobalt ores of Cobalt, South Lorrain, and Gowganda, Ontario.
(2) The arsenopyrite-gold ore of the Hedley Gold Mining Company, Hedley, B.C.
(3) Concentrates from the gold-quartz veins and slate belts in Nova Scotia.

[1] Rept. Dept. of Mines, Nova Scotia, 1908, p. 109.

There appear, at the present time, to be no deposits in Canada sufficiently rich to warrant development and operation solely for their arsenic content. This is especially true in view of the uncertain trend of the arsenic market and the consequent financial hazard involved in opening up deposits which contain arsenic as the principal element of value.

In most of the arsenical deposits in Canada, the arsenic content is of less importance than that of other elements such as gold, silver, lead, zinc, copper, or cobalt. The successful operation of these deposits will largely depend, therefore, on the value of the principal metal or metals which they contain and only incidentally on the price of arsenic. Hence it seems likely that arsenic will continue to be obtained in Canada as a by-product of other metal mining operations until such time as its price becomes stabilized at a figure which will make its extraction profitable regardless of the other elements present.

A brief résumé of the distribution and importance of the various occurrences of arsenic in Canada is given below:

YUKON

Arsenic occurs in at least ten localities in the Yukon. The deposits most deserving of mention are those located in the vicinity of Dublin gulch and in Windy Arm district.

BRITISH COLUMBIA

Arsenic has been reported in thirty-four localities in British Columbia. The most important of these is Hedley district where the Hedley Gold Mining Company has mined arsenical gold ore for nearly twenty years. Other occurrences in this district, though numerous, are widely scattered and do not appear to be extensive enough to warrant further development at the present time.

In Hazelton district arsenic occurs in veins containing gold; silver, lead, and zinc; cobalt and molybdenum; or copper. On the whole the deposits are too small and too widely scattered to be operated individually, unless arrangements can be made to treat the ores in a centrally-located plant within the district. The most promising deposits are on the American Boy and Red Rose properties.

Arsenic is present in some abundance in the lead-zinc-copper deposits on Hudson Bay mountain. The best showings occur on the Mamie, Coronado, and Victory properties. Although development has shown the deposits to be rather erratic and too small to warrant the erection of individual treatment plants, still they could no doubt furnish a considerable tonnage of ore if a custom plant were erected in the district.

The Wisconsin group of claims on Hughes creek contains one of the most promising showings of arsenopyrite-gold ore examined. Further development of this property would appear to be justified in spite of its remote location.

The J. and L. group of claims on Carnes creek has attractive showings of complex lead-zinc-copper ore containing arsenic, gold, and silver. Owing to the lack of transportation facilities into the district it is doubtful whether ore can be shipped out at a profit. The future of the property lies in the devlopment of a sufficient tonnage of ore to warrant the erection of a treatment plant in the vicinity.

The gold-quartz veins on Cadwallader creek in Bridge River district contain a small percentage of arsenopyrite which might be recovered as a by-product. The Native Son property, situated in the same district and under development in 1924, contains erratic bodies of almost solid arsenopyrite.

The principal deposit in the Hope-Coquihalla area occurs at the Aufeas mine. The veins as exposed, though containining plenty of arsenopyrite, are too narrow to furnish a considerable tonnage of ore.

The lead-zinc-arsenic deposits on Crater creek in Atlin district, as described by Cairnes, appear to be worthy of further investigation.

Several gold-arsenopyrite-quartz veins of considerable promise have been partly developed in the vicinity of Tatlayoko lake.

ONTARIO

Arsenic has been reported to occur in thirty-eight localities in Ontario. The bulk of these occurrences appear, at the present time, to be chiefly of mineralogical interest.

Cobalt district, including South Lorrain and Gowganda, contains the most important deposits of arsenical ore in Canada. The ore is not only rich in arsenic, but also in silver and cobalt.

Next in importance are the gold-quartz veins of Marmora township, Hastings county. The principal deposit and the one formerly worked most extensively, occurs on the Deloro and neighbouring properties. Although arsenic is present at a number of places in Hastings county, the deposits appear to be too small and too erratic to be developed separately. Should the price of arsenic become sufficiently attractive to warrant the resumption of mining operations throughout the district there is no doubt that a considerable tonnage of ore could be furnished. As an arsenic-recovery plant is already in operation in the district it seems logical that this area will be one of the first to receive attention if the demand for arsenic be substantially increased.

Of the other deposits in Ontario the one most deserving of mention is at Howry creek where a small tonnage of arsenopyrite-gold-iridium ore has been developed.

NOVA SCOTIA

Arsenic has been reported from more than forty localities in Nova Scotia. Arsenopyrite is almost universally present in the many gold-quartz veins scattered throughout the eastern half of the province. As these deposits have been largely worked out they cannot be regarded as an important source of arsenic.

The most promising source of arsenic in Nova Scotia is to be found in the mineralized slate belts such as occur at the Richardson and Cochrane Hill mines in Guysborough county and at the Dufferin and Moose River mines in Halifax county.

A small tonnage of arsenical concentrates can probably be recovered by treating tailings in conjunction with regular mining operations.

The occurrences of arsenic in Saskatchewan, Manitoba, North West Territories, Quebec, and New Brunswick are simply of mineralogical interest at the present time.

CHAPTER V

FOREIGN DEPOSITS

Arsenic enjoys a widespread distribution. Its occurrence is not confined to any one country or section of the globe. In some localities, however, natural concentration of arsenic has taken place, and to such deposits the world must look for its supply of raw material. The important resources of arsenical ore are found in: United States, United Kingdom, Canada, Japan, Germany, Mexico, France, Queensland, Western Australia, and Southern Rhodesia. In none of these, with the exception of the United States, do the domestic requirements greatly exceed the amount of arsenic produced and hence exportable surpluses are available for shipment to other parts of the world. The principal importing countries are: United States, Argentine, Brazil, Italy, India, and Union of South Africa.

Information concerning arsenic-bearing deposits in foreign countries is, for various reasons, difficult to obtain. Arsenic has, until recently, been regarded as a nuisance in some localities, and hence reference to its occurrence has been minimized in the literature. Most of the world's supply of arsenic is obtained as a by-product from the smelting or treatment of ores mined primarily for copper, lead, zinc, tin, tungsten, cobalt, silver, or gold, with the result that little attention has been paid to its mode of occurrence. Only within recent years have deposits been worked solely for their arsenic content and descriptions of such occurrences have not been widely published.

Brief descriptions of some foreign arsenic-bearing deposits are given in the following pages. Owing to the scarcity or inaccessibility of information on the subject a complete survey of the arsenic deposits of the world could not be assembled.

AUSTRALIA

New South Wales

Arsenic-bearing minerals[1] have been found in at least thirty localities in New South Wales. The principal deposits occur at: the Ottery tin mine, near Tent Hill; the Valla gold mine at Urunga on the east coast; at Brungle, in Tumut district; the Conrad mine at Howell, and at the Webb's Consols mine near Emmaville. The production of arsenic really began[2] in 1920, most of it coming from the Ottery mine which, in 1922, produced 2,823 tons of ore, yielding 268 tons of white arsenic. A recovery plant has been erected at the Valla gold mine to treat ores containing arsenopyrite. Small shipments of arsenical ores have been made from several other localities in the eastern and southern parts of the state to Bendigo (Sandhurst) or Ballarat, Victoria, for treatment.

[1] Geol. Surv., New South Wales, Dept. of Mines, Bull. 5, pp. 3-4 (1924).
[2] Geol. Surv., New South Wales, Dept. of Mines, Ann. Rept. 1921-22.

EMMAVILLE DISTRICT

Arsenic occurs in some abundance in the tin-bearing deposits near Tent Hill in Emmaville district, northeastern New South Wales. The area is underlain[1] by Permo-Carboniferous claystones, quartzites, and conglomerates, which have been intruded first by basic and later by acid granitic rocks. Associated with the bodies of acid granite are masses of greisen, pegmatite dykes, and quartz veins having a peripheral disposition with regard to the parent massifs. The ore-bodies occur only in the later series of siliceous intrusions.

At the Ottery[2] tin mine near Tent Hill the veins or lodes occur in dyke-like masses of hornblende granite and eurite which follow the contact between claystones and porphyrite. The main ore zone has an average width of 3 feet and has proved productive for a distance of over one-quarter of a mile and to a depth of 160 feet. The mineralization consists chiefly of cassiterite and mispickel in a quartz gangue. The deposit has been worked intermittently since 1883 for its tin content, but within recent years considerable arsenical ore has also been extracted. In 1920, 1921, and 1922 the total output of white arsenic amounted to 484 tons.

At the old Webb's[3] Consols silver mine, 11 miles south of Emmaville, 200 tons of arsenical pyrites, stated to average 10 per cent of arsenic, were raised in 1922. The gangue consists of quartz and feldspathic material containing bunches, veins, and impregnations of galena, mispickel, chalcopyrite, and sphalerite. The lode is understood to have been a wide one, and is said to have been 13 feet at the bottom of the main shaft, 209 feet deep.

CONRAD MINES, HOWELL[4]

Crude arsenic was produced at the Conrad mines in 1908 and 1910. The lodes occur in a tongue of acid granite near its contact with the basic Tingha granite. The ore is complex in character owing to the association of stannite with arsenopyrite, pyrite, chalcopyrite, and sphalerite. The lodes are persistent and show a change in metal content from silver and lead near the surface to copper and tin in the lower levels of the workings.

Queensland[5]

Arsenic, in the form of arsenopyrite or mispickel, has been found in many localities in Queensland and in a great variety of mineral deposits, but not in such quantities that any single deposit can be said to be abnormally large. The principal deposits occur in the following districts.

STANTHORPE DISTRICT

Arsenic has been mined intermittently since 1917 in Stanthorpe district, southeastern Queensland. The early production came largely from the Beecroft mine, but in 1919 the government commenced mining

[1] Geol. Surv., New South Wales, Min. Res., 14, p. 22 (1911).
[2] idem, pp. 142-3.
[3] Geol. Surv., New South Wales, Bull. No. 5, p. 4 (1924).
[4] Dept. of Mines, New South Wales, Bull. No. 5, p. 4 (1924).
[5] Geol. Surv., Queensland, Pub. No. 268, Article 9, pp. 291-295 (1921).

on its own concessions at Jibbinbar, and erected a plant for the recovery of white arsenic in an effort to cope with the prickly pear nuisance. During 1923 the State arsenic mine produced about 50 tons of white arsenic monthly and in 1924 somewhat less. Considerable arsenic also occurs in the tin concentrates from the Sundown mine in the same district.

The Jibbinbar arsenic lode being worked at the State mine is in places about 12 feet thick, but 2 feet is considered a good working average width. The ore is fairly clean mispickel with traces of copper pyrites, and is contained in a quartz gangue, the country rock being granite and altered sedimentary rocks, the lode passing from one into the other. A bulk sample of the ore was found to have the following composition: silica, 57·9 per cent; arsenic, 13·8 per cent; sulphur, 6·6 per cent; iron, 15·1 per cent; copper, 0·05 per cent; bismuth, trace; tin, nickel, cobalt, and gold absent; silver, a few pennyweights.

The Sundown lodes in Stanthorpe district are tin-copper-arsenic deposits, some with copper absent, and occasionally with wolfram and a little silver and gold present, these minerals occuring in irregular jointings, or as impregnations close to the joints, in much altered sedimentary rocks. Granite is in the neighbourhood, and the sedimentary rocks are intruded by a system of diorite dykes and by two huge quartz porphyry dykes.

BURNETT DISTRICT

In Burnett district, particularly at Auburn river, and in numerous places in and about the mines of mount Biggenden and mount Shamrock, mispickel commonly occurs with gold, bismuth, and copper ores. The Biggenden bismuth mine contains a very large, irregular lode of magnetite, in places containing bismuth only, in other places bismuth with mispickel and mispickel without bismuth. The portion worked has been opened for its bismuth contents, and the 10 to 20 per cent of mispickel in the saved bismuth concentrate has always been a nuisance.

CHILLAGOE DISTRICT

The Boonmoo arsenic lode in Chillagoe district is said to be a very large deposit containing mispickel, native bismuth, wolfram, gold, and silver. It is situated in a belt of porphyry. The quantity of arsenic present, estimated as arsenious oxide, is said to be about 17 per cent.

PORT CURTIS DISTRICT

The Norton arsenic-gold lodes are the most promising in Port Curtis district. They are occasionally in the form of fissures, but usually as "formations" containing mispickel, galena, blende, and copper pyrites. One large lode is estimated to contain 15·5 per cent of arsenic. The country rock is a fine-grained biotite granite.

South Australia

Deposits of arsenical ore occur at several places in Callington-Monarto and Cape Jervis districts, South Australia.

CALLINGTON-MONARTO DISTRICT[1]

A number of properties have been operated in this district for gold, copper, silver-lead, and arsenic. The workings lie along a mineralized belt consisting chiefly of mica schist. The principal arsenical deposit occurs at the Preamimma mine which has been worked periodically since 1854 for copper. This deposit[2] consists of quartz-arsenopyrite veins associated with a pegmatite dyke. The veins cut across the structure of the biotite-quartzite-schist which forms the country rock in the vicinity of the mine. Arsenopyrite occurs as irregular masses in the quartz veins or as small crystals disseminated through the schistose wall-rocks. The mineralization extends over widths up to 13 feet in places, but is usually much less. Average ore contains about 13 per cent of arsenic, a little copper, a trace of gold, and no silver, lead, or antimony. Ore shipments from this district totalled 68 tons in 1924.

CAPE JERVIS DISTRICT[3]

Several narrow veins containing arsenic occur in this district. The area is underlain by thin-bedded micaceous quartzite containing many quartz veins which may cut across the country rock or be interbedded with it. The veins range in width up to 9 inches and consist of quartz with more or less solid arsenopyrite. They contain some gold, but no silver, lead, zinc, or copper.

Tasmania

Arsenical minerals have been found in a number of localities in Tasmania, though nowhere in quanitites large enough to be of economic importance at the present time. The occurrence of arsenopyrite has been noted particularly in the tin ores of Mount Bischoff and Dundas districts; in the copper deposits at mount Lyell; in the silver-lead lodes at Magnet; and in the auriferous quartz veins of Golconda district.

MOUNT BISCHOFF[4]

The development of the tin deposits in the vicinity of mount Bischoff began in 1872 and mining was continued without interruption until 1919, when, due to war conditions and the exhaustion of the high-grade ore-bodies, the principal mines were closed down. The area is underlain by intensely folded and crushed Cambro-Ordovician sandstones, slates, and quartzites, intruded by dykes of pyroxenite and peridotite now largely altered to dolomite, chlorite, and serpentine. Following the basic intrusions great masses of granite invaded the older rocks, causing them to be highly fractured and broken. Dykes and sills of quartz porphyry, 1 to 70 feet thick, were then injected into the fractures or along the bedding planes of the sedimentary rocks. The porphyry intrusions were accompanied or followed closely by mineralizing solutions, to which the ore-bodies owe their origin. It is thought that the deformation of the strata, the igneous

[1] Dept. of Mines, South Australia, Min. Rev., No. 41, pp. 69 and 80 (1924).
[2] Ibid., No. 40, p. 46 (1924).
[3] Ibid., No. 40, pp. 44-5 (1924).
[4] Geol. Surv., Tasmania, Dept. of Mines, Bull. 34 (1923).

activity, and the formation of the ore deposits took place before the close of the Devonian period. The ore-bodies occur as fissure or replacement veins or as impregnations in the porphyry and aplite dykes, in pegmatites, and in greisen. The main dyke is from 15 to 150 feet wide and has been traced over 5,000 feet. It is much altered, the feldspar being replaced by quartz and topaz with some tourmaline. It is in fact a greisen rich in topaz. The deposits contain a great variety of minerals which, with the exception of cassiterite, are not sufficiently abundant to be of much economic importance. The mineral association includes chiefly cassiterite, galena, sphalerite, pyrite, pyrrhotite, chalcopyrite, arsenopyrite, wolframite, and in fewer cases molybdenite, bismuthinite, and stibnite.

Victoria

Small quantities of white arsenic are recovered in Victoria from ores mined and treated in the Bendigo and Ballarat gold-fields or imported from New South Wales. In view of the remarkable similarity existing between the Bendigo reefs and the gold-quartz veins of Nova Scotia the former will be described in some detail below.

BENDIGO[1]

Bendigo district is underlain by little-altered Ordovician slates and sandstones which have been compressed into numerous, parallel anticlines and synclines. The axes of the anticlines are from 300 to 1,300 feet apart and pitch north and south from the centre of the field. The sediments were intruded during late Silurian or early Devonian time by two batholiths of granitic rock, probably quartz monzonite. It is thought that the gold-quartz reefs of the district owe their origin to these intrusions. Subsequent erosion of at least 3,000 feet has reduced the region to an undulating surface. A system of parallel monchiquite dykes, probably Middle Tertiary in age, intersects the reefs and strata and follows closely the trend of the anticlinal axes. The rocks are also cut by numerous faults, most of them being of the reverse or upthrust variety.

The quartz reefs occur within the folded Ordovician rocks and as a rule follow conformably the strike of the strata, though in some cases they cut across it. They may be grouped according to their form into: (*a*) bedded reefs or those which occur between the bedding planes of the sediments at the crests or saddles of the anticlines, in the troughs of the synclines, and along the limbs of the folds; (*b*) fault reefs or those which lie along lines of fracture and intersect the bedding planes of the sediments; (*c*) spurs or irregular bodies extending usually from a bedded reef into the hanging-wall or foot-wall. In some instances ten or more of the saddle reefs are known to occur in vertical succession and three parallel series lie within an horizontal distance of about a mile. The vein-filling consists predominantly of quartz with variable amounts of gold and sulphides, chiefly pyrite and arsenopyrite, and occasionally galena, sphalerite, molybdenite, and stibnite. Ankerite, chlorite, albite, and white mica may also be present.

[1] Lindgren, W.: "Mineral Deposits," 1919, pp. 578-582.

The Bendigo veins have been worked to a depth of 4,600 feet in the Victoria mine, situated on the New Chum reef line. A body of quartz containing at best $17 a ton was mined at a depth of about 4,200 feet, but it is said that on the whole little profitable mining has been done at Bendigo below a depth of 2,500 feet. In 1915 the ores yielded about $7.50 in gold a ton.

Concerning the genesis of the Bendigo reefs, authorities are pretty well agreed that the granitic batholiths in the neighbourhood were the source of the mineralization. Some divergence of opinion exists, however, as to the way in which the reefs were actually formed. According to Dunn,[1] the saddle reefs owe their origin to the deposition of silica in cavities formed by the bending and arching of beds differing from one another in texture, composition, rigidity, and thickness. This view has been most widely accepted. He also intimates that the quartz bodies, owing to the force of crystallization, were able to increase their bulk by mechanically displacing the enclosing country rock. This hypothesis has been advocated most strongly by Taber,[2] who says:

> The solutions penetrated slowly along the lines of least resistance, such as fault fractures and planes of bedding or schistosity. Appreciable openings were filled, and, under favourable conditions, some of the country rock was replaced, but both of these processes were of minor importance. As the vein minerals separated from solution, pressure was developed tending to force apart the enclosing rock and thus make room for the growing veins......... The forms assumed by the growing deposits were largely determined by the nature of the passage ways along which the solutions entered and by the forces resisting enlargement, the tendency always being to produce that shape which required the least expenditure of energy.

Stillwell[3] has pointed out that replacement of slate by quartz has been of considerable importance in the formation of reefs consisting of banded or "ribbon quartz". Hitherto, it was generally believed that the banded appearance of the veins was due to the presence of laminæ of slate which had been stripped or separated from the walls of the cavities during the accretion of the quartz. Microscopical observations have led Stillwell to the conclusion that such laminæ represent replacement residues rather than leaves or fragments of slate split off and suspended in the vein-filling. In this connexion Lindgren expresses the belief that metasomatic processes (replacement) play only a small part in the veins, since the slates are little altered except by the introduction of pyrite and occasionally of some carbonates of calcium and magnesium.

What has been said concerning the mode of occurrence and character of the Bendigo reefs applies equally well to the Nova Scotian deposits, with this outstanding difference, that the latter do not persist to anything like the depths found in the Victoria field. This difference may be accounted for in several ways. If the amount of erosion which has taken place since the formation of the gold-quartz veins is greater in Nova Scotia than at Bendigo, as seems very likely, then the deposits in the former locality probably represent the roots or stumps of veins now largely worn away. If erosion has been equally effective in both localities, then the persistence of the Bendigo reefs must be due to structural conditions which are lacking

[1] Dunn, E. J.: "Reports on the Bendigo Gold Field," Nos. I and II, Victoria Dept. of Mines, Spec. Repts., 1896, p. 22.
[2] Taber, S.: Econ. Geol., vol. 13, pp. 538-546 (1918).
[3] Stillwell, F. L.: Econ. Geol., vol. 13, pp. 100-111 (1918).

in Nova Scotia. The depth at which cavities may develop as a result of the compression of strata depends on the relative competency (composition, hardness, rigidity, and thickness) of the rocks involved, and on the intensity of the deforming stresses. In the Bendigo field the folds are closely spaced, anticlines being from 300 to 1,300 feet apart, and the saddle reefs occur in vertical succession to a depth of 4,600 feet, whereas in Nova Scotia the anticlines are 3 miles apart on the average and the reefs seldom persist more than several hundred feet below the surface. These conditions suggest that the rocks in Bendigo district either were subjected to more intense deformation than the rocks in the Nova Scotian field or else they possessed just the right degree of relative competency necessary for the strata to be easily folded and cavities formed and maintained at great depth.

Western Australia

The three localities in Western Australia in which arsenical pyrites occurs in considerable quantities are: Southern Cross, Yilgarn gold-field; Lancefield, Mount Margaret gold-field; and Randell's, East Coolgardie gold-field. The production of arsenic has not been very large, only 3,594 tons of arsenical ore up to the end of 1922. This came from the Transvaal mine near Southern Cross.

YILGARN GOLD-FIELD[1]

The Southern Cross district is underlain by patches of greenstone (amphibolite, epidiorite, hornblende schist, hornblendite) surrounded and intruded by large bodies of granite and granite porphyry. Numerous dykes of aplite and pegmatite intersect both granite and greenstone. The principal deposit[2] of arsenical ore in the district occurs in the lower levels of the Transvaal mine, where the gold-bearing lode is made up largely of arsenopyrite. This lode is the chief ore-body of a number of parallel, vertical lodes outcropping for a distance of nearly three-quarters of a mile and varying in thickness from 6 to 20 feet. The ore-body occurs in a large, banded quartz vein associated with a lens of ferruginous schist which lies within and forms a part of the main greenstone area of the district. An average sample of the ore yielded 26 per cent arsenic and about $16 in gold a ton.

MOUNT MARGARET GOLD-FIELD[3]

Arsenopyrite occurs quite abundantly in the ore at the Lancefield mine near Laverton. The region is underlain by massive or schistose greenstones, many considerably decomposed and altered, which have been intruded by dykes or masses of granite and feldspar porphyry. The principal deposits occur in the greenstones and consist of hematite-bearing quartz veins or lenses many of which are so admixed with schist that definite walls are lacking. The Lancefield lode has an average thickness of 17 feet and has been traced for over 1,000 feet in length. It is oxidized

[1] Geol. Surv., Western Australia, Bull. 49 (1913).
[2] Geol. Surv., Western Australia, Bull. 89, p. 67 (1924).
[3] Geol. Surv., Western Australia, Bull. 24, pp. 13-19(1906).

to a depth of 200 feet, at which level sulphides, particularly arsenopyrite, become abundant. The gold values throughout the deposit are remarkably uniform, the average being about 0·36 ounce a ton.

MURCHISON GOLD-FIELD[1]

Gold-bearing lodes carrying arsenopyrite occur in Meekatharra district. The area is underlain by massive and schistose greenstones intruded by bodies of granite and porphyry. The ore-bodies have been formed by replacement of the schists along certain zones characterized by the presence of auriferous quartz veins. The mineralization consists chiefly of arsenopyrite and pyrite in a schistose gangue composed of carbonates, chlorite, and serpentine. The ores yield concentrates containing from 11 to 30 per cent of arsenic.

BRAZIL

Arsenic occurs in the form of arsenopyrite at the Morro Velho and Passagem mines in the province of Minas Geraes. White arsenic, amounting to 127 tons in both 1920 and 1921, was recovered as a by-product at the Morro Velho mine. The bulk of the arsenic used by the coffee-planters is imported from Europe.

MORRO VELHO MINE[2]

This mine is noteworthy for several reasons. In the first place it is the deepest mine in the world, the lowest workings being over 6,700 feet vertically below the surface, and, secondly, there is practically no change in the gold content from top to bottom of the deposit. The country rock consists of much sheared, rather calcareous schists, with mica and chlorite. The payable ore-body takes the form of an immense shoot, pitching down a vertical plane at about 45 degrees. The stope length is about 700 feet and the width varies from 1 to 30 feet, averaging 10 or 12 feet. The gangue consists of quartz, siderite, dolomite, and calcite, with arsenopyrite, pyrite, pyrrhotite, and a little chalcopyrite. The deposit is mined for its gold content, most of which is in the arsenopyrite, very little being free. In the year 1915 the average return was about $11.50 a ton in gold and silver. Some of the ore is said to carry as much as 5 per cent of arsenic.

PASSAGEM MINE[3]

The country rock in the vicinity of this mine consists of quartz-schists and quartzites overlain by the iron-bearing rocks known as itabirite and jacutinga. The ore-body lies at the contact of the quartzite and itabirite. There are two types of ore: white lodes, up to 36 feet thick, consisting of white quartz with pyrrhotite and arsenopyrite, the last named carrying most of the gold; and black lodes with much tourmaline, quartz, and the same sulphides. The black lodes are richer, but smaller than the white lodes, and lie below them. Both types appear to be replaced quartzite, but the genetic relations are not obvious; the abundance of tourmaline in the black lodes suggests pegmatitic affinities and formation at considerable depth. The average yield of gold is about $7 a ton.

[1] Geol. Surv., Western Australia, Bull. 68 (1916).
[2] Rastall, R. H.: "The Geology of the Metalliferous Deposits," 1923, p. 463.
[3] Ibid., p. 464.

CHINA

In China arsenic occurs chiefly in the provinces of Yün-nan and Hu-nan. The deposits in Yün-nan[1] lie east of Mekong (Cambodia) river, at an elevation of 8,100 feet, where mining is carried on with considerable difficulty. The rocks in the immediate vicinity of the mines consist of reddish, reddish purple, and hard, greyish, quartzitic sandstones with black bands in places and reddish nodular shales. The deposit appears to be confined to one particular band of greyish quartzite associated in places with soft, blackish shales. The whole band is more or less mineralized, there being no distinct vein. A thorough shattering of the rock has taken place and orpiment has been deposited along bedding, joint, and fracture planes, or has replaced the rock itself to some extent. Small quantities of realgar and minute cubes of pyrite are also present. The arsenic sulphides occur in irregular stringers, swelling out into patches or bands which in some cases attain a thickness of over 12 inches. The mineralized band is about 4 feet thick, its lateral extent being unknown. Brown offers no opinion as to the origin of the deposit. The ore is hand-picked and concentrated before being shipped to Burma by caravan. From 250 to 800 tons of orpiment are shipped out of the district annually.

The arsenic produced in Hu-nan[2] is mined with ores of tin, antimony, lead, zinc, and tungsten and is recovered as a by-product at the smelting plants of Chang-sha and Hankow. Arsenopyrite is the principal source of arsenic in this region and occurs most plentifully in the tin ores.

In 1916 about 80,000 tons of arsenic ore were produced in China. Approximately 70 per cent of the output is utilized in the country.

CZECHO-SLOVAKIA

A small quantity of arsenical concentrates, amounting to 24 tons in 1923, has been recovered within recent years from gold ores mined at Roudňy in Bohemia.

ROUDŃY, BOHEMIA[3]

In this district, quartz veins, aplites, and pegmatites are associated with granite bodies of Carboniferous age. The deposit consists of an auriferous quartz vein which traverses biotite-gneiss and has an average width of 12 inches. Along the margins of the vein the gneiss has been converted to a breccia by fracturing and the introduction of quartz veinlets which are also gold-bearing. The mineralized zone varies in width from 6 to 25 feet and, in places, as much as 60 feet. The deposit is 150 to 400 feet in length and has been followed to a depth of over 1,250 feet. The gold (with 33 per cent silver) occurs in the native state and is enclosed in pyrite and arsenopyrite. The gold content varies between 0·13 and 0·8 ounce a ton and is not uniformly distributed throughout the deposit. About 78 per cent of the gold values are recovered by amalgamation. 5 per cent by cyanidation, and the remaining 17 per cent are contained in the arsenical concentrates shipped to Freiberg for treatment.

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1 Brown, J. C.: Geol. Surv., India, Memoirs, vol. XLVII, pt. 1, p. 142 (1920).
2 U.S. Geol. Surv., Min. Res. of the U.S., pt. 1, p. 180 (1923).
3 Susta, V.: Geol. Zentrablatt, vol. 29, p. 4 (1923).

JOACHIMSTHAL[1]

This district, formerly a part of Austrian Bohemia and now in Czecho-Slovakia, lies on the southern slope of the Erzgebirge range, and is underlain by mica-schists and crystalline limestones intruded by bodies of granite and dykes of quartz porphyry. These rocks are cut by Tertiary dykes of basalt and phonolite. The deposits occur in fissure veins which vary in width from 15 to 60 cms. and rarely reach 1 to 2 metres. In some veins the gangue consists of brittle clay, with hornstone and quartz, and in others of calcite and dolomite. The ores occur as stringers and pockets scattered irregularly through the gangue. The ore minerals are: niccolite, chloanthite, smaltite, arsenopyrite, native arsenic, native bismuth, native silver, silver sulpho-salts, and pitchblende. A little mining is carried on in the district at the present time.

FRANCE[2]

Gold-arsenopyrite deposits occur in the departments of Aude and Puy-de-Dôme in southern and central France. Realgar is mined at Duranus in the Maritime Alps and at Matra in Corsica. The entire output of the mines is utilized by the Compagnie minière et métallurgique d'Auzon which manufactures various arsenical compounds. The consumption of white arsenic in France is estimated at 1,200 metric tons annually. The production of arsenious oxide during 1923 was in the neighbourhood of 1,500 metric tons.

GERMANY

The principal deposits of arsenic occur at Reichenstein, Altenberg, and Rothenburg, in Silesia. Smelters and refineries are located at Reichenstein and at Freiberg, both in Saxony. The Silesian deposits furnish about 65 per cent of the German arsenic produced, the remainder being recovered from ores mined in the Mansfeld copper district or from ores imported and treated at Freiberg. The deposits formerly worked at Annaberg in Saxony are of interest because of their resemblance to the veins at Cobalt, Ont.

REICHENSTEIN[3]

The deposits were worked for gold as early as 1270. Arsenopyrite was mined in the eighteenth century, but no arsenic was recovered until 1883. The deposits are associated with a lenticular mass of serpentine diopside rock and limestone enclosed in mica-schists which are highly altered and contain tourmaline. Intrusions of granite occur in the vicinity. Under the contact-metamorphic influence of these intrusions magnesian silicates such as tremolite and diopside were developed in the dolomitic parts of the limestone. These silicates were changed in part to serpentine

[1] Beck, R., and Weed, W. H.: "The Nature of Ore Deposits," 1909, pp. 283-7.
[2] U.S. Geol. Surv., 1923, Min. Res. of the U.S., pt. 1, p. 176.
[3] Stelzner and Bergeat: "Die Erzlagerstätten," vol. 2, p. 1,136 (1905-6).
Beyschlag-Krusch-Vogt: "Die Lagerstätten der nutzbaren Mineralien und Gesteine," Bd. 1, 1914, pp. 441-4.
Berg, G.: Central. f. Min. Geol. u. Paleo, 1920, pp. 206-213.

during the period of ore deposition which followed. The ore-bodies are numerous and irregular. They consist of impregnations of löllingite, arsenopyrite, and leucopyrite in the serpentine, diopside, and tremolite rocks, and silicate-bearing limestone. The largest deposit, that at the Reicher Trost mine, has a maximum thickness of 35 metres and has been worked along the strike for 1,200 metres. The sulphides carry from 0·15 to 1·02 ounces of gold a short ton. Other minerals present are galena, zinc blende, chalcopyrite, hematite, bornite, pyrrhotite, pyrite, apatite, fluorite, and vesuvianite.

ALTENBERG[1]

The deposits are associated with Silurian sediments consisting chiefly of slate, quartzite, and hornblende schist which have been intruded by bodies of porphyry, porphyrite, and kersantite. The ore-bodies occur in fissure veins which are accompanied by more or less replacement of the wall-rocks. The mineralization appears to have taken place in two stages. The first stage was characterized by the formation of quartz-arsenopyrite-pyrite veins in fissures resulting from the intrusion of quartz-porphyry and porphyrite masses. During the second stage, gold-bearing copper ores were deposited in fractures formed in the earlier veins and the intrusive rocks were altered in places to propylite. In some sections of the district the second stage followed the introduction of kersantite dykes and consisted of silver-lead-zinc-copper ore deposited in open spaces along either side of the dykes. The veins vary in width from 4 to 10 inches and may even reach 36 inches where the wall-rocks have been replaced. Some of the veins have been followed for nearly 1,500 feet in length and to a depth of about 400 feet. The mineralization consists of arsenopyrite, pyrite, chalcopyrite, galena, zinc blende, and tetrahedrite in a gangue of quartz, barite, and dolomite. The gold values ar· associated with chalcopyrite chiefly, and the silver values with galena and tetrahedrite. The arsenopyrite[2] carries a trace of gold and 4·7 ounces of silver to the ton.

ROTHENBURG[3]

At Rothenburg in Hirschberg district, various crystalline schists have been intruded by granite which forms the core of the Riesengebirge. In the highly-metamorphosed and steeply-tilted schists is a bed about 500 metres long and 0·5 to 3·5 metres wide, which consists of a coarse-grained mixture of quartz and arsenopyrite. In part the contacts with the wall-rocks are sharp and in part gradational. The ore-bodies are irregularly distributed and consist principally of arsenopyrite with some chalcopyrite, pyrite, galena, and zinc blende. At depth the arsenopyrite gives way to a mixture of quartz and pyrrhotite which contains copper and arsenic in unworkable amounts. The raw ore contains on the average 27 to 28 per cent of arsenic, 2 to 4 grammes of gold and 40 to 60 grammes of silver a ton.

Concerning the genesis of the deposit Berg[4] states that, as a result of the contact-metamorphic effects of the granite intrusion, large masses of

[1] Stauffacher, J.: Zeit. f. prakt. Geol., 23, 1915, pp. 53-88.
[2] Beyschlag-Krusch-Vogt: "Die Lagerstätten der nutzbaren Mineralien und Gesteine," 1921, Bd. II, p. 364.
[3] Beyschlag-Krusch-Vogt: "Die Lagerstätten der nutzbaren Mineralien und Gesteine," Bd. 11, 1921, pp. 434-5.
[4] Berg, G.; Central. f. Min. Geol. u. Paleo., 1920, pp. 229-230.

pyrrhotite were developed in lenses of limestone and lime-silicate contained in the schists. Subsequent fracturing was followed by a second period of mineralization in which hydrothermal solutions deposited arsenopyrite in fissures parallel to the schistosity of the enclosing rocks.

ANNABERG, SAXONY[1]

Annaberg district, on the Saxon side of the Erzgebirge, is underlain by mica-gneiss which has been intruded by stocks of granite and tongues of microgranite. Dykes of lamprophyre and basalt intersect the older rocks. Over three hundred veins occur in the district. They may be divided into two groups, according to age: (a) an older group of tin and copper-lead-zinc veins; and (b) a younger group of silver-cobalt-nickel-arsenic veins. The latter group is of most importance. Most of the veins have been followed along the strike for distances of 800 metres up to 2 kilometres. They vary in thickness from 10 to 20 centimetres, up to 2 metres, and have been mined to a depth of 400 metres. The vein-filling consists mainly of barite, fluorspar, quartz, and siderite with chloanthite, smaltite, bismuthinite, gersdorffite, native bismuth, native silver, ruby silver, and pitchblende. Very little mining has been done in the district since 1850.

SCHNEEBERG, SAXONY[2]

The veins at Schneeberg are contained in contact-metamorphic clay slates in an area underlain by granite. The primary gangue consisted of calcite, ankerite, barite, and fluorite, now largely replaced by quartz. The ore minerals are smaltite, chloanthite, niccolite, bismuthinite, and native bismuth. Native silver and rich silver minerals are subordinate in the silicified veins, but appear in the primary barytic veins. Over one hundred and fifty veins have been exposed in mining. The veins vary in thickness from 2 centimetres to 3 metres, but are mostly less than 0·5 metre. They have been worked to a depth of 480 metres in places. The deposits in this district have been largely worked out.

ANDREASBERG[3]

Andreasberg district, in Harz mountains, is underlain by Devonian slates and limestones which have been intruded by bodies of granite. The deposits occur in fissure veins having a width of from 1 centimetre to 0·5 metre. The filling consists of calcite containing veinlets and pockets of galena, zinc blende, native arsenic, proustite, dyscrasite, arsenical silver, native silver, breithauptite, niccolite, and zeolites. The distribution of the ores in the veins is very irregular. Some mining is carried on in the district at the present time.

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[1] Beck, R., and Weed, W. H.: "The Nature of Ore Deposits;" 1909, pp. 287-292.

[2] Lindgren, W.: "Mineral Deposits," 1919, p. 626.
Beck, R., and Weed, W. H.: "The Nature of Ore Deposits," 1909, pp. 342-346.

[3] Beck, R., and Weed, W. H.: "The Nature of Ore Deposits," 1909, pp. 272-275.

JAPAN

About twenty-five small mines[1] in Japan are worked for their arsenic content alone. Nearly half of these are situated in the boundary region between the provinces of Bungo and Hyuga, on the island of Kiushiu, southern Japan. White arsenic has been recovered from arsenopyrite ores since 1908. Most of the production since 1918 has been derived as a by-product from the smelting of copper and lead ores containing a small percentage of arsenic. The production of white arsenic in Japan has increased from 398 tons in 1918 to 4,287 tons in 1923. It is said that sufficient ore containing from 15 to 30 per cent of arsenic occurs in known deposits to furnish as much as 4,000 tons of white arsenic annually, if the industry is given adequate support.

The principal arsenical minerals[2] mined in Japan are arsenopyrite, realgar, and orpiment. Arsenopyrite occurs in fissure veins, replacement deposits, and contact-metamorphic deposits. Veins containing arsenopyrite are well developed both in Tertiary and pre-Tertiary rocks, but the other two types are found in the pre-Tertiary only. Realgar and orpiment occur chiefly in post-Tertiary volcanic rocks as veins or effused masses associated with sulphur.

Information concerning the arsenic-bearing deposits in Japan is not readily obtainable. The following occurrences may be mentioned.

At the Yoshioka[3] mine in Bitchu province, fissure veins and replacement bodies, 1 to 15 feet in width, occur within Palæozoic slates and sandstones, or along the contacts of porphyry dykes intruded into the sediments. The ores consist chiefly of chalcopyrite, pyrrhotite, and pyrite, with minor amounts of arsenopyrite and sphalerite. The gangue minerals are quartz and calcite, with some hornblende and fluorite. At the Sasagatani[4] mine in the province of Iwama, a large liparite dyke traverses Palæozoic slate, sandstone, and limestone. The mineralization is in the form of contact-metamorphic bodies having a maximum thickness of 50 feet. The ore consists of chalcopyrite associated with arsenopyrite, sphalerite, and argentiferous galena. The gangue is chiefly quartz, limestone, and hornblende. At the Otogafuchi[5] mine in Hyuga, and the Kawauchi mine in Echigo, arsenopyrite occurs in contact metamorphic deposits associated with bodies of quartz porphyry and granite which are intrusive into Palæozoic sediments. At the Ogiri[6] mine, in the province of Bungo, fissure veins containing arsenopyrite occur in Palæozoic rocks. In the same district veins formed partly by replacement occur under similar conditions at the Uridani mine. Veins[7] containing auriferous arsenopyrite are found in granite at the Sudzukura mine in the province of Kai. At the Yakuôji mine[8] in Yamaguchi, Palæozoic sandstone and hornstone have been contact metamorphosed by the intrusion of hornblende granite. The veins vary in width from 1 to 3 feet and occur both in granite and in sandstone. The ore is composed chiefly of chalcopyrite with small quantities of native bismuth, bismuthinite, arsenopyrite, and scheelite in a gangue of calcite, quartz, and tourmaline.

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[1] U.S. Geol. Surv., Min. Res. of the U.S., pt. 1, p. 172 (1923).
[2] Bur. of Mines of Japan: "Mining in Japan, Past and Present," 1909.
[3] Imp. Geol. Surv. of Japan, "Geology of Japan," 1902, pp. 149-150.
[4] Ibid., pp. 150-1.
[5], [6], and [7], Same as 2.
[8] Geol. Zentrallblatt, vol. 28, No. 1338, p. 393 (1922-23).

JUGOSLAVIA

For centuries considerable quantities of arsenical ore have been obtained from the antimony mines at Allchar, near the village of Rozsdan, southeastern Jugoslavia. The deposit[1] occurs between mica schist on the hanging-wall and limestone or dolomite on the foot-wall, and consists of nests, druses, stringers, and lenses of antimony and arsenic ores. In 1891 the deposits had been followed for 4 kilometres along the strike. Masses of pure ore 1·5 metres in width are not uncommon. The north part of the deposit consists of realgar and orpiment. In addition to antimony minerals, pyrite, calcite, aragonite, and aluminite accompany the ores. Stelzner and Bergeat state that the ore-bodies may represent metasomatic deposits rather than veins.

At Srebrenik[2] in northeastern Bosnia realgar occurs associated with dolomite in a vein about 2 metres thick. At Hrmsa in central Bosnia realgar and orpiment occur with fluorspar in a vein about 3 metres wide, which is intimately associated with intrusive masses of porphyry in the Triassic limestones.

At Bor[3], in Serbia, an irregular quartzose replacement of intrusive porphyry is mineralized with pyrite, enargite, quartz, barite, and covellite.

MEXICO

Arsenic[4] is produced in Mexico chiefly as a by-product from the smelting of lead ores. In the past the bulk of the arsenic has been recovered at the Mapimi smelter, operated by the Compania minera de Penoles and owned by the American Metal Company. In 1923 the Penoles Company shipped 786 metric tons of white arsenic. The American Smelting and Refining Company, which operates smelters at Matehuala, Asarco, Chihuahua, and San Luis Potosí, shipped 433 tons during the same period.

White arsenic is recovered from gold-arsenopyrite ores which are mined near Triunfo in Lower California. It is expected that this district will become an important producer of arsenic in the future.

MAPIMI, DURANGO[5]

The vast deposits of silver- and gold-bearing lead ore at Mapimi, form a system of columnar ore-shoots in Middle Cretaceous limestone. The main deposit is a pipe of ore 98 feet in diameter and opened to a depth of over 1,600 feet. According to Naumann, the tube-like ore-bodies represent volcanic necks, though other deposits in the vicinity appear to be due to contact-metamorphism by plutonic masses. Ore consisting of a compact mixture of arsenopyrite, galena, pyrite, sphalerite, and fluorite predominates. Other minerals present are chalcopyrites, boulangerite, ruby silver, and tetrahedrite. The gangue consists of quartz, fluorite, barite, calcite, rhodochrosite, and ankerite. The deposits are capped by a thick gossan containing secondary lead, iron, and silver minerals.

[1] Stelzner-Bergeat: "Die Erzlagerstätten," vol. 2, pp. 884-5 (1905-6).
[2] U.S. Geol. Surv., Min. Res. of the U.S., pt. 1, pp. 177-9 (1923).
[3] Lazarevic, M.: Zeit. f. prakt. Geol., 1912, pp. 337-370.
[4] U.S. Geol. Surv., Min. Res. of the U.S., pt. 1, p. 173 (1923).
[5] Beck, R., and Weed, W. H.: "The Nature of Ore Deposits," 1909, pp. 572-3.

NORWAY[1]

The Kjorisfjeld arsenopyrite deposit is probably the largest deposit of arsenic in Norway and is very little known. It is situated in a remote part of the mountains of Skjömen, in Ofoten. The country rock is a coarse-grained potash granite. Near the ore deposit are hornblende schist and gabbroic eruptive rocks older than the granite. Still older are some zones of partly dolomitized limestone in which contact-metamorphic deposits predominate. These deposits contain arsenopyrite, pyrrhotite, chalcopyrite, and magnetite, with traces of sphalerite and galena. The ore-body, which is about 7 feet wide, is visible for 90 feet and may extend 500 feet. A sample across the thickest part of the lode gave 26·5 per cent arsenic and 11 grammes of gold to the ton.

RUSSIA

Little information is available concerning the occurrence of arsenic in Russia. Numerous quartz-arsenopyrite-gold veins occur in Kotschkar[2] district, Ural mountains. The rocks in the area consist of schists of various kinds which have been intruded by masses of porphyritic granite and by dykes of aplite and pegmatite. The veins occur almost entirely in the granite, the wall-rocks being impregnated with auriferous pyrite and changed to beresite. The veins are less than 1 metre thick and only continue a few hundred metres. The mineralization consists of auriferous arsenopyrite and pyrite, galena, chalcopyrite, and antimonite, in a gangue of quartz. The deposits are overlain by gossan, 10 to 15 metres thick, which contains silver halides and arseniosiderite. The average gold is 8 to 10·5 grammes a ton.

A deposit of realgar and orpiment containing nickel, cobalt, and silver occurs in the district of Kars,[3] formerly a part of Turkish Armenia.

It is reported[4] that arsenic works designed to produce about 500 tons of metallic arsenic and 700 tons of calcium arsenate per annum have been constructed by the Anil Trust at Kurtatinsk.

SOUTH AFRICA

Arsenic[5] occurs in a number of gold ores of Rhodesia and the eastern Transvaal, in the tin ores of the Waterberg and in the antimony ores of the Murchison range in northern Transvaal. The concentrates of the Consort gold mine near Barberton and at the Stavoren tin mine contain sufficient arsenic to make its recovery payable. White arsenic was first produced in the Union of South Africa in 1917, when 3 tons were recovered as a by-product at the Stavoren mine. In 1918 the production rose to 15 tons, but fell off to 2 tons in 1921. It is reported that considerable arsenopyrite has since been discovered in the Transvaal.

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[1] U.S. Geol. Surv., Min. Res. of the U.S., pt. 1, p. 176 (1923).
[2] Stelzner-Bergeat: "Die Erzlagerstätten," vol. 2, p. 624 (1905-6).
[3] Geol. Zentralblatt, vol. 28, 1922-23, No. 1411, p. 422.
[4] Min. Jour., vol. CXLIII, No. 4602 (Nov. 3, 1923).
[5] Official Year Book, Union of South Africa, 1920-21.

A much larger production of white arsenic has been recovered as a by-product from the gold mines of Umtali[1] and Bulawayo districts, Rhodesia. The output in 1921 amounted to 361 tons and in 1922 to 497 tons, most of it being shipped to the Union of South Africa, where it is used in the manufacture of sodium arsenite for sheep and cattle dips.

BARBERTON DISTRICT[2]

Arsenopyrite is present in a number of deposits in the Barberton gold field, eastern Transvaal. It occurs most abundantly at the Consort mine near Jamestown. The district is underlain by slates, quartzites, and basic igneous rocks belonging to the Swaziland system, which have been intruded by large bodies of granite. The Consort mine lies in the contact belt between the granite and the older rocks. The deposit belongs to the group of arsenopyrite-contact deposits and is thought to owe its origin to the granite intrusive. It occurs between an altered basic igneous rock and chiastolite slate. The reef itself most probably represents a metamorphosed and thoroughly mineralized sedimentary rock. It may be described as a graphitic slate which has been changed into a more or less completely silicified hornstone, a change accompanied by intense mineralization and the introduction of granitic material and tourmaline, the latter indicating a probable pneumatolytic origin for the deposit. The ore-bodies are overlain by a silicified zone which is not mineralized and which fades outward into chiastolite slate. Arsenopyrite, pyrite, and pyrrhotite are the principal sulphides present. Gold values are confined chiefly to the sulphides and are not uniformly distributed throughout the reef, but occur in lenticular shoots varying from a few inches to 7 feet in width and 20 to 30 feet in length.

MUTUE FIDES–STAVOREN TIN-FIELDS[3]

The tin-bearing section of central Transvaal is underlain by granite and granophyre belonging to the uppermost part of the Bushveld Igneous Complex—a great interformational laccolith intruded between the Transvaal and Waterberg systems of sedimentary rocks. The principal deposits in this area occur at the Mutue Fides and Stavoren mines.

At the Mutue Fides mine the ore-bodies consist of tabular replacement veins associated with gently inclined fractures in granite, or as irregular impregnations along the lower contacts of pegmatite sheets. Sericitization of the granite and development of greisen occur along the fractures. The ore-bodies vary in width from a few inches to several feet and consist of stanniferous greisen containing cassiterite, pyrite, arsenopyrite, and chalcopyrite. Subordinate quantities of specularite, molybdenite, wolframite, zinc blende, and galena are also present. The gangue minerals are chiefly sericite, quartz, feldspar, chlorite, fluorite, apatite, and calcite.

At the Stavoren mine the deposits consist of irregular replacements in pipe-like bodies of pegmatite which occur in granophyre. The diameter of the ore-bodies ranges from less than a foot up to 15 feet. The behaviour

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[1] Rhodesia Chamber of Mines, Ann. Repts., 1920-22.
[2] Union of South Africa, Geol. Surv., Mem. No. 9, 243-250 (1918).
[3] Wagner, P. A.: Union of S. Africa, Geol. Surv., Mem. No. 16 (1921).

of the pipes at depth is extremely erratic. The primary ore minerals are cassiterite, scheelite, molybdenite, arsenopyrite, chalcopyrite, pyrite, galena, zinc blende, and bismuthinite. The gangue consists of orthoclase, quartz, raven-mica, chlorite, fluorite, calcite, apatite, sericite, and tourmaline. An arsenic-recovery plant was erected in 1917 and several small shipments of arsenious oxide have been made.

UNITED KINGDOM

Cornwall and Devon are the only counties producing arsenic at present. The deposits lie[1] chiefly in the Camborne-Redruth and Kit Hill-Calstock districts of Cornwall and near Tavistock in Devon. The production of white arsenic, amounting to about 1,000 tons annually, comes largely from the Devon Great Consols, from the Cornwall Arsenic Company at Portreath, from the British Mining and Metal Company at Gunnislake, and from the Wheal Jewell and Mary Tavy mines. It is expected that the South Crofty mine at Camborne, which has large reserves of arsenical ore, will again produce considerable arsenic.

CORNWALL AND DEVON

The tin-bearing district of Cornwall and Devon[2] in southwest England is underlain by folded Palæozoic slates and sandstones which have been intruded by five large bosses and several smaller bodies of granite. These intrusions probably represent domes or cupolas on the surface of a great batholith that underlies the district at no great depth. Dykes of pegmatite, aplite, and quartz porphyry intersect both granite and sediments. Subsequent pneumatolytic alteration has converted the normal granite to greisen and to rocks rich in tourmaline. All the granite masses are more or less heavily mineralized, especially round their margins, and the mineralization extends for a considerable distance into the slaty rocks. The ores contain chiefly tin, copper, tungsten, arsenic, lead, zinc, and iron, with smaller quantities of antimony, bismuth, molybdenum, cobalt, nickel, gold, silver, and uranium.

The deposits occur in fissure veins and in lodes formed by replacement along belts of shattering. They traverse both granites and slates. Some of the lodes have been traced for several miles along the strike. They vary in width from a foot up to 40 or 50 feet, with an average of about 4 feet. The most productive area lies in the Camborne-Redruth district in which is located the famous Dalcoath lode. This lode exhibits a change in the character of the ore with depth, which is generally true for the whole field. From the surface down to the 900-foot level the lode was very rich in copper; from this to a depth of 1,140 feet there were both copper and tin; and below this tin only. Arsenic is present in arsenopyrite which is associated with the copper and tungsten ores found chiefly above the 1,200-foot level. The ores contain from 7 to 23 per cent of arsenic, of which about 60 per cent is recovered and 40 per cent lost in the slimes.

The mineral association[3] is exceedingly varied and complex. The copper veins contain grey copper, tennantite, cuprite, native copper,

[1] Dewey, H.: Memoirs Geol. Surv. of Gt. Britain, vol. 15 (1920).
Imp. Min. Res. Bur., "Arsenic," 1920 and 1923.
[2] Rastall, R. H.: "The Geology of the Metalliferous Deposits," 1923, pp. 262-272.
[3] Beck, R., and Weed, W. H.: "The Nature of Ore Deposits," 1909, p. 212.

malachite, azurite, pyrite, arsenopyrite, and sphalerite. The tin-bearing veins are composed of cassiterite, stannite, chalcopyrite, scheelite, sphalerite, arsenopyrite, and native bismuth. The principal gangue is quartz with associated orthoclase, tourmaline, chlorite, lithia-mica, and fluorite.

UNITED STATES

The chief deposits[1] of arsenical ores occur in the western states, particularly in Utah, Nevada, Montana, South Dakota, Colorado, California, New Mexico, and Arizona. During 1924 nearly two-thirds of the whole arsenic production in the United States came from plants where the ore was directly treated for its arsenic content. The remaining third of the total domestic output was largely the by-product from the regular ore charges of copper and lead smelting. Arsenical ores were mined in 1924 in the states mentioned above and together with the by-product recovered from miscellaneous ores and concentrates were made into white arsenic at refineries situated at Tacoma, Wash.; Globe, Ariz.; Murray and Midvale, Utah; Anaconda and Jardine, Mont.; Martinez, Cal.; Perth Amboy, N.J.; and Keystone, S.D. The principal producers operating arsenic refineries were the American Smelting and Refining Company; the United States Smelting, Refining, and Mining Company, Inclusive; the Anaconda Copper Mining Company; International Smelting Company; Jardine Mining Company; Toulon Arsenic Company; Chipman Chemical Engineering Company; and the Keystone Arsenic Company.

As a result of the active search for arsenical deposits during 1923 and 1924 the known resources in the country have been greatly increased and are thought to be adequate to supply the demand for white arsenic for some time if the market become sufficiently stable to encourage production. The minimum requirements of white arsenic are estimated at 12,000 tons annually, and the capacity of the smelters and refineries at about three times that amount. The inability of producers to gauge the needs of consumers has led to years of over- and under-production, during which corresponding fluctuations took place in the volume of foreign imports. This is well illustrated by the table given in Chapter VI, which shows the production, imports, and supply of white arsenic in the United States. The principal deposits of arsenical ores are briefly described below.

BATTLE MOUNTAIN,[2] NEV.

An important deposit of arsenic ore occurs at the Irish Rose mine, near Battle mountain, Lander county. Ore was mined from this property for many years for its content of silver. The ore deposits of the district occur in a series of quartzite and limestone intruded by porphyry. Veins formed along bedding planes of the sedimentary rocks may contain copper-gold, iron-zinc, or silver-lead-arsenic ore. The latter predominated in the Irish Rose property, which is developed by a tunnel about 600 feet long driven on the vein with stopes and upraises. The vein developed by this tunnel is said to be several hundred feet long, and pinches and

[1] Mineral Industry, vol. 33, p. 63 (1924).
[2] Min. Res. of the U.S., pt. 1, pp. 39-40 (1924).

widens from 6 inches to 3 feet. Arsenopyrite is the principal sulphide present. The milling ore averages 8 per cent of arsenic, about 80 cents in gold, and 5 ounces of silver to the ton, 2 per cent of lead, 11 per cent of sulphur, 13 per cent of iron, and 45 per cent of insoluble. The ratio of concentration is 3 into 1. The ore directly roasted is much higher in arsenic, averaging 15 per cent. According to a conservative estimate the ore reserves above the tunnel level amount to about 60,000 tons.

BRINTON,[1] VA.

The deposit at Brinton, Floyd county, Virginia, is the only one in the eastern United States from which arsenic ore has been extracted and white arsenic recovered in a plant erected at the mine. The making of white arsenic began in 1903 and was continued intermittently until 1910 when the property was closed down.

The region is underlain by Precambrian rocks consisting chiefly of what Keith has called the Carolina gneiss. Intercalated with the coarser phases of the gneiss are bands of dark grey, mica-quartz schist which forms the country rock in the vicinity of the mine. The gneiss has been cut by bodies of granite and numerous pegmatite dykes that vary from a few inches to 2 feet in thickness. The dykes in general follow the gneissoid structure, but some cut across it. In the immediate vicinity of the mine the rock is a fine-grained, grey schist consisting of muscovite and quartz and a little epidote. The arsenic deposits occur as impregnations of arsenopyrite, adjacent to faults along which aplite or pegmatite has been intruded and later crushed to schist. The deposits could not be followed readily on the surface and are not believed to be continuous for a great distance, but it is probable that similar deposits occur at a number of places in the vicinity. Impregnation veins of nearly solid arsenopyrite 2 to 8 inches thick and mineralized lenses in the schist as much as 8 or 9 feet in width and 30 feet in length were developed by underground workings. In places a quartz vein 2 or 3 inches thick occurs with the arsenopyrite, but as a rule a white, mica-quartz schist reaching 5 feet in thickness accompanies the ore. This schist is believed to be a squeezed pegmatite or aplite in which the feldspars have been largely altered to muscovite. With the arsenopyrite is more or less pyrite carrying some copper. The arsenopyrite contains only small amounts or traces of gold and silver. As the arsenopyrite is in immediate association with the crushed pegmatite or aplite at the mine and no granite is known in the vicinity it is probable that the arsenopyrite was deposited by solutions accompanying the intrusions of the acidic rock.

BUTTE, MONT.[2]

A large proportion of the white arsenic produced in the United States is obtained as a by-product from the smelting of Butte copper ores. The deposits form a system of east-west, steeply dipping veins cutting quartz-monzonite, as well as dykes of aplite and granite-porphyry. They are mainly disseminated pyritic replacements along fissures and contain

[1] Hess, F. L.: U. S. Geol. Surv., Bull. 470, pp. 205-211.
[2] Lindgren, W.: "Mineral Deposits," 1919, pp. 862-5.

pyrite, enargite, tennantite, tetrahedrite, bornite, chalcocite, zinc blende, and a little chalcopyrite and covellite. There is a scant gangue of quartz. Extensive sericitization along the veins is characteristic. These veins are cut by a system of veins trending northwest and characterized by much enargite, besides most of the other minerals mentioned. Copper and arsenic have been leached from the zone of oxidation, which extends to a depth of about 300 feet. Below this is the zone of enrichment, containing secondary copper sulphides. In depth the enriched ore decreases in value, but low-grade ore of about 2·5 per cent copper persists to depths of 3,000 feet or more.

GOLD HILL,[1] UTAH

The greatest reserve of arsenic ore thus far developed in the United States is at Gold Hill, Tooele county, Utah. Butler,[2] in a brief description of the geological conditions, says:

> The sedimentary rocks have been intruded by a body of quartz monzonite which has been exposed by erosion and occupies numerous areas amid the sedimentary rocks. Many of the smaller limestone bodies appear to be underlain at no great depth by monzonite and in fact appear to be sedimentary blocks resting on monzonite. The general arrangement of the sedimentary and intrusive rocks suggests that the present surface is near the more or less irregular top of an extensive body that occupies a large area in the district.

Near Gold Hill limestone and shale form the eastern flank of the Deep Creek range and locally reach altitudes of 1,000 to 1,500 feet above the desert plateau. The member of these sedimentary rocks of most interest to the miner is a massive limestone approximately 2,000 feet thick. Overlying the massive limestone is several hundred feet of impure, sandy limestone and jasperoidal quartz, followed by 2,000 feet of shale and sandstone. Mineralization has consisted in the replacement of the limestone at its contact with the quartz monzonite by deposits of silver-lead arsenic ore. The commercial part of the ore-body, which is oxidized to the lowest levels, is a cellular mass of scorodite and brownish oxidized mineral (pharmacosiderite?), with small amounts of mimetite, cerussite, and monheimite. In the lower levels bismuth minerals have been found. Small residual masses of primary ore consist of arsenopyrite and small quantities of galena, pyrite, sphalerite, and chalcopyrite, named in the order of their relative abundance, together with a little gold and silver.

The principal ore-shoot has been developed on its dip of 53 degrees to a depth of 750 feet. It is as a whole lenticular, with horizontal cross-sections measuring between 7,000 and 8,000 square feet on the different levels. The ore crops out in a very distinctive manner as a heavy brown to black iron gossan, exhibiting a marked contrast with the light-coloured limestone. The arsenic content of the ore appears constantly large from the 700-foot level to the surface, except on the 400-foot level where it is small and spotty. This body of ore, on the 700-foot level, measures 290 feet in length and averages about 60 feet in thickness, although it has been opened in one place for an horizontal distance of 90 feet. A raise from the 700-foot level was in ore for about 125 feet, and a winze from the same level was in ore at a depth of 50 feet, with indications good for the continuance of the ore for another 100 feet.

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[1] Min. Res. of the U.S., pt. 1, pp. 165-167 (1923).
[2] Butler, B. S.: "Ore Deposits of Utah"; U.S. Geol. Surv., Prof. Paper 111, p. 473 (1920).

According to the record of the mining company, the average analysis of the ore shipped from May to October in 1923, most of it mined above the 300-foot tunnel level, was 2·6 ounces of silver, 0·8 per cent of lead, 0·2 per cent of copper, 12·1 per cent of insoluble matter, 24·9 per cent of iron, 0·4 per cent of lime, 1·4 per cent of zinc, 1·4 per cent of sulphur, and 21·3 per cent of arsenic. The sampling of the ore on the 700-foot level gave a higher assay for silver, lead, and iron, but less insoluble matter and less arsenic. An average of the most moderate estimates of ore in reserve is 250,000 tons of 20 per cent arsenic ore, which includes ore on the deepest level.

The Last Dollar (Gerster) property, on the west slope of the ridge, is developed by a 100-foot vertical shaft, with a short drift and crosscut driven northeast at the 90-foot level. After passing through a greenish shaly deposit of scorodite, ranging in content from 2 to about 15 per cent of arsenic, the shaft was continued in a body of massive arsenopyrite for 42 feet, to a depth of 72 feet, where the arsenopyrite changed to a mixture of arsenopyrite, galena, pyrite, and sphalerite, in a quartz gangue. Below these sulphides scorodite of commercial grade and arsenopyrite continued to the bottom of the shaft and in the drift from the 90-foot level. Possibly 50,000 tons of 20 per cent arsenic ore was opened through this development at the end of 1923.

JARDINE, MONT.[1]

The deposit at Jardine, near the north boundary of Yellowstone park, occurs in Precambrian micaceous schists, cut by large quartz dykes. It consists of lenses or veinlets of quartz, carrying arsenopyrite, pyrite, scheelite, and gold, which occur along shear zones or parallel to the schistosity of the intensely folded and contorted schists. The mineralizing solutions are believed to have ascended along certain permeable planes of schistosity. The deposits were formed largely by replacement of the soft schist, although there is also evidence of the filling of open spaces by quartz. Paralleling some of the ore-bodies is a dense band of quartz-biotite schist or "diorite," as it is called by the miners. The ore-bodies mined may be divided into three types: large masses of decomposed, iron-stained schist which carry small particles of arsenopyrite and gold; high-grade arsenical ore in which large crystals of arsenopyrite occur embedded in the "diorite"; and, siliceous ore consisting almost entirely of quartz but carrying paying quantities of gold and a small per cent of arsenopyrite. The ore-bodies occur as lenses in the mineralized zones and are in many places intersected by faults of varying age and magnitude. Individual lenses range in length from 300 to 800 feet and in width from 50 to 200 feet, with stoping widths of 3 to 20 feet. These ore-bodies have been developed by several open-pits and by twenty-four tunnels which lead to over 5 miles of crosscuts and drifts. The ore is said to contain about 4 per cent of arsenic and $7 in gold a ton. The mill, with a capacity of 200 tons a day, is said[2] to save $3 a ton in gold by amalgamation and to produce concentrates running 38 to 40 per cent arsenic and $40 to $60 a ton in gold. In 1923 an arsenic-recovery plant was installed at a cost of $12,000 and the concentrates are now roasted, the arsenic recovered, and the calcined residue cyanided or shipped to a smelter where the balance of the gold is extracted.

[1] Min. Res. of the U.S., pt. 1, pp. 167-169 (1923).
[2] Sayre, R. H.: Eng. Min. Jour.-Press, vol. 118, p. 931 (1924).

KEYSTONE, S.D.

Arsenic occurs[1] in numerous veins throughout an extensive area of the southern Black hills near Mystic and Hill City. The region is underlain by tilted Algonkian slates or schists which are traversed by shear zones and penetrated by quartz veinlets. Near Keystone the schists are cut by great pegmatite dykes from which an important production of spodumene, beryl, columbite, and tantalite is obtained. The Ida Florence and Bullion mines on the Liberty lode, 1½ miles from Keystone, were reopened in 1923. Arsenopyrite[2] in a quartz vein in schist is the principal gold-bearing mineral. The ore is said to average $5 in gold and contains 12 per cent of arsenic. The ratio of concentration is 3½ to 1. A 10-stamp mill, with concentrators and an arsenic-recovery plant, have been erected.

MANHATTAN, NEV.[3]

Manhattan district lies within one of the smaller ranges of the Great Basin area. The region is underlain by folded sediments of Palæozoic age, Mesozoic granitic rocks, Tertiary volcanic and intrusive rocks, and Pleistocene gravels. The sediments have been intensely altered and metamorphosed by the intrusion of great masses of granite and related rocks. The principal ore deposits are associated with closely folded and faulted beds of schistose slate, quartzite, sandstone, and limestone. These rocks comprise the Gold Hill formation and are thought to be Cambrian in age. The most important member of the series is the White Caps limestone, in which large bodies of ore have been formed by replacement. The principal deposits of arsenical ore in the district occur at the White Caps mine where the limestone contains many cavities filled with realgar, orpiment, and stibnite. The cavities owe their origin to the loss in volume due to solution of the limestone or due to its replacement by quartz. Pyrite and auriferous arsenopyrite occur as finely disseminated crystals in the siliceous parts of the limestone. The gangue minerals are calcite, quartz, and, less commonly, dolomite, fluorite, and mica. The realgar and orpiment are auriferous, but visible gold is completely lacking even in the upper, oxidized parts of the deposit.

In 1920 the White Caps mine was developed by seven levels, the lowest at a depth of 800 feet below the collar of the shaft. Recent work has extended the depth to 920 feet. The ore is all within the White Caps limestone which is cut by four major faults. The two principal zones of mineralization lie on the two sides of the White Caps fault. To the east of the fault the ore-body has yielded ore from the surface to the 800-foot level and to the west from the 100-foot to the 550-foot level. Orpiment is present in minor amount only, and is rarely found as low as the 450-foot level or in any quantity above the 310-foot level. Realgar is present below the 310-foot level to the bottom of the mine, but occurs in greatest abundance between the 450 and 665-foot levels. On the 800-foot level it is present in small amounts only. The realgar is thought by Ferguson to be of hypogene origin and not derived by alteration of the relatively small amount of arsenopyrite in the primary ore. The orpiment has been derived from realgar, presumably through the action of oxidizing waters.

[1] Sayre, R. H.: Eng. Min. Jour.-Press, vol. 118, pp. 931-2 (1924).
[2] Min. Res. of U.S., 1923, pt. 1, p. 169 (1923).
[3] Ferguson, H. G.: U.S. Geol. Surv., Bull. 723 (1924).

MONTE CHRISTO, WASH.[1]

Monte Christo district is situated on the western slope of the Cascade range about 40 miles due east of Everett. The region is underlain by early Tertiary sediments, chiefly arkoses, and extrusive masses of andesite. These rocks were intruded by bodies of tonalite. Further outpourings of lava took place towards the close of the Tertiary when the area was uplifted and the rocks greatly fractured. Then followed the period of erosion and ore-deposition which, though most pronounced during the Pleistocene, has continued to the present.

The ore deposits occur chiefly along joints and fractures in the bodies of tonalite, in fewer cases in the other igneous rocks, and rarely in the sedimentary arkose series. The mineralization consists largely of sphalerite, galena, and chalcopyrite in the upper zones, and of arsenopyrite and pyrite in the deeper zones. Realgar, as an alteration product of arsenopyrite, is quite common. Among the rarer minerals in the deposits are chalcocite, bornite, molybdenite, and stibnite. The gangue consists of quartz and calcite with some epidote and amphibole developed in the wall-rock near the veins. The ores carry relatively small amounts of gold and silver. The chief oxidation products are malachite, limonite, hematite, melaconite, and scorodite.

It is thought that the deposits owe their origin to downward-moving surface waters which circulated along joints in the tonalite, replacing it and distributing from the surface downward the various minerals, roughly in the order of their relative facility of precipitation. The zone of maximum water circulation is as a rule less than 250 feet below the surface. This accounts for the fact that the mineralization decreases from the surface downward and disappears at no great depth. It is not thought that the district can furnish any large quantity of arsenical ore.

OTHER COUNTRIES

AUSTRIA

A small production of arsenic has been derived from arsenical slimes shipped to Freiberg smelting works from the mine of the Gewerkschaft Rathausberg in Salzburg. This section of the Austrian East-Alps contains the largest gold deposits in Europe. These deposits[2] occur as veins traversing the Sonnblick massif of granite-gneiss. The veins have an average width of about 5 feet and consist of quartz containing löllingite, arsenopyrite, pyrite, chalcopyrite, galena, and various silver-antimony compounds. The ore reserves were estimated in 1923 at 18,000,000 tons. In addition to gold, silver, and lead it is thought that arsenic, to the extent of 460,400 tons, could be obtained from the deposits.

CHILE

Small quantities of orpiment occur in the province of Copiapo. The primary ore of the great copper deposit at Chuquicamata contains enargite, but in amounts too small to be of commercial importance.

[1] Spurr, J. E.: U.S. Geol. Surv., Ann. Rept., pt. II, pp. 785-865 (1900-1901).
[2] Geol. Zentralblatt, vol. 29, No. 1331, p. 451 (1923).

CUBA

Exploration[1] on the isle of Pines, off the southwest coast of Cuba, is said to have developed about 3,000,000 tons of gold-silver ore valued at $5 a ton, which also contains about 5 per cent of arsenic and 5 per cent of antimony. The vein is said to crop out for more than 8,000 feet and to have an average width of 45 feet.

GREECE[2]

White arsenic, amounting to about 60 tons a month, is recovered as a by-product from the smelting of silver-lead ores. Most of the output is shipped to France.

INDIA[3]

Arsenic sulphide was reported, in 1922, to occur near the village of Partsan in Chitral. The mineral realgar is disseminated in calcareous shale over a width ranging from a few inches to several feet. The deposit is associated with rocks o Cretaceous age.

ITALY[4]

An antimony mine in the commune of Iglesias, province of Cagliari, Sardinia, produced in 1921, 60 metric tons of ore containing 38 per cent of arsenic.

PERU[5]

Arsenic occurs in the ore of the famous quicksilver mine at Huancavelica. The district is underlain by Jurassic shales, conglomerates, sandstones, and limestones. Young eruptive rocks and occasionally granite are present. The deposit is a bed-like impregnation zone in close connexion with fractures in the sandstone. The minerals present are: pyrite, arsenopyrite, realgar, orpiment, calcite, and barite.

PORTUGAL[6]

Arsenic is mined in severa' localities in Portugal, but chiefly at the Minas de Pintor which lies about 30 kilometres south of Oporto and is operated by the Anglo-Peninsular Mining and Chemical Company, Limited. The ore consists of arsenopyrite and occurs in veins in granite. The output of the Portuguese refineries is estimated at 800 to 1,200 tons of white arsenic per annum.

SPAIN[7]

White arsenic has been recovered from ores mined at several localities in the provinces of Coruña and Orense in northwestern Spain. Deposits containing arsenopyrite also occur in northeastern Spain in the province of Gerona. The mines in the provinces of Gerona, Coruña, and Ponte-

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[1] Eng. and Min. Jour.-Press, vol. 115, p. 132 (1923).
[2] U.S. Geol. Surv., Min. Res. of the U.S., pt. 1, p. 177 (1923).
[3] Ibid., p. 180.
[4] Ibid., p. 178.
[5] Stelzner-Bergeat: "Die Erzlagerstätten," vol. 2, p. 916 (1905-6).
[6] Foote, F.W., and Ransom, R.S.: Eng. and Min. Jour.-Press, vol. 106, p. 47 (1918).
[7] U.S. Geol. Surv., Min. Res. of the U.S., pt. 1, p. 179 (1923).

vedra are said to be capable of supplying 6,000 to 8,000 tons of ore containing from 25 to 35 per cent of arsenic annually. The arsenic content of the pyritic deposits at Rio Tinto in the province of Huelva is said to be too small to warrant its recovery as a by-product. At Mieres,[1] in Asturia, realgar, orpiment, and native arsenic are associated with cinnabar in a brecciated bed lying between schist and quartzite of Upper Carboniferous age.

SWITZERLAND[2]

There is no production of arsenic in Switzerland and only one deposit of arsenical ore is worked. This deposit is at Lusin-sur-Salanfe, near Salvan, Bas Valais. The arsenical mineral is leucopyrite, containing from 30 to 40 grammes of gold to the ton. About 100 tons of the ore were exported to Lyon in 1923.

TURKEY[3]

Considerable orpiment has been produced in the past from mines in Asia Minor. The chief deposits of arsenic lie near Yenikeui on the sea of Marmora; at Zara in the province of Sivas in eastern Anatolia; in the province of Van in Armenia; and in the province of Adrianople. The chief source of arsenic in 1922 was the Baltia lead mines which produced 200 tons of arsenical ore in that year.

GENERAL CONCLUSIONS

Arsenic enjoys a widespread distribution and is not confined to any one country, nor to any one section of the globe.

The foreign countries having important reserves of arsenical ore are: United States, United Kingdom, Australia, Japan, Germany, Mexico, France, and Southern Rhodesia.

The world supply of arsenical ore is adequate to satisfy all requirements for some time to come, especially if the price of white arsenic should become stabilized at a figure which would make the development of known resources profitable.

Changes in the demand for arsenical products will be accompanied by corresponding fluctuations in the price of white arsenic, which in turn may be followed by periods of over- and under-production.

White arsenic recovered as a by-product of smelting operations carried on primarily for gold, silver, lead, zinc, copper, and tin, will form the most reliable and uniform contribution to the world supply. The amount obtained in this way will be regulated by the arsenic content and tonnage of ore being treated from time to time.

Freight charges are an important item in the distribution and marketing of arsenical ores and white arsenic.

Arsenical deposits exhibit considerable diversity in form, mode of occurrence, origin, mineral association, and richness. Although individual occurrences may differ widely from one another, taken as a whole the various types, by duplication of certain characteristics, show a tendency to merge one into the other.

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[1] Stelzner-Bergeat: "Die Erzlagerstätten," vol. 2, p. 890 (1905-6).
[2] U.S. Geol. Surv., Min. Res. of the U.S., pt. 1, p. 178 (1923).
[3] Chem. and Met. Eng., vol. 29, No. 21, Nov. 19 (1923).

Most arsenical deposits appear to owe their origin to emanations given off during differentiation of intrusive bodies of acid igneous rock, chiefly granite. These emanations may take the form of dykes of pegmatite or aplite; they may be localized in fractures or openings to form fissure veins; they may impregnate rocks of favourable structure and composition and by so doing give rise to replacement bodies or veins at some distance from the intrusion; they may be responsible for the formation of contact-metamorphic deposits in the immediate vicinity of the intrusion; and they may be injected as masses of sulphide or oxide, formed as a result of magmatic differentiation, into the overlying rocks. Only in rare instances are arsenical deposits affiliated with basic igneous rocks.

Arsenic-bearing deposits may be classified as follows:

(A) *Those of primary or hypogene origin*

(1) *Pegmatites.* Arsenic-bearing pegmatites usually contain most or all of the following elements: Sn, Wo, Mo, Bi, Sb, Cu, Pb, Zn, Li, F, B; and some Au, Ag, and Ur.

(2) *Vein-like deposits*

(*a*) Fissure-veins or those in which the vein matter is confined to fractures or openings without appreciable replacement of the wall-rocks. In such deposits arsenic is commonly associated with Au and in fewer cases with Ag, Pb, Cu, Zn, Sb, Bi, or Hg. The close genetic connexion between some fissure veins and pegmatites is indicated by the occasional presence of Sn, Wo, Mo, B, and feldspar. The gangue is usually quartz, in some cases with carbonates.

(*b*) Deposits due to a combination of fissure filling and replacement. Such deposits lose their vein-like character, lack distinct walls, and become irregular in form where replacement has been the dominant process of mineralization. Arsenic is usually associated with Au, Ag, Cu, Pb, Zn, Co, Ni, Sb, or Bi in deposits of this type. The gangue consists of quartz, carbonates, or country rock.

(*c*) Deposits due largely to replacement. These are characterized by extreme irregularity in form and by lack of distinct walls. In such deposits arsenopyrite or löllingite is usually accompanied by sulphides of Cu, Pb, Zn, and Fe. Gold and silver may or may not be present. The gangue is mostly unmineralized country rock.

(3) *Contact-metamorphic deposits.* Deposits of this type are very irregular in form; they lack distinct walls; and are characterized by the development of silicates of Mg, Ca, Al, and Fe near the intrusive contact. Arsenic occurs as arsenopyrite or löllingite associated with sulphides of Cu, Pb, Zn, and Fe, in some cases with hematite or magnetite. Occasionally Au and Ag may be present.

(4) *Igneous Injections.* Arsenic may, in rare instances, accompany the injection of masses of iron and nickel sulphides, or magnetite, resulting from magmatic differentiation. Sperrylite ($PtAs_2$) probably occurs in this way.

(B) *Those of secondary or supergene origin*

The action of descending surface waters on deposits of primary arsenical minerals results in the leaching out of arsenic or the formation of oxidized and hydrated (secondary) compounds such as: scorodite, cobalt bloom, nickel bloom, arsenolite, etc. Native arsenic, realgar, and orpiment are also formed in this way.

CHAPTER VI

STATISTICS

White Arsenic Production in Canada

Year	From ores treated in Canada		From ores exported	
	Short tons	Market value	Short tons	Value to shipper
		$		$
1885	440	17,600	....	....
1886	120	5,460	....	....
1887	30	1,200	....	....
1888	30	1,200	....	....
1889	Nil	Nil	....	....
1890	25	1,500	....	....
1891	20	1,000	....	....
1892–3	Nil	Nil	....	....
1894	7	420	....	....
1895–8	Nil	Nil	....	....
1899	57	4,872	....	....
1900	303	22,725	....	....
1901	695	41,676	....	....
1902	800	48,000	....	....
1903	257	15,420	....	....
1904–5	Nil	Nil	....	....
1906	201	14,058	....	....
1907	330	36,209	656	11,094
1908	715½	41,060	986	17,506
1909	1,129	64,100	224	3,346
1910	1,502	75,328	547	5,716
1911	2,097	76,237	....	....
1912	2,045	89,262	....	....
1913	1,692	101,463	....	....
1914	1,737	104,015	....	....
1915	2,396	147,830	....	....
1916	2,186	262,349	....	....
1917	2,656	658,231	280	11,200
1918	2,482	520,525	1,078	43,114
1919	2,859	488,706	530	21,218
1920	1,831	425,617	628	22,231
1921	1,491	233,763	Nil	Nil
1922	2,058	299,940	518	21,097
1923	3,036	731,583	609	*146,765

*Market value.

The exports of white arsenic and of metallic arsenic from Canada since 1913 were as follows:

Exports[1]

Year	White arsenic		Metallic arsenic	
	Short tons	Value	Short tons	Value
		$		$
1913	1,303	107,094	....	....
1914	1,876	132,567	....	....
1915	2,318	174,190	....	....
1916	1,975	197,458	....	....
1917	2,286	507,898	....	....
1918	2,672	393,883	....	....
1919	2,506	355,654	....	....
1920	1,655	313,311	....	....
1921	767	108,535	....	....
1922	1,367	198,005	222	5,238
1923	1,564	348,646	588	25,003

[1] Figures 1885-1920 taken from "Reports of the Mineral Production of Canada," published by the Mines Branch, Dept. of Mines, Canada.

Figures 1921-1923 taken from "Mineral Production of Canada," published by the Dominion Bureau of Statistics, Ottawa.

Imports[1]

Year	White arsenic		Sulphide of arsenic		Arsenate of soda	
	Pounds	Value	Pounds	Value	Pounds	Value
		$		$		$
1913	18,788	1,961	455,394	17,759	22,892	987
1914	5,012	249	11,494	756	14,389	604
1915	14,222	657	171,993	5,415	9,090	503
1916	41,090	7,086	239,991	11,839	15,779	1,228
1917	247,610	32,083	252,848	22,053	4,469	588
1918	995	222	301,985	33,351	121	34
1919	4,706	1,325	304,694	26,613	5,566	1,661
1920	962	201	337,153	43,445	48,863	10,568
1921	1,847	230	185,685	26,348	11,993	3,002
1922	441,168	32,520	525,246	39,264	7,961	1,402
1923	457,522	66,280	7,339	1,244	4,940	475

[1]Figures 1913-1920 taken from "Reports on the Mineral Production of Canada," published by the Mines Branch, Dept. of Mines, Canada.

Figures 1921-1923 taken from "Mineral Production of Canada," published by the Dominion Bureau of Statistics.

World's Production of White Arsenic and Arsenic Ore, 1915-1924, in Metric Tons

Country	Form	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924
Australia........	As_2O_3	....	....	10	67	1,100	381	627	702	987*	573*
"	Ore	....	11	91	910	6	1,793	1,124	3,688	11,677*	(a)
Austria..........	Ore	....	18	(a)	(a)	(a)	46	54	103	553	(a)
Belgium..........	As_2O_3	....	....	....	....	50	(a)	(a)	1,008	(a)	(a)
Brazil...........	As_2O_3	....	....	....	....	....	127	127	154	162	(a)
Canada..........	As_2O_3	2,174	1,983	2,663	3,230	3,075	2,231	1,353	2,337	2,912	2,119
China (exports).	AsS	8	431	259	99	225	472	258	549	413	(a)
"	As_2O_3	49	59	51	39	58	49	100	30	176	(a)
Chosen (Korea).	As_2O_3	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	95	(a)
"	Ore	(a)	(a)	(a)	(a)	(a)	(a)	(a)	56	26	(a)
Czecho-Slovakia	Ore	....	....	....	....	....	....	....	....	24	(a)
France..........	As_2O_3	323	874	677	993	735	606	328	425	(a)	(a)
"	Ore	1,300	1,800	344	728	600	582	580	790	4,245	10,552
Germany........	As_2O_3	1,456	1,280	2,081	3,592	1,475	2,077	2,342	2,000	(a)	(a)
Greece..........	As_2O_3	....	....	436	(a)	686	854	768	967	1,176	(a)
Italy............	Ore	....	....	....	....	3	....	60	450	206	(a)
Japan............	As_2O_3	15	....	....	245	835	933	1,395	2,044	4,287	(a)
"	Ore	....	....	....	830	968	2,173	1,506	2,295	4,245*	(a)
Mexico..........	As_2O_3	....	....	1,285	1,881	2,246	2,183	785	272	1,402	1,283
Norway.........	Ore	....	....	....	12	20	....	....	....	577	(a)
Portugal.........	As_2O_3	859	(a)	(a)	(a)	536	653	268	(a)	(a)	(a)
"	Ore	146	(a)	(a)	(a)	62	62	11	(a)	(a)	(a)
S. Rhodesia.....	As_2O_3	....	....	....	103	220	396	327	451	774	534
Spain............	As_2O_3	83	73	61	104	42	76	....	....	(a)	(a)
"	Ore	....	....	....	250	150	1,000	....	....	(a)	(a)
Switzerland.....	Ore	....	....	....	....	....	....	39	10	(a)	(a)
Turkey..........	Ore	....	....	....	....	162	14	(a)	200	(a)	(a)
Union of S. Africa.........	As_2O_3	....	....	3	13	7	10	2	3	5	(a)
United Kingdom	As_2O_3	2,536	2,586	2,668	2,387	2,568	2,029	1,049	994	1,631	3,259
	Ore	428	305	441	485	76	1,197	(a)	360	741	304
United States...	As_2O_3	4,988	5,430	5,580	5,736	5,469	10,434	4,342	9,096	12,946	13,112

(a) No data available.
*Incomplete returns.
Table compiled from data given in Mineral Resources of the United States, U.S. Geol. Surv., pt. 1, p. 171 (1923), and pt. 1, pp. 42-3 (1924).

Statistics of Arsenic in the United States[1]

(Short Tons)

Year	White arsenic					Sulphide of arsenic	
	Production	Imports	Supply			Imports	
	Tons	Tons	Tons	Value	Per ton	Tons	Value
				$	$ cts.		$
1913..............	2,513	1,519	4,032	292,833	72 62	3,344	285,537
1914..............	4,670	1,594	6,244	422,268	67 42	2,040	165,266
1915..............	5,498	1,400	6,898	415,793	60 28	1,787	154,517
1916..............	5,986	1,071	7,057	663,063	93 96	1,090	124,844
1917..............	6,151	1,178	7,329	1,382,847	188 50	2,776	410,341
1918..............	6,323	1,847	8,170	1,654,212	202 47	5,651	998,011
1919..............	6,029	4,389	10,418	1,804,494	174 17	2,151	316,687
1920..............	11,502	3,740	15,242	2,553,991	167 95	4,080	684,016
1921..............	4,786	1,669	6,455	970,950	150 42	3,343	531,322
1922..............	10,027	2,542	12,569	1,819,219	144 74	3,815	472,044
1923..............	14,271	10,152	24,423	4,794,201	196 29	1,097	268,311
1924..............	14,453	8,877	23,330	4,252,448	182 27	234	45,246

[1]From "The Mineral Industry," vol. 33 (1924).

INDEX TO LOCALITIES AND DEPOSITS