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Énergie et Ressources naturelles Québec

PROVINCE OF QUEBEC, CANADA

DEPARTMENT OF MINES

GEOLOGICAL REPORT 20

GEOLOGY OF QUEBEC

VOLUME III

ECONOMIC GEOLOGY

JOHN A. DRESSER and T. C. DENIS

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PREFATORY NOTE AND ACKNOWLEDGMENTS

This volume describes the mineral resources of the Province of Quebec, as far as they are known at this time. It does not attempt to give full descriptions of all the known developed and undeveloped mineral resources of the Province but is to be regarded rather as a report of progress which, it is hoped, may assist in the discovery of new deposits.

In the first and main section of the volume, the principal gold, with some associated base-metal, deposits are discussed, grouped for description according to their regional occurrence. Following this is a chapter dealing with deposits of the base metals, in which the arrangement is alphabetical. The final chapters of the volume are devoted to a discussion of deposits of the non-metallic 'industrial' minerals and of minerals and rocks that are used as building materials.

Areas of active production are described in what is thought to be suitable detail; areas that are inactive, whether from exhaustion or other conditions, are treated less minutely; and new areas of probable or possible production are described as fully as circumstances permit.

The general geology and structure of each area is discussed only at sufficient length to clarify the geological setting of the mineral deposits. For more detailed accounts, the reader is referred to Volume II, *Descriptive Geology*, published in 1944.

Many persons have contributed in various ways to the completion of Volume III, to all of whom we offer sincere thanks. The managers of the operating mines afforded ready access to their properties and to their records, including those of exploration and discovery. In several instances, members of their staffs were assigned to help us, and gave much valuable assistance in local examinations and otherwise. Where they have made written contributions to the volume, these are duly acknowledged in the text.

The descriptions of the mineral deposits of the Precambrian region were assembled for the most part by JAMES B. MAWDSLEY, Professor of Geology, University of Saskatchewan, who had previously made extensive study in that part of the Province as an officer of the Geological Survey of Canada, and, later, in active consulting practice. Certain individual deposits or groups of deposits are described in detail by other geologists, who have special knowledge of them. These include: MORLEY E. WILSON, Geological Survey of Canada, the Powell and Granada mines; PETER PRICE, Chief Geologist for Noranda Mines, Limited, the Horne mine and the Waite-Amulet group; BERTRAND T. DENIS, Quebec Department of Mines, the Guillet Lake group; J. W. AMBROSE, Geological Survey of Canada, the deposits of brucite in the Wakefield locality; J. E. GILL, McGill University,

the Beauchastel area; E. W. SHAW, the Mic-Mac mine; E. B. GILLANDERS, the Siscoe mine; and G. F. FLAHERTY, the western Cadillac group. Many others have aided with data that are acknowledged in the text.

In southern Quebec, I. W. JONES, Quebec Department of Mines, prepared a review of the mineral prospects of Gaspé peninsula; F. J. ALCOCK, Geological Survey of Canada, described the zinc and lead deposits of Lemieux township; and H. W. McGERRIGLE, Quebec Department of Mines, the placer gold deposits of southern Quebec.

R. C. ROWE, Mining Engineer, Editor of *The Canadian Mining Journal*, furnished a review of the graphite industry in Quebec, with which he has had intimate experience. E. J. CARLYLE, Secretary of the Canadian Institute of Mining and Metallurgy, gave much appreciated help at various times, affording the use of the library of the Institute and numerous photographs and plates for reproduction. For many of the photographs used to illustrate the volume, and for permission to publish them, we are indebted to the Geological Survey of Canada and the Department of Mines of Quebec. As for the preceding volume, R. P. D. GRAHAM, McGill University, edited and in large part re-wrote the manuscript and attended to the printing.

JOHN A. DRESSER
T. C. DENIS

DEPARTMENT OF MINES OF THE
PROVINCE OF QUEBEC,
JUNE, 1949

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Surface plant of Horne mine and smelter
of Noranda Mines, Limited

MINERAL DEPOSITS OF QUEBEC

GENERAL INTRODUCTION

In describing and discussing the mineral deposits of the Province, two alternative methods of treatment suggest themselves: (1) To adopt the method customary in presenting statistics of mineral production, that is, to subdivide the mineral products as metallics, industrial minerals, and building materials, and to deal, alphabetically or in order of importance, with the several items within each division. (2) To describe the deposits, of whatever nature, occurring within each of certain natural geological sub-divisions of the Province and, for this purpose, the regions selected might best be: (*a*) Ungava, or New Quebec; (*b*) Western Quebec, or the Abitibi region; (*c*) the Grenville region; and (*d*) the St-Lawrence region, including the Eastern Townships and Gaspé peninsula.

A disadvantage of the first method is that deposits of the ores of certain of the metals, for example zinc and lead, are found in two or more of these natural geological regions — in the case of lead and zinc, in Abitibi, in the Grenville region, and in Gaspé peninsula.

A disadvantage of the regional treatment is that descriptions of deposits of the ores of certain metals would not follow one another consecutively but would appear in widely separated sections of the volume.

However, it so happens that, in Quebec, important deposits of ores of certain metals, and also of certain industrial minerals, are largely restricted to a single geological sub-division or region. Thus, almost the whole of the gold production, a very large proportion of the copper, zinc, and lead, and the whole of the production of certain other metals, as arsenic, selenium, and tellurium, is derived from deposits in the 'Abitibi' region; the largest deposits of titaniferous iron ore and of many of the industrial minerals, such as feldspar and mica, are found in the 'Grenville' region; the whole of the asbestos, talc, and chromite output comes from deposits in the Eastern Townships; and New Quebec contains the only large known deposits of iron ore of possible economic importance.

Balancing the advantages and disadvantages of the two methods of treatment outlined, it has been deemed best, in the present volume, to adopt, primarily, the regional scheme. Since almost the whole of the present gold production of the Province comes from deposits in one single region — Western Quebec — descriptions of all the important producing gold mines and known gold occurrences will be found in this regional section of the Volume. Included also are brief descriptions of occurrences of copper and other base-metal sulphide mineralization, since they are frequently closely associated with the gold deposits. Mines from which these base metals are produced, however, are described in a following chapter which deals, in alphabetical order, with all base metals of which there is production in the Province.

Separate chapters are then devoted to the 'industrial' minerals and the minerals and rocks used as building materials.

A number of statistical tables of production are included at the end of the volume.

UNGAVA or NEW QUEBEC

(See Volume II, pp. 227-249)

INTRODUCTION

Ungava, or New Quebec, embraces territory, formerly known as the District of Ungava, which was incorporated in the Province of Quebec in 1912, under the Quebec Boundaries Extension Act. It includes all that portion of the Province lying north of Eastmain river and the height-of-land extending eastward from the headwaters of that river to Labrador, a meandering line which lies generally between latitudes 52° and 53° (see Figure 1). The region is bounded on the west by James bay and Hudson bay, on the north by Hudson strait and Ungava bay, and on the east by the Quebec-Labrador boundary. This boundary, defined in 1927 by a ruling of the Judicial Committee of the Privy Council as the height-of-land of the Atlantic drainage, has not yet been surveyed.

Geological mapping of this vast area of approximately 270,000 square miles has been limited almost entirely to reconnaissance surveys adjacent to the coast and to some of the main waterways of the interior, carried out by Robert Bell between the years 1875 and 1902 and by A. P. Low between 1885 and 1904 — both in the service of the Geological Survey of Canada. In more recent years, other officers of the Geological Survey have done a limited amount of mapping in selected areas, and some exploration has been carried out by mining and prospecting companies in the search for mineral deposits. While, as a result of this work, the broad features of the geology of the region are known, we have little detailed knowledge of the distribution and relationship of the several formations represented. The following summarized outline of the geology is reproduced from Volume II (p. 228):

> "It would appear . . . that southeast of a line between Mistassini lake and the headwaters of Hamilton river, the rocks encountered are predominantly gneisses, quartz-, mica-, and garnetiferous-schists, and crystalline limestones, together with anorthosite and other intrusive bodies. On the other hand, to the northwest of this line, occurrences of presumably Archæan volcanics and associated sediments have been reported in a number of localities, as well as more recent, less disturbed sediments of Huronian or at least Proterozoic type. The presumably Archæan volcanic and sedimentary assemblages occur along the east coast of Hudson bay in the region of cape Smith and at intervals southward to near Portland promontory and, still farther southward, on the Great Whale (south branch), Eastmain, Broadback, and Nottaway rivers. Three general areas of presumably late-Precambrian sediments of Huronian type have been mapped: on the east coast of Hudson bay and on the off-shore islands between Portland promontory and cape Jones; a large area in the interior, along the Koksoak and Kaniapiskau rivers; and in the basin of Mistassini lake. It has been suggested that the Mistassini sediments may be Palæozoic, but they have been little studied.
>
> "Sediments that are definitely of Palæozoic age occupy a large area along and inland from the south coast of James bay, mainly in

Ontario but extending eastward into Quebec as far as the mouth of Nottaway river; and they are found also on Mansel or Mansfield island, about forty miles off the northern part of the east coast, and on Akpatok island in the northern part of Ungava bay".

Topographically, the region is a lake-studded plateau, with local relief rarely more than 300 to 400 feet. Its highest part, the watershed between Hudson bay and the Atlantic ocean and St-Lawrence river, rises to between 2,000 and 2,500 feet above sea level. Southward from James bay and Ungava bay, the country is generally low for a considerable distance inland, but the coasts of Hudson bay and Hudson strait are high and rocky, with elevation

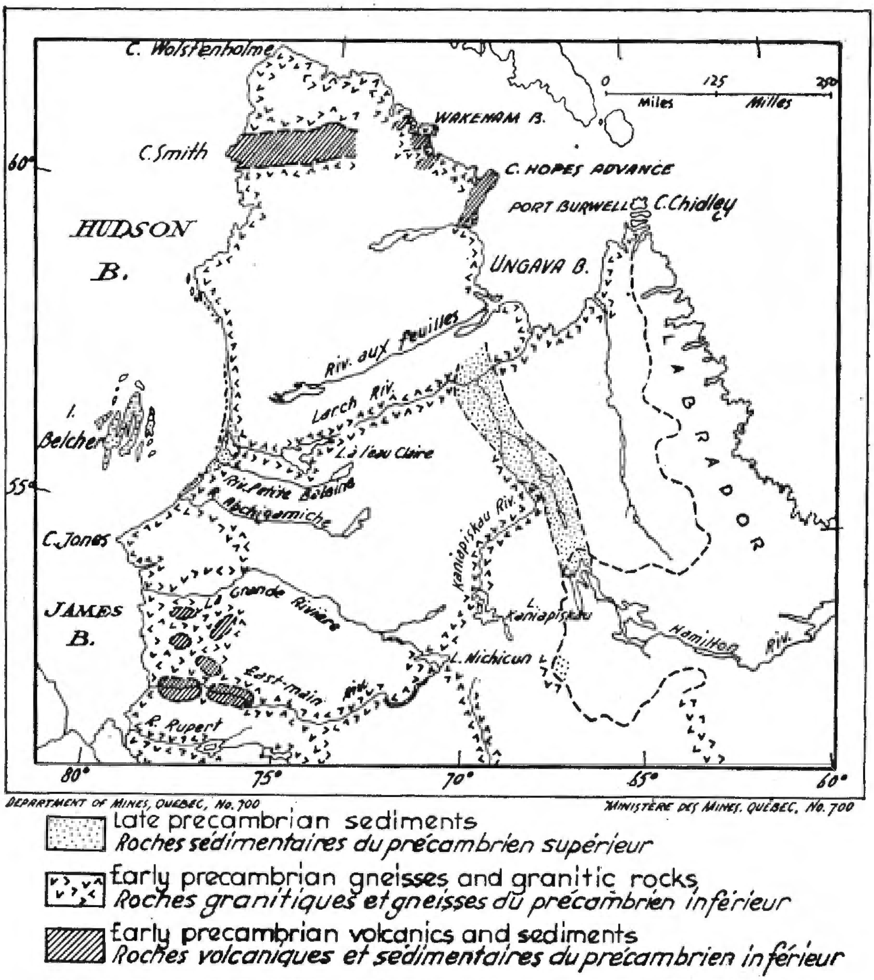


FIGURE 1.—*Territory of New Quebec:* Areas known to be underlain chiefly by: early Precambrian volcanics and some sediments, diagonal lines; early Precambrian gneisses and granitic rocks, v symbol; and, late Precambrian sediments, dots.

of 1,000 feet within a short distance of the sea, followed by a sharp rise to a general elevation of 1,500 to 2,000 feet. Lakes abound in the west-central and southeastern part of the region but are relatively few in number eastward from James bay for about 100 miles, where bed-rock is heavily mantled by post-glacial marine sands and clays. Marine beaches 435 feet and 675 feet above sea level at cape Smith and Richmond gulf, respectively, along the eastern shore of Hudson bay, show that, in this western part of the plateau, post-glacial uplift has been considerable.

Sulphide and gold mineralization is known in several localities, notably in a belt of 'greenstones' extending eastward from cape Smith, and iron formation, some of which is of ore grade, is extensively developed at Richmond gulf and on off-shore islands along the east coast of Hudson bay, and at the headwaters of Hamilton river. Up to the present, however, no producing mines have been developed in the region.

Extensive deposits of high-grade hematitic iron ore have been discovered in the region extending to the north and to the south on both sides of the height of land — as yet uncharted — separating the Atlantic drainage basin from the Hudson Strait basin, between longitudes 66° and 68° West. Systematic exploration and development of these deposits, commenced in 1942, are proceeding satisfactorily. A large future production of iron ore from this region appears assured (see pages 402-404).

Mineral Occurrences

Sulphide Deposits in Greenstone Belt at Cape Smith

In the course of his exploration along the east coast of Hudson bay in 1898, Low (1903*a*) observed sulphide mineralization and quartz veins in 'diabase trap' in the vicinity of cape Smith. Assays of material collected by him showed that the sulphides contained both copper and nickel — though in very minor amount — and he suggested that the occurrences warranted further examination. Owing to its remoteness, however, the area had little attraction for the prospector. Cape Smith is about 125 miles south of cape Wolstenholme and 675 miles north of Moose Factory, at the head of James bay. It has direct connection with the outside world only once a year, when a Hudson's Bay Company supply ship calls at the Company's post on Smith island.

It was not until 1931 that a serious attempt was made to investigate the economic possibilities of the deposits. In that and the two succeeding years, a field party in charge of W. B. Airth and financed jointly by the Cyril Knight Prospecting Company, Huronian Mining and Finance Company, Newmont Exploration, Limited, and Quebec Prospectors, Limited, did a considerable amount of exploration work and geological mapping in the area. Large bodies of sulphides, chiefly pyrrhotite with lesser pyrite, were discovered on Smith island and the neighbouring mainland, and similar mineralization was encountered at intervals along a 'greenstone' belt (Figure 2) which, with a width up to forty miles, extends eastward from cape Smith for at least 150 miles inland and possibly continues completely across the peninsula to Wakeham bay, on Hudson strait (Airth, 1933). The results of systematic sampling of these deposits were disappointing. The

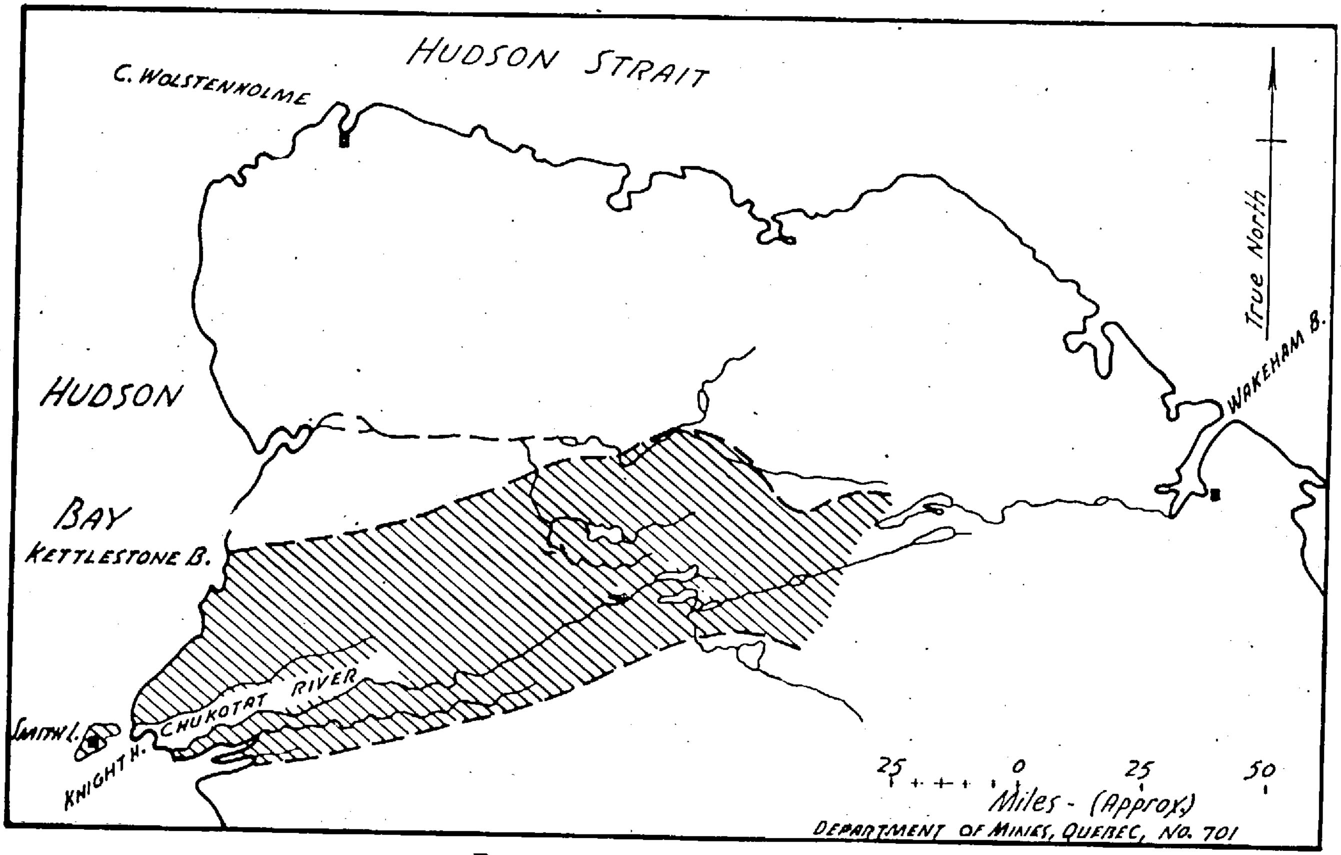


FIGURE 2.—*Cape Smith greenstone belt.*

companies concerned reported that assays of the sulphides revealed only 'traces' of copper, nickel, and gold, and that none of the quartz veins examined contained gold in important amount. During the summer of 1933, H. C. Gunning, of the Geological Survey of Canada, made a brief examination of the geology and sulphide deposits of the area. Summarizing his conclusions concerning the economic possibilities of the belt, he says (1934, p. 154):

> "The deposits examined by the writer, and sampled during 1933, represent but a small part of a long zone in which similar mineralization is known to occur. It is obvious, therefore, that the disappointing results obtained do not necessarily apply to the whole zone. Nevertheless, the work done shows that, within a length of some twenty miles along the mineralized zone, all the sulphide bodies examined are much too low grade to encourage development. Further, all the mineralization examined by the writer within this twenty-mile stretch is remarkably uniform in grade, appearance, and occurrence. We have to do, therefore, not with a series of deposits that are, *on the average*, very low grade, with some minor encouraging enrichments, but that *all* are uniformly poor with no known enrichments of any importance whatever. Possibly these deposits are products of a magma that contained only very minute amounts of copper and nickel and was incapable of producing deposits that contained commercial quantities of these metals. At least such a possibility should be borne in mind in considering the likelihood of finding commercially valuable deposits elsewhere in the lengthy zone in which similar mineralization is known to occur.
>
> "The preceding statement applies only to sulphide deposits that occur within a relatively narrow zone trending about N.60°E. from the south side of Smith island and should not be taken as constituting a condemnation of the mineral possibilities of the whole greenstone belt running east from the Hudson bay. The belt has been barely explored, not to say prospected, and it compares favourably in size with any of the larger areas of similar rocks that, throughout the Canadian shield, are generally considered to constitute favourable ground for prospecting".

Following are brief descriptions of the deposits in the vicinity of cape Smith.

Round Lake, ¾ mile east of Knight harbour

A sulphide body occurs here in dark grey slates and fine grained grey tuffs exposed along the west face of an abrupt hill, about 100 feet high, of augite diorite. Farther to the west, the ground is drift covered. The massive sulphides are well exposed along the base of the hill over a length of some 1,700 feet, beyond which, to the north, they are concealed by drift and, to the south, pass gradually to poorly mineralized tuffs. The exposed width of sulphides varies between 18 inches and about 20 feet, but in most places the footwall is drift covered. The sediments here form the nose of a broad anticline, modified by a series of generally tightly compressed minor anticlines and synclines, all plunging to the northeast, and the sulphide body is widest along the minor anticlines. Along the crests of these minor folds, the overlying diorite is fractured and in places sheared, and is cut by irregular, barren quartz veins, locally in swarms. From the exploration work, it appeared that these veins in the diorite were an indication of sulphides in the sediments beneath, and this belief received support from a dip-needle survey, which showed strong magnetic attraction at the vein zone.

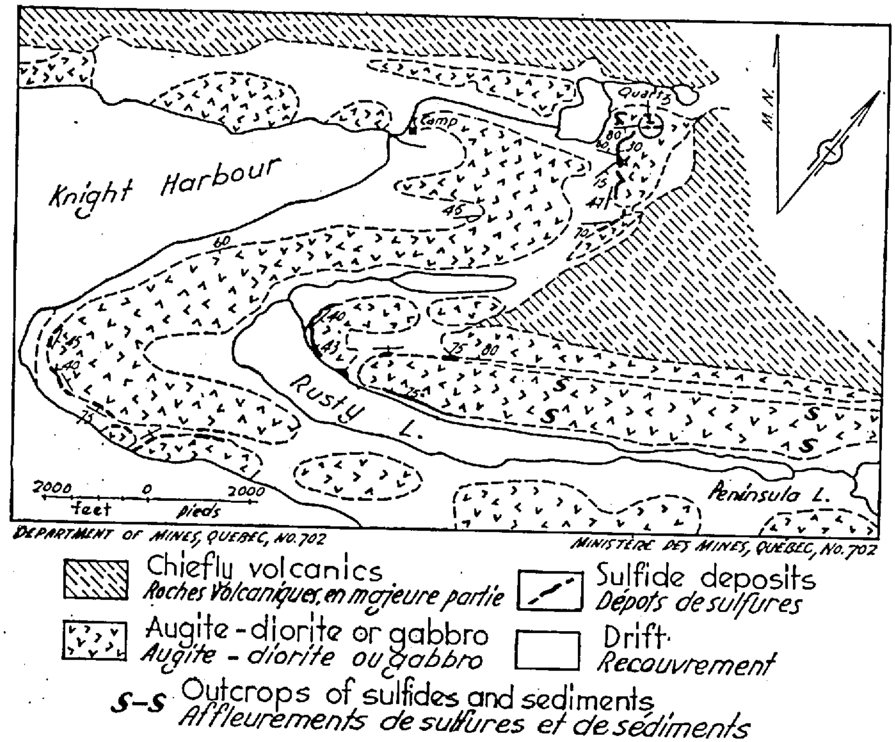


FIGURE 3.—*General geology and location of sulphide deposits near Knight harbour, cape Smith:* chiefly volcanics, broken diagonal lines; augite-diorite or gabbro, v symbol; sulphide deposits, heavy solid or broken line; and drift, dots.

Northwest Shore of Rusty Lake, about one mile south of the head of Knight harbour

The sulphides occur in sediments beneath diorite on the nose and south limb of an easterly-plunging syncline, and, including two drift covered stretches of 250 feet and 700 feet, they are exposed for a length of at least 4,500 feet; some rusty outcrops indicate that they may extend eastward beneath the drift for nearly two miles. The maximum width of heavy sulphide mineralization is about 15 feet, but at one place sulphides are plentifully distributed through the slates for a width of 25 feet. Around the nose of the fold, the sulphides include a fair proportion of pyrite, and much of the pyrrhotite is the late, coarse grained type, but very little chalcopyrite is visible.

The 'H' Lead, 750 feet north of Rusty and Peninsula lakes

Sulphides occur here along a narrow, easterly trending depression between low, steep walls of augite diorite. The depression varies in width from less than a foot at one place to a maximum of about 200 feet, and it can be followed for a distance of two and a half miles. Over most of this length, the surface is covered with sand, boulders, and débris from weathering of the underlying sediments, but at many places along both walls there are outcrops of sediments or sulphides and, although no development work has been done, indications are that a series of lenticular sulphide bodies, largely pyrrhotite, with length up to 600 feet or more and width up to at least 25 feet, occur along the depression. In a few places, tongues of the sulphides project for some feet into the diorite wall-rock.

Glory Hole Showings, 3½ miles N.75°E. of head of Knight harbour

These deposits occur around the north, east, and south sides of a broad, boulder floored basin, where black, slaty sediments and sulphides are exposed against abruptly rising walls of lavas and diorite. Dense, black sulphides, veined by later, coarse pyrrhotite, are exposed over widths up to thirty feet. Chalcopyrite, in very minor amount, is associated with the other sulphides. As at Round lake, the structure appears to be a northeasterly pitching anticline, around the nose of which there are tight minor folds. The sulphides occur chiefly along these folds. The outcrops indicate that mineralization might be expected to continue, at least intermittently, over a length of at least 2,000 feet.

Smith Island

The largest showing of sulphide mineralization on Smith island is on the south shore, two miles east of the Hudson's Bay Company post, where, in a shallow cove, almost solid banded sulphides are exposed for a length of 250 feet and a width ranging up to 25 feet across the nose of a plunging anticline in the sediments that floor the cove. The footwall of the deposit is concealed by drift. The hanging-wall is pillow lava which forms steep walls, up to sixty feet high, at the back of the cove. The sulphides are of the usual type: dense pyrrhotite with some pyrite, veined and in part replaced by later, coarse pyrrhotite. Chalcopyrite is visible in only a few places, and then in very small amount. Less intense mineralization occurs in exposures about 200 feet west of the cove, and from a quarter to half a mile eastward from it.

Other Sulphide Mineralization

Near Cape Gertrude, east coast of Hudson bay, 100 miles south of cape Smith

Low (1903*a*, p. 59) recorded the occurrence of magnetite, pyrite, and pyrrhotite in Archæan-like chlorite and mica schists on the small, low islands adjacent to the shore near cape Gertrude. An analysis by Hoffman of a sample from a band about four feet wide, composed largely of pyrrhotite, gave: copper, 0.06 per cent; nickel, 0.08 per cent.

Richmond Gulf and Little Whale River, east coast of Hudson bay

Galena, accompanied by some pyrite and sphalerite, occurs in a band, about twenty-five feet thick, of drusy dolomitic limestone near Little

Whale river. Bell (1879, p. 20) states that: "In 1858-59, the Hudson's Bay Company obtained nine tons of this ore from numerous small openings which were made about three miles northeast of their establishment at Little Whale river; but it appears to be equally or more abundant in some spots in the same band of limestone on the south side of the river. This band is traceable to Richmond gulf, at the entrance of which I found bunches of galena in it, which would weigh upwards of a hundred pounds". He reported that samples from the 'mine', analyzed by B. J. Harrington, assayed 5.104 oz. silver per ton, and others from the south side of the inlet of Richmond gulf gave 12.03 oz. Bell also observed occurrences of chalcopyrite in the vicinity of Richmond gulf.

Paint Hills and Solomon Temple Islands, east coast of James bay, 35 miles north of cape Hope

Extending across these islands is a band, three to five miles wide, of Archæan-like rocks, chiefly hornblende schists, with which are associated some thin beds of friable sandstone and graphitic schist. In places, the schists are heavily impregnated with pyrite, and it is to the rusty weathering of the rocks containing this mineral that the 'Paint hills' owe their name. These occurrences were described by Low (1903*a*, p. 66), who says: "The pyrites appears to occur in segregation masses along certain bands, and some of these masses contain many tons of ore and have been staked as mineral claims". The schists are intruded by granite and by syenite and pegmatite dykes, and in one of the latter on a small island at the southeast side of Paint-hills bay, Shaw (1942) noted the presence of minor amounts of molybdenite and spodumene.

Koksoak River

Low (1897, p. 272) reported heavy sulphide mineralization in Proterozoic-like black shales at two points along Koksoak river or, rather, Kaniapiskau river, the name given to its upper reaches. Along the east side of Manitou gorge, about eight miles above (south of) the point where Larch river enters the Koksoak, "pyrites in cubes is scattered in considerable quantities through the shales . . . Numerous small veins of quartz penetrate the shales; they are usually barren, but sometimes carry pyrites, and in one place a small quantity of galena was observed". About sixty miles south of here, at Pyrites chute, a few miles north of where Swampy-bay river enters the Kaniapiskau from the east, "the black shales and limestones are all highly charged with pyrites, usually occurring as separate cubes, but sometimes in large masses". These shales form part of a series of sediments that were mapped by Low along Kaniapiskau river from just below Larch river southward to the upper end of Cambrian lake, a distance of some 120 miles. Particularly important in this series are beds of iron formation, to which reference is made below.

Near the Height of Land

During 1944, the *Hollinger North Shore Exploration Company, Limited*, prospected in a preliminary way a sulphide body uncovered in the iron-bearing territory under investigation by them in New Quebec near the height of land, about 350 miles north of the village of Seven Islands on the gulf of St-Lawrence. The total length of the body was not determined but trenching traced it for 660 feet and drilling gave a width of 13 feet. The indicated grade of the ore was 6.75 per cent zinc, 1.32 per cent copper, and $2.00 per ton in precious metals. The occurrence is in sediments at their contact with a mass of diorite (Hollinger Cons. Gold Mines, Ltd., *Report to Shareholders*, 1944).

Iron Formation

Richmond Gulf, east coast of Hudson bay (see Vol. II, pp. 234-237)

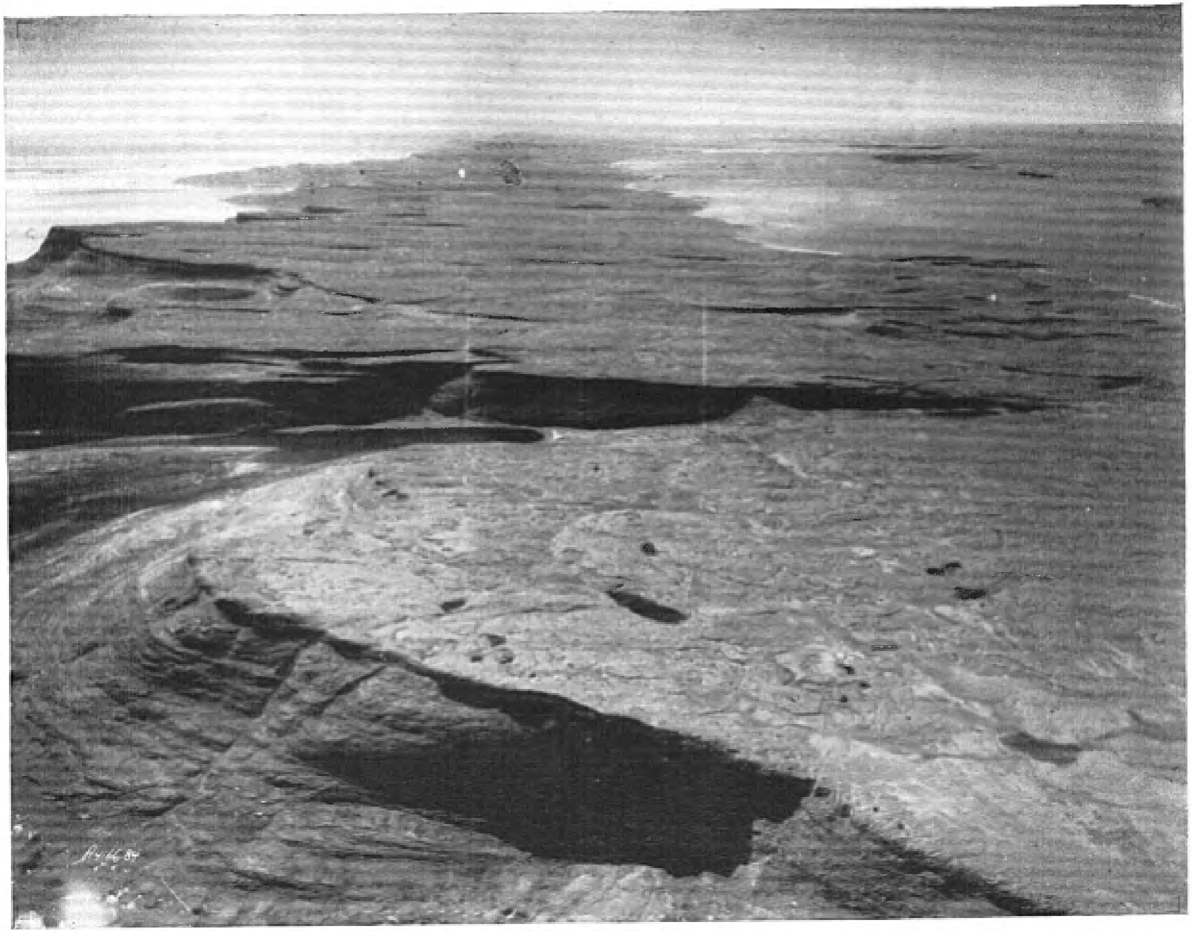
Beds of 'iron formation' are exposed at various points along the east coast of Hudson bay, as for example at Richmond gulf (Plate II) and on Long island, adjacent to the coast near cape Jones (Bell, 1879; Low, 1903*a*).

The iron formation is extensively developed on the Nastapoka islands, which form a chain paralleling, and 2½ to 5 miles distant from, the coast for some ninety miles northward from Little Whale river and Richmond gulf (Low, 1903*b*), and also on the Belcher islands, 85 miles due west of the gulf (Young, 1922). The geology of these islands, which are not in the Province of Quebec, is discussed in Volume II, pp. 234-237.

Kaniapiskau (*Koksoak*) *River*

Beds of iron formation form part of a series of Proterozoic-type rocks that are exposed along both sides of Kaniapiskau river from its mouth (at the junction of Larch and Koksoak rivers) southward to the head of Cambrian lake, a distance of about 115 miles. From this junction, the Koksoak flows northeastward to enter Ungava bay, some ninety miles distant. The beds exposed along the river are similar to, and doubtless are to be correlated with, those on the Nastapoka islands and adjacent coast of Hudson bay. They have a general north-northwesterly strike, with dip to the east, ranging from 10° to nearly vertical.

The Kaniapiskau was trâversed by Low in 1893 (1897, pp. 268-273, 283-286) in the course of his exploration along the main waterways of Labrador peninsula. He found almost continuous exposures of iron formation along a stretch of more than ten miles from just below Shale chute, which is a few miles north of Cambrian lake, to the mouth of Swampy-bay river, a stream that enters the Kaniapiskau from the east. In the first exposures, "a thin section of 'jaspery' magnetite is overlain by twenty feet of cherty limestone containing large blotches of carbonate of iron". Analyses of the jaspery magnetite and carbonate ore gave, respectively, 31.28 and 33.62 per cent iron. Two miles below the chute, the beds exposed along the right bank of the river for more than a quarter of a mile include "a 25-foot bed of 'jaspery' ore, composed largely of magnetite with a small admixture of hematite, underlain by ten feet of siliceous, ferruginous limestone holding spathic iron ore in bands and nodular masses up to several hundred pounds in weight. A great part of the magnetite is nearly pure and contains little jasper". Four miles beyond here, in a high hill on the west side of the river, "fifty feet of red garnetiferous, siliceous, ferruginous shale and jasper are overlain by 200 feet of 'jaspery' ore, composed chiefly of magnetite". An analysis of the 'jaspery' ore gave 48.29 per cent iron. A section on the side of this hill half a mile farther downstream shows "400 feet of 'jaspery' mag-



Iron Formation, Richmond Gulf

netite and hematite, overlain by 50 feet of cherty carbonate ore". Analysis of a sample of the 'jaspery' ore gave 54.35 per cent iron. Iron formation is exposed for a further three miles to near the mouth of Swampy-bay river, where the beds strike N.15°W, and stand nearly on edge. This strike takes them away from the river which, for the remainder of its course to the Koksoak, is bordered by beds of shale and limestone.

Low called particular attention to the wide distribution of the iron formation in the Upper Kaniapiskau region, and to its great economic possibilities. Results of recent prospecting and exploration confirm this belief. These iron ore deposits are in the New Quebec part of the Ungava peninsula north of the height of land, but extend profusely to the south of it (see pp. 402-404).

Headwaters of Hamilton River

Sedimentary rocks similar to those along Kaniapiskau river were mapped by Low (1897, pp. 273-280, 285-286) far to the southeast, along the Ashuanipi branch of Hamilton river. He described occurrences of iron formation along the shores and in the hills surrounding several lakes on this branch of the river.

About seventy-five miles yet farther south, Gill, Bannerman and Tolman (1937) have mapped occurrences of iron formation within and near the Wapussakatoo mountains in an area some twenty-five miles northwest of the north end of Ashuanipi lake, which lies just east of the north-south height-of-land separating the Atlantic slope from that of the St. Lawrence river. They report, however, that "no part of the iron formation observed in these areas is rich enough in iron for commercial exploitation under present conditions". This area is approximately 200 miles due north from the towns of Seven Islands and Moisie, on the north shore of the St-Lawrence.

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EASTMAIN RIVER

Eastmain river forms the boundary between the territories of New Quebec to the north and Mistassini to the south. It is a large, westerly flowing river which empties into James bay a short distance north of latitude 52°N. Its headwaters are some 300 miles east of the bay and 90 miles northeast of Mistassini lake. The country across which it flows rises gradually from the coast to an elevation of about 1,000 feet above sea level, attained a short distance east of the Great Bend, 100 miles from James bay.

The earliest geological work along Eastmain river was carried out by Low (1897) in 1892 and 1893, in the course of extensive explorations in this northern region of Canada. In 1941, G. Shaw (1942, 1943) made a reconnaissance survey of an area which includes the lower 150 miles of the river. The summary that follows is based mainly on this later work by Shaw. Data relating to operations by Dome Mines, Limited, were furnished by that Company.

Extending eastward along and on both sides of Eastmain river from within a few miles of its mouth to 150 miles inland is a belt of volcanic and sedimentary rocks, flanked on the north and south by younger granite (Figure 4). Over most of its length, the belt has a width of eight to ten miles, but in the vicinity of Kausabiskau river, a tributary entering the Eastmain from the south at a point about fifteen miles east of Conglomerate gorge, and again some thirty miles farther east, near the west side of the Great Bend, embayments of granite on the south side of the belt reduce its width to less than four miles. These constrictions in width, and the lack of continuous exposure, have led some observers to refer to the belt as three separate belts, following one another eastward.

The oldest rocks of the belt are Keewatin-like lavas, with some interbedded tuffs and sediments. The lavas are for the most part andesitic in composition, and they are commonly pillowed. Overlying these, with apparent conformity, is a series of Temiscamian-like sedimentary rocks, the main types represented being conglomerate, quartzite, arkose, and greywacke. The whole sequence bears a striking similarity, both as regards lithology and stratigraphy, to that occurring in the Broadback River area, some seventy miles south of Eastmain river (see p. 16).

The granite which flanks the belt to north and south is typically a medium grained variety containing hornblende or biotite, or both these minerals. Related to the granite are light coloured pegmatites, which intrude both the granite and the older rocks. In places, also, there are later basic intrusives.

The rocks of the belt are all more or less metamorphosed, the lavas and associated tuffs and older sediments to amphibolites and biotite gneisses, and the Temiscamian-like sediments to quartz-mica and garnet-quartz-mica schists or, as just above Conglomerate gorge, they are granitized. The general strike of the schistosity and gneissic banding and also of the bedding where this is recognizable, is S.75°W., slightly oblique to the westerly course of the river.

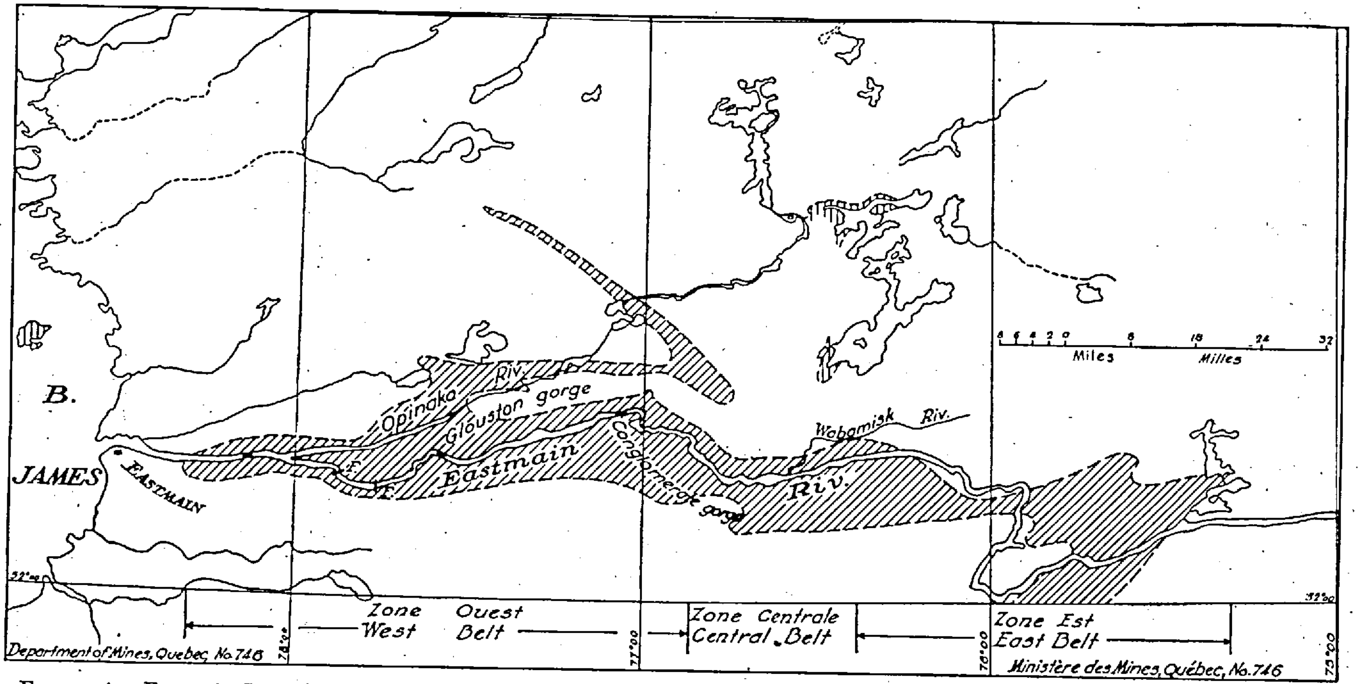

FIGURE 4.—*Eastmain River:* areas chiefly underlain by early Precambrian volcanics and sediments, diagonal lines; chiefly granites and gneisses, blank.

In the extreme western section of the belt, the whole width is occupied by the volcanic and associated Keewatin-like rocks, but from about four miles east of Clouston gorge a band of the younger sediments extends eastward, with gradually increasing width, flanked on either side by the older rocks. Shaw (1943, p. 94) interpreted the structure here as probably a syncline, followed on the north by an anticline whose axis closely follows the course of Opinaca river, extending westward from the nose of the tongue of granite already referred to. The eastern section of the belt, east of the Great Bend, is apparently underlain exclusively by the Keewatin-like lavas and associated rocks, intruded by numerous dykes of gabbro and diorite, and the structure here is not known.

Low, in the report referred to (1897, pp. 252-254), called attention to heavy pyrite mineralization in the schists at several localities along and adjacent to the river. During the summers of 1935 and 1936, an investigation of this and other sections of the belt was carried out by Dome Mines, Limited. This work included geological mapping by J. E. Gill and B. S. W. Buffam, an extensive surface exploration, and some diamond drilling in localities that were indicated by the mapping as favourable for the occurrence of mineral deposits. The belt as a whole, however, has by no means been thoroughly prospected.

Western Section

In the section of the belt eastward for ten to fifteen miles from Clouston gorge, the volcanics are in places strongly sheared and heavily mineralized with pyrite, and quartz veins also are numerous. Such of these occurrences as have been investigated, however, have failed to reveal the presence of gold in appreciable amount. Prospecting here is handicapped by heavy overburden, which covers fully 85 per cent of the surface.

Central Section

Three zones of sulphide mineralization along the central section of the belt were investigated. One of these is exposed along the north shore of Eastmain river about half a mile east of the mouth of the Wabamisk, or about midway between Conglomerate gorge and the Great Bend. Here, pyrite and pyrrhotite have replaced the sediments somewhat irregularly along a fault zone forty feet wide and traceable for about two hundred feet, with trend N.80°E. Some sections up to one foot wide along this zone consist of massive sulphides. A grab sample of this material is reported to have assayed 0.04 oz. gold per ton. It is of interest to note that Low (1897, p. 253) described this occurrence more than forty years before it was examined by Dome Mines, and that assays of samples collected by him showed the presence of gold.

Eastern Section

The great part of the work carried out by Dome Mines was concentrated on a group of eighty claims commencing sixteen miles east of the west side of the Great Bend and extending along the river for 3¼ miles, with a north-south width of 1¼ miles. Altogether, some 4,000 feet of trenching was done, and 1,400 feet of diamond drilling in eight holes, mainly near the centre of the group of claims, designated the *A* area.

The claims are underlain in about equal amount by andesitic flows and diorite, the latter in masses of irregular outcrop or in dykes which commonly strike N.75°E., parelleling the schistosity of the adjacent volcanics. Shear zones in these rocks contain quartz veins, and also carbonate stringers, which in places are mineralized with pyrite, arsenopyrite, and a little chalcopyrite. Where such veins cut diorite, the rock is generally impregnated with sulphides, tourmaline, and carbonate and locally it is completely replaced by these minerals. Where the veins are in andesite, there is as a rule little wall-rock alteration.

The initial discovery on these claims was made in 1935, in the *A* area, in an outcrop of diorite on the north shore of a small lake (Deadhead lake). The outcrop appears to be the central part of a diorite dyke, 800 feet wide, which is separated by a narrow band of greenstone from a similar diorite dyke to the north. Assays of drill core and of material exposed in trenches gave disappointing results.

Several other occurrences of sulphide mineralization in this group of claims were investigated, but in each of these the gold content was reported as negligible.

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DRAINAGE BASIN OF RUPERT, BROADBACK, and NOTTAWAY RIVERS

Rupert, Broadback, and Nottaway rivers empty into Rupert bay, at the extreme southeast corner of James bay (Figure 5). The country drained by these three rivers lies at the junction between Mistassini territory to the north and Abitibi territory to the south, and measures some 260 miles east-west by 100 miles, north-south. It extends from 73° to 79° west longitude, and from 50° to 51°30′ north latitude.

With the probable exception of certain limestones along the east side of Mistassini lake, the area is underlain by Precambrian rocks, and, over considerably more than 90 per cent of the area, these are granite and gneiss. Keewatin-like volcanics, including flows, tuffs, and agglomerates and their schistose equivalents, occur in places in the eastern section of the area, near its south boundary, and a band of similar rocks, up to fifteen miles wide, crosses Broadback river immediately east of Evans lake. The volcanics east of Evans lake are followed eastward by a band of sedimentary rocks, consisting of conglomerate, arkose, quartzite, and mica schist. The granitic rocks are intrusive into the volcanics and sediments. Later gabbro and more basic dykes occur in the area, but they are rare.

Bordering the east side of Mistassini lake throughout its length, and underlying the lake itself, are almost flat-lying, bluish-grey limestones, with intercalated shaly and cherty beds. The age of this limestone is in doubt. The only fossils observed in the beds are stromatoporoid-like forms that were described by W. A. Parks as being "very like *Cryptozoon proliferum* (Barlow *et al.*, 1911, p. 133). Barlow and his associates suggested that the beds are "possibly of Lower Ordovician age and the equivalent of the Chazy formation".

Economic Possibilities

Over large sections of the area, bed-rock is concealed beneath glacial deposits, chiefly varved or banded clay. Also, the rivers are laborious routes to travel, with numerous portages necessitated by falls and rapids. As a consequence of these handicaps, and of its remoteness from settlements, the area has attracted comparatively few prospectors. Nor, indeed, do geological conditions here appear so favourable as farther south for the occurrence of mineral deposits of commercial value.

In a few places within the volcanic schists east of Evans lake, Cooke (1914, p. 341) found the rock heavily impregnated with pyrite, and also cut by stringers, and more rarely by veins and lenses up to two feet wide, of quartz, but assays of samples he collected gave negative results for gold.

From time to time, specimens carrying galena and sphalerite have been brought out from Mistassini lake. Most of them have apparently come from a locality two miles north of the Hudson's Bay Company's post near the south end of the lake. Here, at intervals along the lake shore for 500 feet, the sulphides occur in small aggregates and 'splashes' in flexures and shears in the limestone. Assay of a sample consisting of selected small pieces of the mineralized rock gave: silver, 0.99 oz. per ton; lead, 8.9 per cent (Barlow *et al.*, 1911, p. 213).

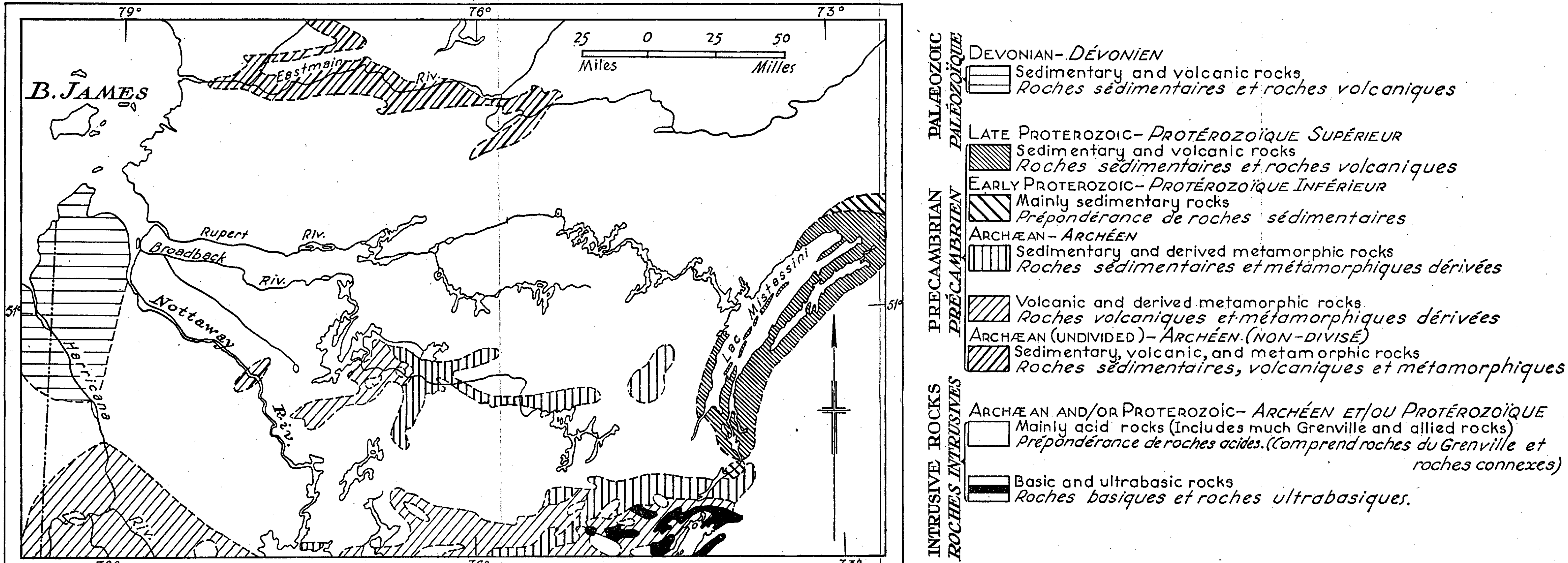

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FIG. 5

TERRITORY DRAINED BY RUPERT, BROADBACK AND NOTTAWAY RIVERS | TERRITOIRE DRAINÉ PAR LES RIVIÈRES RUPERT, BROADBACK ET NOTTAWAY

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WESTERN QUEBEC

GOLD DEPOSITS

And Associated Sulphide Deposits Containing Copper and Other Base Metals

Introduction

Prior to 1926, Quebec's gold production had been derived from placer deposits in the Chaudière River basin, and as a by-product in the treatment of zinc-lead ores of the Tétreault mine, Portneuf county, and of copper-bearing pyrite ores of the Eastern Townships. Annual production had averaged only a few hundred ounces and had never exceeded 2,000 ounces. In 1928, the production jumped suddenly to 60,000 ounces, and since that year it has increased at a rapid rate to more than one million ounces in 1940, far exceeding, in value, any other item in Quebec's mineral production. This great increase in gold production was the result of the discovery and development of numerous deposits in the section of the Province usually designated 'Western Quebec'. In some of these deposits, copper and other base-metals accompany the gold, and copper production has increased from less than three million pounds in 1926 to nearly 144,000,000 pounds in 1941. In addition, there has been an important production of silver, zinc, and lead from the mines of the region, and also of other metals, including selenium, tellurium, arsenic, molybdenum, and tungsten. However, most of the active mines produce gold only (with silver as a by-product).

The mineralized belt of Western Quebec lies along and on both sides of the watershed separating the Hudson Bay and St-Lawrence River drainage systems and, broadly speaking, may be defined as bounded on the north by Eastmain river, which flows westward into James bay, following approximately latitude 52°30′N.; on the west by the Quebec-Ontario boundary, beyond which the belt continues in the latter Province; and on the south at a line drawn in a northeasterly direction from lake Témiscamingue, at latitude 47°N., to the vicinity of Chibougamau lake, 300 miles to the northeast.

For a bibliography of the literature on the geology and mineral deposits of the region, the reader is referred to Volume I, or to Volume II (pp. 154-161). The geology is discussed at some length in Volume II (pp. 74-154) and is only briefly summarized in the pages that follow. The descriptions of many of the mining properties have been supplied by the managements and staffs of the mines concerned, whose generous co-operation has assisted very materially in the preparation of this volume.

It is fitting here to record the great contribution which a host of able and indefatigable prospectors, by their numerous discoveries, have made to the development of the mineral industry of Western Quebec.

Historical

It is of historical interest that one of the first recorded occurrences of metallic mineralization in North America (excepting Mexico) was noted in Western Quebec. This is a deposit of argentiferous galena on the east shore of lake Témiscamingue which was examined by white men as early as 1686 (see the Wright mine, p. 307). The first discovery of gold in the region in modern times was in 1906, in Beauchastel township, on the Lake Fortune property (p. 132). Then, starting in 1911, a series of discoveries of gold and copper mineralization were made at several localities in Rouyn, Dubuisson, and other townships east of the Quebec-Ontario boundary, along the eastern continuation of the Kirkland Lake 'gold belt'. Development of several of these occurrences proceeded apace. In 1926 there was a small production of gold from development work at the O'Brien mine (p. 197), in Cadillac township, and in the following year regular production of gold started at the Siscoe (p. 240), in Dubuisson township. In that year, also, shipments commenced from the Horne mine of Noranda Mines, Limited (p. 338), which has been the largest producer of the region, of both gold and copper. Since that time, numerous other occurrences, chiefly of gold, have been discovered as exploration was extended eastward along the belt and also to north and south of it. In 1940, there were some three dozen mines in this region producing gold.

General Geology

With the exception of very minor occurrences of Palæozoic beds on the east shore, and on some of the islands, of lake Témiscamingue, the region is underlain by rocks of Precambrian age. Stated most broadly, these consist of a series of belts, with general easterly trend, of Keewatin-like volcanics and overlying Temiscamian-like sediments which are intruded and separated by bodies of granitic rock which, individually, also have an easterly trend. These belts are the eastward continuation of similar belts in Ontario where, also, they contain important mineral deposits, chiefly gold.

The Keewatin-like volcanics range in composition from basic to acidic. Flows that were originally basalt or andesite are usually greatly altered and are now typical 'greenstones'. Trachyte and rhyolite flows, as a rule, are less highly altered. The Temiscamian-like sediments are chiefly greywackes and conglomerates. They overlie or are interlayered with the volcanics with apparent conformity and, almost everywhere, the rocks of the two series are highly folded and have steep dip.

The intrusive bodies are chiefly acidic in composition, and they represent several distinct periods of intrusion. Like the volcanics and sediments, however, they are all of early-Precambrian age, with the exception of occasional diabase and gabbro dykes, which are late-Precambrian.

Late-Precambrian (Huronian) sediments occupy small areas in the extreme western section of the region — west of Rouyn and in the vicinity of lake Témiscamingue—and continue westward beyond the Quebec-Ontario boundary. In Quebec, no mineralization of interest has yet been noted in the Huronian beds.

In Western Quebec, prospecting has been most successful in areas of volcanic and sedimentary rocks cut by relatively small intrusive bodies, the gold deposits or sulphide bodies occurring both within such bodies and in the adjacent country rock.

Glacial débris and lake clays mantle the bed-rock over large sections of the region, adding materially to the difficulties of prospecting and exploration (see Vol. II, pp. 104-5).

Structure

(Vol. II, pp. 105-113, 120, 152)

Structure has played an important role in the localization of concentrations of the gold and other economically valuable minerals. Due, however, to lack of exposure over large sections of the region, much remains to be learned of its structural features.

Folding

Almost everywhere, the volcanic and sedimentary rocks of the belts are highly folded, with strike broadly east-west and dip steep to vertical. In many places, the folds are overturned. Conglomerates within the sedimentary series suggest more than one period of uplift or folding.

The structural relationship of the volcanics to the sediments is obscured by a series of strong faults which occur along or close to their junction, but enough evidence is available to show that sedimentary series of different ages are involved, some interlayered with the volcanics and well down in the series.

Faults and Fault Zones

Numerous faults and fault zones have been observed in the region. They have been studied chiefly in districts where there are active mines or where mineral deposits have been found. For the most part, the faults are of small displacement and, as a consequence, they are usually difficult to recognize, particularly in the case of strike faults.

Some of the strike faults and east-west shear zones are remarkably persistent, as for example the zone that extends for more than one hundred miles westward from Bell river through Rouyn township to the Quebec-Ontario boundary and for at least eighty miles beyond, through the Ontario gold mining districts of Larder Lake, Kirkland Lake, and Matachewan. In Western Quebec, numerous gold mines as well as copper and other base-metal mines are situated along or adjacent to this zone. The alignment of their headframes, as seen from an aeroplane, is quite remarkable.

A similar zone, twenty miles to the north of this, crossing Duparquet and Destor townships, is thought to be the eastern continuation of the structural zone which contains the gold deposits of the Porcupine district, about one hundred miles west of the interprovincial boundary.

Other belts of east-west shearing and faulting, with some associated gold mineralization, are known far to the northeast, in the Chibougamau Lake district.

Faults and shear zones having a northeasterly strike are known in many places, possibly related to adjustments along the southeastern margin of the area, where the formations described give way to those of the Grenville sub-province along a northeasterly-trending line. Such faults are found, for example, in Guillet township, east of lake Témiscamingue, in Bourlamaque township, and in the extreme northeast, in the Chibougamau Lake area. Gold and sulphide mineralization has been noted in subsidiary structures related to some of these faults.

Lastly, there is a widely prevalent type of faulting consisting of two possibly related sets, one striking northeast to north and the other in the northwest quadrant. These are later than the east-west strike faults and possibly later than the northeast faults referred to above. Although later than the bulk of the vein-forming minerals, there is evidence indicating that they preceded, and aided in, the gold enrichment of many veins.

Relative Competence of Rocks Under Stress

In nearly all the mineral deposits of the region, it has been found that the veins or ore shoots favour a particular type of rock or rock contact — rock which, owing to its relative incompetence, has failed under the stress to which it has been subjected and thus has afforded channel-ways for the mineralizing solutions and has localized their circulation. It is evident that many of the strong or master faults of the region have been the loci of recurrent movement and that, at successive periods, mineralizing solutions have advanced along the original or adjacent channels, pervading and replacing the wall-rocks. The late gold and other mineralization has favoured these complex and structurally weak zones or belts.

The Mineral Deposits

The deposits of the region are of two general types: massive sulphide replacement bodies, and gold-bearing quartz veins.

Pyrite and pyrrhotite, with usually lesser chalcopyrite, are the characteristic minerals of the sulphide bodies, but sphalerite and galena, also, are almost invariably present. Usually, these latter minerals are in small amount, but sphalerite is the principal sulphide in the Normetal orebody (p. 439), and in some of the Amulet deposits (p. 361).

In the vein deposits, gold may be present alone, but usually it is accompanied by one or more of the sulphides mentioned above, or by arsenopyrite *e.g.*, Beattie mine (p. 84), or, more rarely, by scheelite, molybdenite, and various tellurides. In many of these deposits, tourmaline and carbonates are closely associated with the quartz, Adopting Lindgren's classification, they would be classed as deep and intermediate vein types.

For the most part, the gold is exceedingly fine, but in some ore shoots it is coarse and, locally, spectacularly so. It ranges in colour from very pale yellow to deep golden-yellow, depending on the silver content, and in some mines, as the O'Brien, both varieties are found. The sulphides are usually fine grained but in the several known deposits they range from extremely fine (*e.g.*, Beattie mine) to the 'giant' pyrite cubes common in many deposits along the eastern margin of the Bourlamaque batholith.

Age and Sequence of Mineralization

Although it is believed that all the metallic mineralization of the region is genetically related, it is evident, from detailed studies that have been made of the ore in various mines along the structural belts, that the gold and sulphide minerals are by no means contemporaneous.

The evidence at hand favours the assumption that the gold along the zones of fracture was introduced mainly at one general time and that it is later than the bulk of the associated metallic mineralization, and in many cases very much later. The pyrite is not all of one age.

Quartz veins were introduced at more than one time, even in one and the same deposit, but with few exceptions they are older, and in general very much older, than the 'later diabase' dykes, Some may be of early-Precambrian age. When they contain gold or copper mineralization, this is much later than the vein quartz, although in some deposits additional quartz has been introduced with the metals. Pyrite may be older or younger than, or contemporaneous with, the vein quartz.

When arsenopyrite is present, the evidence seems to indicate that it is more or less contemporaneous with the older pyrite and the older vein quartz.

Scheelite and molybdenite, if present, are apparently of the same age as the quartz with which they occur.

It is evident that these successive waves of mineralization were not evenly distributed along all sections of the belts. Thus, the largest known bodies carrying chalcopyrite in important amount have been found in the western part of the area, although some, such as the Fleming occurrence, are known toward the eastern end. Arsenopyrite occurs chiefly in deposits at the western end of the belt, as far east as Malartic township, but, along a zone south of that containing the copper sulphide orebodies, gold is more widely distributed. In some orebodies, as the Central Cadillac (p. 200), it occurs in, or closely associated with, the sulphide masses, but, in other mines, such masses may contain very little gold. In most of the presently developed mines, however, only minor sulphide minerals are associated with the gold.

NORTHERN PART OF THE COUNTIES OF ABITIBI-WEST AND ABITIBI-EAST

Introduction

The two counties of Abitibi-West and Abitibi-East, which adjoin each other, extend northward as far as Abitibi Territory — to parallel of latitude 50°10′. The northern part of these two counties, which is dealt with in this chapter, constitutes a region at present largely unsurveyed. It embraces a strip seventy miles wide, lying generally between latitudes 49° and 50°, and stretching eastward from the Quebec-Ontario boundary to beyond Chibougamau lake, between longitudes 79°30′ and 74°, a distance of some 250 miles. It occupies an area of approximately 15,000 square miles.

The area lies in the Hudson Bay watershed, the divide between which and the St-Lawrence watershed is close to parts of its southern and eastern boundaries. It is without railways, but the main line of the Canadian National railway traverses the country to the south, being distant some sixty miles in the eastern part of the area and about fifteen miles at the interprovincial boundary. Within the area, good canoe routes are afforded by the waters of Harricana, Bell, and other rivers, and the numerous large and small lakes provide safe landing for aeroplanes. Aerial photographs of practically the whole of the area are available. These factors have been of considerable aid to prospectors in their exploration of this extensive region.

General Geology

Although there has been no very detailed geological mapping in this part of Abitibi counties, sufficient work has been done to establish the larger features of the bed-rock geology.

From one-quarter to one-third of the area is occupied by closely folded Keewatin-like volcanics, both flows and tuffs, which extend completely across the area, mainly as an easterly trending belt, or belts, with intervening intrusive granitic bodies of batholithic dimensions which also, in general, have an east-west trend. Associated with the volcanics are minor amounts of sedimentary rocks, which are believed to be closely contemporaneous with the volcanics.

Mineral Deposits

Gold mineralization has been reported in numerous and widely separated localities within the area, and during 1938 and 1939 there was some production of gold from the property of Lake Rose (Quebec) Mines, Limited, in Currie township (p. 35). A considerable amount of development work has been done also on the property of Flordin Mines, Limited, in Desjardins township, which adjoins Currie on the west (p. 34). Other occurrences are in the Pénache-Eagle River section of the area; in the vicinity of Opawica lake; near and south of Kitchigama and Mattagami lakes; and near Harricana river.

Chalcopyrite, in minor amount, is associated with other sulphides in a number of localities, but up to the present no large deposits have been found. These occurrences of gold and sulphide mineralization are confined to the Keewatin-like rocks.

The principal known mineral occurrences of the area are described in the pages that follow.

TURGEON RIVER—LOWER HARRICANA RIVER AREA

The area here described embraces the rectangle extending eastward from the Quebec-Ontario boundary to longitude 78° between parallels of latitude 49° and 50°* and includes also the country adjacent to Harricana river along its northerly course to James bay, which it enters a little north of latitude 51° (Figure 6).

Three rivers — the Harricana and its tributaries, the Turgeon, and the Wawagosik — afford the chief means of transportation within the area. Lakes are few and far between. However, such lakes as there are, and many reaches along the Harricana, are suitable for the landing of aircraft. The area is accessible from the south by various routes.

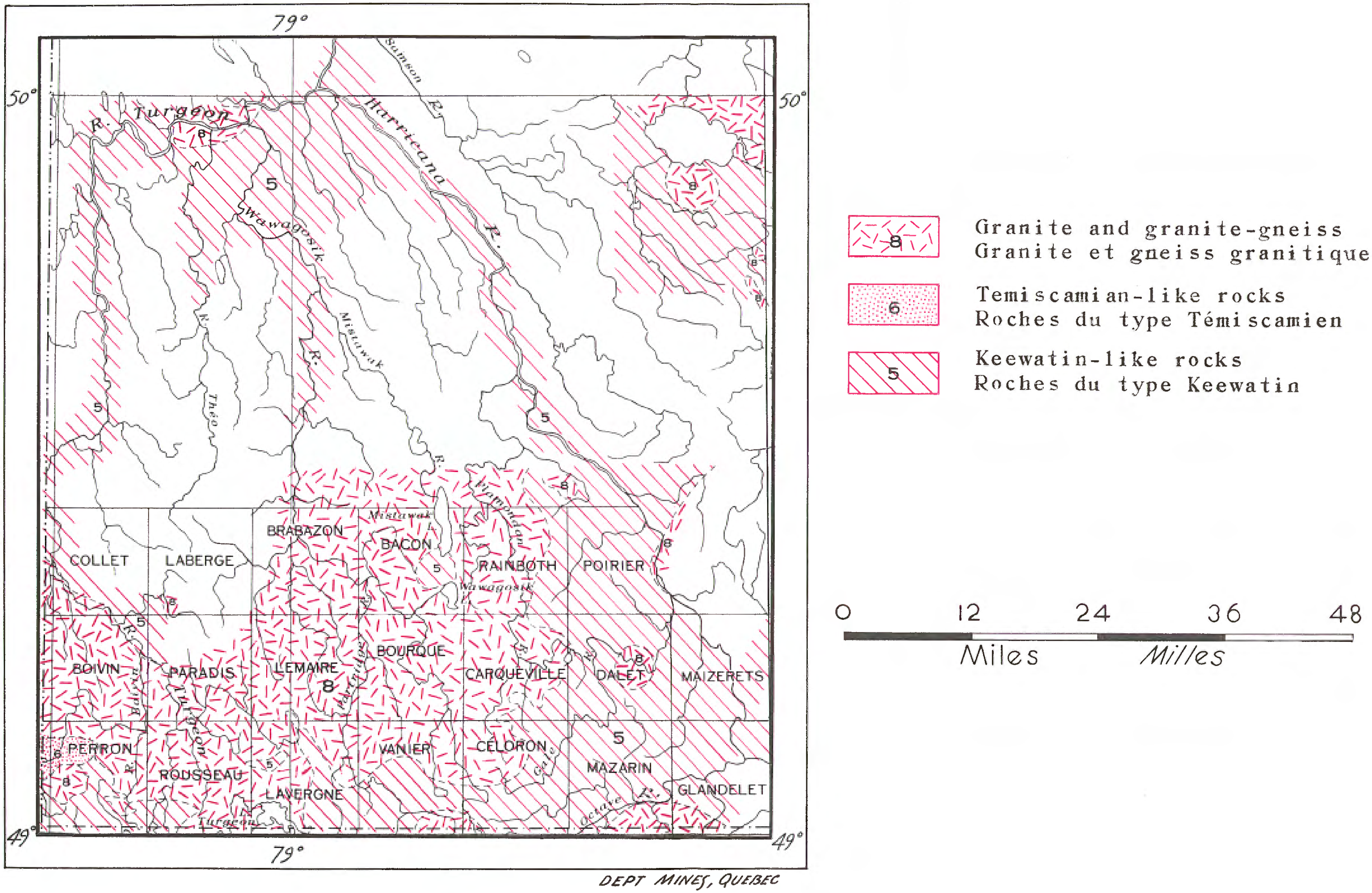
Only the southern half of the area has been subdivided into townships, and, of this section, recently published geological maps on the scale of one inch equals two miles are available — Maps 533A and 554A (G.S.C., 1938). Northward from here, geological mapping has been limited to the vicinity of the main rivers — Maps 183A and 190A (G.S.C., 1918, 1927).

General Geology

The present incomplete mapping indicates that a belt of Keewatin-like volcanic rocks, some forty miles wide, extends across the northern half of the rectangular area outlined, beyond which it is known to continue eastward as the Kitchigama-Mattagami-Goéland Lakes belt (pp. 27-30). Similar rocks appear along the southern margin of the area, these being the northern fringe of the important belt of the Rouyn-Bell River area (p. 68-76). Lying between these belts and occupying the southern half of the area are two large bodies of granite, separated by a southerly trending belt, ten to twenty-five miles wide, of Keewatin-like volcanic rocks which, in the southeastern part of the area, flank Harricana river and connect the volcanics on the north with those on the south. One of these granite bodies, the Mistowak batholith, extends eastward from the interprovincial boundary for some fifty miles with a width, north-south, up to thirty-five miles; the other, whose western margin is at the Harricana, continues eastward far beyond the boundary of the area here discussed, its length, east-west, being nearly forty miles. Small granite masses occur here and there within the volcanics and, conversely, patches of the volcanics are in places included within the two large granite bodies.

*As a matter of convenience, Perron township, in the southwest corner of this rectangular block, is discussed in the section dealing with the northwest part of the Rouyn-Bell River area (pp. 68-76). Similarly, the environs of Kitchigama lake, in the northeast corner, are included in the section on the Kitchigama-Mattagami-Goéland Lakes belt (pp. 27-30).

Figure 6 (folded insert)—*Turgeon River—Lower Harricana River area.*



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TURGEON RIVER-LOWER HARRICANA RIVER AREA
Counties of Abitibi-West and Abitibi-East

RÉGION DES RIVIÈRES TURGEON-HARRICANA INFÉRIEURE
Comtés d'Abitibi-Ouest et d'Abitibi-Est

Judging by the wide extent of granite in the region east of the northern boundary of the area, it appears probable that granite underlies the drift and clay covered section along the lower Harricana as far north as the vicinity of James bay, where occasional outcrops of flat-lying Ordovician and Silurian sedimentary rocks make their appearance.

Volcanic flows, from acidic to basic in composition, the latter typical 'greenstones', form the great bulk of the Keewatin-like rocks. Narrow bands of interbedded tuffs, or their schistose equivalents, have been observed in places, but apparently they are in very minor amount. No water-lain sedimentary rocks of normal type have been recorded, but iron formation has been noted in one locality and magnetic attraction and outcrops of chert which resembles the non-ferruginous part of the iron formation suggest that it occurs in two narrow bands across the district, one north and the other south of the Mistowak batholith (Tanton, 1919, p. 57). Adjacent to the margins of the granite masses, the lavas are commonly metamorphosed to schists or gneisses, and there may be associated hybrid rocks, including breccias and basic contact facies of the intrusive.

The granite is prevailingly a massive, light coloured mica-bearing type, but hornblende granite is reported in the southeastern part of the area. Near the margins of some of the bodies, the rock is gneissic.

Mineral Occurrences

Published records of the results of early exploration in the area are very meagre. A number of mineral occurrences are referred to in reports by Bancroft (1913) and Tanton (1919), and in marginal notes on maps prepared by J. T. Wilson, (G.S.C., Maps 533*A*, 554*A*).

Gold

Specimens collected by Tanton in 1914 on the west bank of the Harricana at a point fourteen miles north of the Allard River portage were found, when examined under the microscope in 1916, to contain native gold. The rock in which it occurs is a ferruginous dolomite which appears to pass gradationally into a light-grey quartz porphyry. A sample of the dolomite veined with narrow quartz stringers assayed 3.86 oz. gold per ton, but the highest of three assays of material lacking the quartz stringers was 0.10 oz. gold per ton (Tanton, 1916, p. 169).

Within the lavas is a zone, about fifty feet wide and traceable for more than three hundred feet, composed largely of rusty-weathering carbonatized rock, in part massive and in part sheared, which strikes northwest, about parallel to the Harricana, and dips at 60° to the northeast. Some bands within the zone are recognizable as quartz porphyry. The zone is veined in places by a network of narrow quartz stringers and is mineralized with sulphides, chiefly pyrite but with a little chalcopyrite and galena. Panning of the material, and assays of two selected samples, gave negative results for gold.

Similar carbonatized volcanics, quartz veins, and sulphide mineralization are found in outcrops for at least four miles south and a mile and a half west of this occurrence. Assays of material from some of these outcrops showed the presence of gold, but in negligible amount only.

Still farther south, on the east bank of Gale river, in the northeast corner of Dalet township, closely spaced quartz veins up to four inches wide traversing an outcrop of sheared volcanics are mineralized with pyrite, chalcopyrite, and a little galena. Tourmaline also is present in some of the veins. Panning, and four assays, of material from this occurrence yielded negative results for gold.

In 1937, a small but high-grade gold-bearing quartz vein was found cutting the greenstones on Gale river at a point about six miles southeast of the northwest corner of Dalet township. Where exposed, it has a width up to fifteen inches and it has been traced for a length of about three hundred feet, beyond which it is concealed by overburden. Three-quarters of a mile to the southeast there are a few scattered outcrops of granite, presumably representing a small boss, and the eastern margin of the Wawagosik granite batholith is four miles to the west. The vein contains angular inclusions of the greenstone and is mineralized with pyrite and minor amounts of chalcopyrite and galena. Free gold was observed in a 12-foot section along a 'drag' in the vein. It is reported that diamond drilling of the occurrence gave disappointing results.

About nine miles southwest of this occurrence, near the south boundary of Carqueville township and just east of a small lake on the southeast flank of the Hébert hills, a rusty carbonatized zone in the volcanics is sparsely mineralized with sulphides, chiefly pyrite and pyrrhotite, but including some chalcopyrite and molybdenite. The zone has a width up to forty feet and has been traced for a mile and a half along its northwesterly strike. Some surface work and sampling was done here in 1936 by Noranda Mines, Limited. It is reported that "panning of the rusty gossan did not yield gold 'colours' ".

Immediately northwest of the Hébert hills is the eastern margin of the Wawagosik granite batholith, near which the rocks are in places much sheared and contain numerous lenses and small veins of barren quartz.

Copper

Reference has already been made to the occurrence of minor amounts of chalcopyrite at several localities in the southeastern section of the area.

Quartz-calcite stringers up to two inches wide, containing pyrite and a small amount of chalcopyrite, occur in greenstone on the right bank of Patten creek, tributary of Turgeon river, on the Ontario side of the interprovincial boundary, about two miles west of the northwest corner of Collet township. Material collected here by Tanton (1919, p. 54) assayed 0.60 per cent copper and a trace of gold. There is no recorded occurrence of similar mineralization in the eastern continuation of this northern belt of volcanics in the Province of Quebec.

Molybdenite

As already stated, molybdenite occurs with other sulphides in the carbonatized zone near the Hébert hills. The mineral has also been reported four miles to the southeast of that locality, on the south flank of Plamondon hill, which straddles the greenstone-granite contact, its eastern part being composed of lavas and their metamorphic equivalents, and its western and southern part of granite of the Wawagosik batholith. Molybdenite occurs here as scattered flakes in a narrow pegmatite dyke which cuts hornblende schists a few hundred yards north of their contact with the granite (Tanton, 1919, p. 57).

References

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KITCHIGAMA-MATTAGAMI-GOÉLAND LAKES BELT

General Geology

The Kitchigama-Mattagami-Goéland Lakes belt lies between latitudes 49°45′ and 50°00′, and longitudes 78°20′ and 75°45′, with the exception of small sections that extend for short distances north or south of these latitudes. The Lac la Trêve-Opémisca-Chibougamau region is to the east of it.

A low range of hills, rising about three miles south of Mattagami lake, extends westward for more than thirty miles to about eight miles south of Kitchigama lake. Mount Laurier, south of Mattagami lake, rises to a height of 700 feet above the lake and is the most prominent hill in the region. MacIvor hill, southeast of Kitchigama lake, rises to 450 feet above the general level. Along this hilly section, and along the river and lake shores, rock outcrops are abundant, but elsewhere they are only locally numerous, extensive deposits of varved (banded) clays and glacial débris covering the bed-rock surface.

The volcanics are the usual Keewatin-like types, greenstones predominating. Their strike generally, but not everywhere, parallels the trend of the belt, and they dip steeply. Minor offshoots and prongs indicate that there are complexities to the structure that are not all accounted for by intrusive contacts with the flanking granitic rocks.

A narrow band of sedimentary rocks trends along the east-west main arm of Mattagami lake, and smaller bands flank the outer margins of the greenstone band on Olga lake. The beds exposed are conglomerate, arkose, and greywacke and generally they conform in strike and dip to the adjacent volcanics. The conglomerate contains granite and quartz pebbles and is therefore older than at least one granitic intrusive. North of the Mattagami Lake band, the rocks are schists and granitic gneisses.

A large oval mass of gabbroidal rocks, with anorthositic and acidic facies, divides the greenstone into two belts south of Mattagami lake. It has an east-southeasterly length of twenty-five miles and a maximum width of ten miles. Five miles to the east of this mass, and separated from it by younger granite, is a body, about seven miles in diameter, of similar rock, just south of Goéland lake. These gabbroidal intrusives are discussed later in a section dealing with the Opaoka River basic igneous complex (page 31).

Granitic rocks flank the volcanic and sedimentary rocks and occur here and there within the belt as small stock-like masses. A circular boss of granite, seven miles in diameter, underlies Goéland lake and is surrounded by greenstones. The granites are not all of the same type and some are distinctly gneissoid. It is probable that they are not all of the same age. Cutting all the others rocks of the area are occasional gabbro or diabase dykes.

The granite boss lying within the greenstone band at Goéland lake is surrounded by an annular zone of shearing. In places, also, there has been faulting in a north-south direction, and tension fractures having this trend are apparently related to the east-west shearing.

Mineral Deposits

Gold in appreciable amount has been reported in two localities and it is interesting to note that, in both, the gold occurs in fractures having a north-south strike, while neighbouring sulphide zones, with or without quartz, having an east-west strike, are practically devoid of gold. This may or may not be significant, but it suggests that, in prospecting, particular attention should be paid to east-west sulphide zones where they show evidence of cross-fracturing.

Descriptions of the most interesting of the recorded mineral occurrences in this belt follow.

Gold Occurrences

During the seasons of 1938 and 1939, Longley (1939, 1940) collected samples from numerous mineralized veins and zones in the vicinity of Kitchigama and Mattagami lakes. Assays were made of forty-eight of them in the Quebec laboratories of the Bureau of Mines, but only three contained better than 0.03 oz. gold per ton, and in most of them the gold content was negligible. The three highest assays were 0.344, 0.162, and 0.045 oz. Samples collected by Auger (1939, p. 11) from mineralized zones along the east side of Mattagami lake and just west of Olga lake were also assayed at Quebec and were found to contain only very minor amounts of gold.

The sample assaying 0.162 oz. gold per ton was taken from a narrow north-south zone, slightly sheared and mineralized with chalcopyrite, on the south shore of Kitchigama lake, half a mile northwest of the mouth of Imbeault river. The sample assaying 0.045 oz. gold per ton was also from an occurrence on the south shore of the lake.

The assay of 0.344 oz. gold per ton was obtained from a sample of chalcopyrite taken from a quartz stringer on a small river near the south shore of Mattagami lake, about one mile north of the point where Bell river enters the lake. There are many other quartz stringers in the vicinity, but no chalcopyrite was observed in them.

Sulphide Occurrences

There are a number of east-west shear zones with sulphide mineralization in the hilly country south of MacIvor lake, and for as much as twelve miles to the west of the lake. One of the most interesting of these is exposed seven miles east-southeast of the lake, on the east side of Allard river opposite a deep bay on its west side. Here, rather basic volcanics which are intruded and to some extent replaced by quartz porphyry are strongly sheared and contain much disseminated pyrite. Assays of five samples of the mineralized material, however, gave only a 'trace' to 0.01 oz. gold per ton. McIvor lake is about fifteen miles southeast of Kitchigama lake and eight miles west of the southwest end of Mattagami lake.

As already noted, a persistent zone of shearing parallels the south shore of Mattagami lake. In places along this zone, the sheared volcanics, and particularly certain belts of fragmental lavas and tuffs, are highly carbonatized and somewhat silicified, and are mineralized with pyrite, pyrrhotite, arsenopyrite, and usually a very minor amount of chalcopyrite. Some of these mineralized zones are many feet wide, and locally the sulphides are quite massive. Assays, however, indicate that the tenor of gold is negligible. Localities at which there has been some surface or other work include the following.

A considerable amount of diamond drilling and trenching has been done on the *Dunlop* property, about a mile and a half southeast of Dunlop bay. The drilling intersected wide zones replaced by sulphides, but the gold content was not of commercial interest. There is similar mineralization in shear zones two miles west of this property, about half way between Dunlop bay and a small lake (Gouin) to the west of it. Some surface work has been done on mineral claims three-quarters of a mile northeast of this small lake on projected township *609*, and not far from the shore of Mattagami lake, where a dyke of medium grained greyish-pink syenite containing disseminated chalcopyrite is exposed for a length of fifty feet and in places for a width of ten feet. Assays of a sample from this dyke gave 0.53 per cent copper and a 'trace' of gold. On a small island in the lake, just east of Dunlop bay, a quartz vein four inches wide is exposed for a length of fifty feet, striking east-west. It is mineralized with pyrite, chalcopyrite, and galena. To the west of the bay, near a prominent blunt point that juts into the lake about half way between Dunlop bay and Bell river, a strongly sheared east-west striking dyke of grey rhyolite is heavily impregnated with pyrite. Still farther west, pyrite occurs in a carbonatized shear zone about half a mile above Inlet rapids, on Bell river, and three and a half miles above this, on the east side of Bell river at Seven Channel rapids, there is a sheared syenite dyke which is much altered and iron-stained.

Pyrite mineralization occurs at Red Chute on Waswanipi river, at the point where the river leaves the northern tip of Olga lake to flow into the eastern end of Mattagami lake, four miles to the northwest. The mineralization is in a shear zone, striking west-southwest, at the contact between granite to the north and banded sedimentary rocks to the south. The pyritized rock, containing also quartz and garnet, is exposed for a width of thirty-five feet on the east side of the river and of twelve feet on the west side. Both pyrite and arsenopyrite occur in a shear zone in the sedimentary rocks two miles farther southward. Assays of material from both localities show only a negligible content of gold.

References

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ALLARD RIVER-BAPTISTE RIVER BELT

The Allard River-Baptiste River belt of greenstones is the southern of the two forks into which the 25-mile-wide greenstone belt west and southwest of Mattagami lake divides toward the east (see Vol. II, map 703A). It may be arbitrarily considered as starting at Allard river, with its north margin eight miles southwest of the southwest end of Mattagami lake (latitude 49°45′, longitude 77°50′), and its south margin seventeen miles to the south. From here it trends east-southeasterly for forty miles to about the centre of the west boundary of Desjardins township (latitude 49°22′, longitude 77°05′), where it merges with the Florence River-Wedding River area of greenstones. The small, southwesterly flowing Baptiste river is almost wholly within this greenstone belt and the Bell flows directly across it.

For convenience of description, this Waswanipi Lake belt may be considered as the easterly prolongation of the Allard River-Baptiste River belt.

General Geology

The rocks of the belt are predominantly volcanic flows, with some associated tuffs and agglomerates. On the north, these are flanked by the Opaoka River basic igneous complex (see p. 31) or by granite and on the south continuously by granite except for a stretch of five miles in Bruneau and Desjardins townships, where they merge with the volcanics of the Florence River-Wedding River area (p. 32).

The strike of the volcanics, and also the shearing, is east or east-southeast except near the eastern end of the Allard River-Baptiste River belt where, adjacent to the granite, the strike is more southeasterly, parallel to the contact.

Economic Possibilities

A limited amount of surface work has been done at three localities on occurrences of gold or sulphide mineralization within the volcanics adjacent to the Opaoka River basic igneous complex (Freeman and Black, 1940). Three miles west of Cold Spring rapid, on Bell river, gold and silver have been reported in a ferruginous sheeted zone in altered greenstone near its contact with the basic complex; seven miles southeast of here, on the west side of Bell river about a mile and a half above Island rapid, a sheared zone, eight feet wide, in acidic lavas contains some pyrite and arsenopyrite; and four miles farther east, on a tributary of Opaoka river, pyrite occurs in a shear zone in andesite.

Some work has been done on claims in the northeast quarter of Bruneau township, situated near the west bank of Sinclair creek about a mile and a quarter above its entrance to Bell river, which here closely follows the south margin of the belt, where it is in contact with granite. The greenstones are steeply sheared in a northwest direction and are mineralized with galena, pyrrhotite, and pyrite. Samples from a galena-bearing vein are reported to have assayed 3.04 oz. silver per ton, with very low gold content (Douglas, 1937).

At the eastern boundary of Berthiaume township, a short distance north of the east-west centre-line, east-west shear zones in the greenstones contain sulphide-bearing quartz veins (G.S.C., Map No. 570*A*). This occurrence is at the contact between the volcanics and granite which extends eastward to beyond Waswanipi lake and northward to Goéland lake, ten miles distant.

References

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OPAOKA RIVER BASIC IGNEOUS COMPLEX

The Opaoka River basic igneous complex occupies an oval-shaped area about twenty-five miles long in an east-southeast direction and having a maximum width of ten miles. It lies at the fork between the easterly trending Kitchigama-Mattagami-Goéland Lakes greenstone belt and the east-southeast trending Allard River-Baptiste River belt. The northwestern end of the mass is two miles south of Mattagami lake and two miles west of Bell river. Opaoka river crosses the complex near its eastern end.

A smaller mass of similar rock lies to the east of the Opaoka River mass, separated from it by a mass of younger granite, five miles wide. This body is about seven miles in diameter and lies immediately southwest of Goéland lake. The intervening granite includes several small outliers of the basic rock.

The Opaoka complex is made up of intrusive rocks which present a considerable range in composition (Freeman and Black, 1940). A gabbroic type, in places very rich in magnetite, is the most abundant, but some facies consist almost entirely of pyroxene (pyroxenite) or of feldspar (anorthosite), and between these there are many intermediate varieties. Freeman and Black concluded that the complex is probably a closely folded sheet-like body having a general synclinal structure, modified perhaps by minor anticlines and synclines.

It may be noted that there is a large mass of similar anorthosite and gabbroic rock some forty-five miles east of Goéland lake, extending from the eastern part of Opawica lake to and beyond Lessard lake, and fifty to sixty miles northeast of this a still larger body occurs in the Chibougamau area.

Economic Possibilities

With a view to testing the economic possibilities of the complex, assays were made in the laboratories of the Department of Mines of eight samples collected by Freeman and Black (1940) from magnetite-rich bands, four from Channel rapids on Bell river, and four from localities about two miles east of Shallow lake. Chromium was found in all the samples, but the highest assay was 0.44 per cent. One sample gave 0.15 per cent copper, and a 'trace' of nickel; the others gave negative results for these metals. Platinum was not found in any of the samples. The magnetite is evidently a titaniferous variety or has ilmenite associated with it, since titanium was present in all the samples, the range being from 'trace' to 8.92 per cent.

Reference

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FLORENCE RIVER-WEDDING RIVER AREA

The Florence River-Wedding River area lies immediately east of Bell river and includes a block of four townships, Desjardins and Currie on the north, with Franquet and Grevet on the south. The centre of the area is at about latitude 49°18′ and longitude 76°52′ (see Vol. II, Map 703*A*).

The discovery of gold-bearing veins in Currie township in 1934 attracted many prospectors to the area. Among the first stakings were some veins on the south shore of Madeleine (Rose) lake from which, during 1938 and 1939, Lake Rose Mines, Limited, produced a considerable amount of gold. In 1935, a gold-bearing zone was discovered some eight miles southwest of the Lake Rose property, in the southeast corner of Desjardins township. Here, on the property of Flordin Mines, Limited, a considerable amount of exploratory and development work has been done, including diamond drilling and sinking of a shaft. Another interesting gold occurrence along this zone is the Cameron find, in the northwest corner of Grevet township, five and a half miles east-southeast of the Flordin shaft. Gold mineralization has been reported at numerous other points in each of the four townships, but none of the occurrences has been intensively explored and in the case of many of them the adjacent ground is so heavily drift-covered that adequate testing would be both difficult and costly. There is little doubt, however, that this area will receive further detailed attention in the future.

General Geology

The area is at the junction of the Allard River-Baptiste River greenstone belt and a belt of greenstones which extends for approximately one hundred miles in a northeast direction from the Rouyn-Bell River area to Opawica lake.

As in adjacent areas, the oldest rocks are Keewatin-like volcanics with associated tuffs and agglomerates. Flows of diverse composition are represented, but 'greenstone' types predominate.

A narrow band of sedimentary rocks is exposed in outcrops at two places in Currie township, respectively one mile south of the west end of Madeleine lake, and one mile northwest of the west end of Esther lake. The beds exposed are argillite, arkose, and iron formation rich in magnetite. They conform in attitude with the adjacent volcanics, perhaps in a synclinal structure. MacKenzie (1936, p. 90) suggests that they may be younger than the volcanics.

Cutting these volcanic and sedimentary rocks are intrusive bodies, both basic and acidic. Prominent among these are quartz and feldspar porphyry dykes, sills, and larger intrusive masses. Two of the larger masses are granite or quartz-syenite. The more northerly of these is in the southeast corner of Desjardins township, just north of Cameron lake; the other is in the northeast corner of Franquet township. They are, respectively, one mile and four miles in diameter and are separated by a belt of volcanics a little over a mile wide. Quartz porphyry or rhyolite porphyry forms two long, linear masses, one trending east-west across the Franquet-Grevet boundary, the other, three miles farther south, crossing into the southwest corner of Franquet township from the southwest.

Extending from the east along the northern margin of the area, across Currie and Desjardins townships, is a wide belt of gneissoid granite, approaching granodiorite, which terminates on the west against the Allard River-Baptiste River greenstone belt. Near the west boundary of the area, at Bell river, is the eastern end of a large granitic batholith, which borders the Allard River-Baptiste River belt on the south.

The youngest intrusive rocks are gabbro or diabase dykes, which include both quartz and olivine bearing types. Such dykes have been recorded only in the two southern townships. Their strike is northeasterly, following a prominent structural trend in this part of the area.

The regional shearing approximates, in general, the attitude of the flows, as also do certain carbonatized zones in the volcanics. Most notable of these zones is one that trends eastward across the southern part of Desjardins township and then, striking a little south of east, continues across northwestern Grevet. In this zone and striking with it are the gold-bearing quartz veins and sulphides on the Flordin, Cameron, and other properties. The east-west striking veins of the Lake Rose mine also have this direction.

Strong faulting and shearing with a northeasterly trend is prominent in the southern part of the area. Veins having this strike are common, as for example in the southwest part of Grevet township, and in south-central Currie township near Esther lake. In places, there has also been north-south faulting. Fractures with this trend cut across the veins on the Lake Rose, Cameron-Beck, and other properties.

Gold has been recorded in veins or zones having each of the trends mentioned above, but all the orebodies of interest found to date occur in the east-west trending structures. Many of the veins are in carbonatized zones or have selvages of carbonatized material, more or less impregnated with sulphides. Pyrite is the commonest sulphide. Pyrrhotite is less abundant, and chalcopyrite is not uncommon in small amount. These sulphides may also be present in the vein-quartz. Of rarer occurrence are sphalerite, galena, and arsenopyrite. A little tetradymite (bismuth telluride) was found in the veins of Lake Rose mine. Occasionally, fractures in the quartz contain visible gold.

Desjardins Township

Flordin Mines, Limited

The shaft of *Flordin Mines, Limited,* is in Desjardins township, about three-quarters of a mile from its south boundary and three miles from its east boundary. It is near the east end of a gold-bearing zone that has been investigated for a distance, on this property, of close to two miles (MacKenzie, 1936, pp. 107-108; Taschereau, 1937, pp. 110-112; Taschereau and Herring, 1940, p. 72).

The initial discovery was made in 1935 and in 1938 the present Company acquired title to the property. Development was carried out under the direction of the International Mining Corporation, Limited. Up to the time operations were suspended in February, 1941, much surface work had been done, some 16,000 feet of diamond drilling had been completed, and a shaft had been put down to a depth of 350 feet, with workings on two levels.

Gold-bearing veins and lenses of quartz occur in zones in sheared and partially carbonatized rhyolites, andesites, and tuffs. The main mineralized zone is known to extend for at least two miles northwestward from the shaft and for an even greater distance southeastward (S.15°-25°E.), possibly to the south end of Wedding lake. In the latter direction it passes between two small bodies of granitic rock (see map 703*A*) which are about a mile and a quarter southeast and due east, respectively, of the shaft. These intrusive bodies acted as buttresses and localized the stresses in this locality.

Some diorite, syenite, and feldspar porphyry dykes are present near and along the carbonatized and mineralized zones, and are in places sheared and altered, and cut by quartz veins. In the eastern, or shaft, section of the property, where the veins and vein-zone strike S.65°-85°E., a number of cross faults, striking N.60°-85°E., have displaced the veins a few feet.

The gold occurs in the quartz associated with pyrite, or in the adjacent pyrite-impregnated wall-rocks. In the eastern section of the property, in the vicinity of the shaft, the quartz is not so much in distinct veins as in parallel, thin lenses in a thinly banded schist which is partially replaced by quartz and by reddish aplitic material. The quartz and schist are mineralized with pyrite, quite heavily in places, over widths of several feet.

Early work on the 'Wood' showing, at the west end of the property, disclosed two parallel (east-west) vein-zones, one about 230 feet north of the other. The more northerly persists for nearly 2,000 feet and includes three ore-shoots with an aggregate length of 1,367 feet and an average width of two feet. In the southerly zone, quartz is present almost continuously for 4,000 feet east to the point where the general zone of shearing swings southeasterly. About 100 feet north of the east end of this 4,000-foot section is a parallel vein which has been traced for 400 feet, and 1,000 feet east-southeast of this is another vein which has been traced for 900 feet. In these veins, comprising the south vein-zone, some six ore shoots are indicated, ranging from 150 to 750 feet in length and from 3.6 to 8.7 feet in width. Assays are reported to range up to 0.40 oz. gold per ton across mineable widths.

Other Mineral Occurrences in Desjardins Township

The *Consolidated Mining and Smelting Company of Canada*, and *Consolidated Chibougamau Goldfields*, did a considerable amount of exploratory work in 1934 along a shear zone in the volcanics at the outlet of Madeleine lake (MacKenzie, 1936, p. 104). Here, a quartz vein was traced for approximately seventy feet in a direction N.35°E. It is up to three feet wide along its northern exposed portion, but narrows to a few small stringers toward the south. The quartz is heavily mineralized with pyrite and chalcopyrite, but assays for gold were reported to be very low or negative. Other mineralized veins or shear zones to the west and north of Florence river were likewise found to contain only negligible amounts of gold.

About three miles northwest of the southeast corner of the township, *Wedding River Gold Mines, Limited*, have carried out some surface work on a number of gold-bearing quartz veins (MacKenzie, 1936, p. 105). The locality is about a mile and a half north and half a mile east of the Flordin shaft.

The country rocks are andesites, more acidic flows, and interbedded tuffs, which strike N.80°W. and dip 80° north. Regional shearing has a similar trend and attitude. Northerly striking quartz veins, none over two inches wide, cut the volcanics, which, between the veins, are silicified, carbonatized, and mineralized with a little pyrite and pyrrhotite. An assay of this material is reported to have yielded 0.07 oz. gold per ton. To the south of the gold-bearing stringers is a wide east-west striking zone impregnated with sulphides, but so far it has not been found to carry gold.

About a mile farther westward, a small stock of porphyritic quartz syenite intrudes the volcanics. Along its southwest margin, both the volcanics and the intrusive rock are quite heavily mineralized with pyrite, pyrrhotite, and magnetite. A sample of the mineralized volcanics was found to carry only a 'trace' of gold.

CURRIE TOWNSHIP

Lake Rose Mines, Limited

The workings of *Lake Rose Mines, Limited*, are on the south shore of Madeleine lake, near its southeast end, approximately on the east-west centre-line of Currie township, three miles from its west boundary (Taschereau, 1935, pp. 125-131, 1937, pp. 109-110; MacKenzie, 1936, pp. 101-103). Gold was discovered here in the fall of 1934. The property was acquired by Prospectors Airways, Limited, who, in 1936, organized Lake Rose Mines, Limited, to bring the mine to production.

The veins mined, and others, outcrop on a prominent ridge which rises to 200 feet above the lake, within 800 feet from the lake shore. An adit was driven southward into this ridge for a distance of 951 feet, and from it drifts were run out on the veins. A winze was sunk from the adit to a depth of 266 feet and levels were established at the 125- and 250-foot horizons. A 25-ton mill was placed in operation in June, 1938. Results of development on the two lower levels of the mine proved disappointing, however, and in March, 1939, all operations were suspended. The mill is reported to have treated 5,374 tons of ore for a recovery of $118,900, or 0.63 oz. gold per ton.

The property is underlain mainly by volcanics of andesitic composition, with some interbedded volcanic breccia, fine-grained tuff, and graphitic schist. The general strike of the beds is N.65°W., and their dip is northward, at 70° to 80° near the lake, but at only 45° a few hundred feet farther south. The structure is thought to be the north limb of an anticline, whose axis is believed to be approximately two-thirds of a mile south of the lake. Intruding the volcanics is a mass of quartz diorite.

Just to the north of the mine, and hidden beneath the waters of Madeleine lake, is the contact between the lavas and a large body of granite that extends far to the north. The trend of this contact is N.80°W., about parallel to the strike of the adjacent lavas.

The best ore came from veins in the volcanics east of the quartz diorite. The sections of veins in the quartz diorite were found to be relatively low grade.

The type and amount of mineralization varies somewhat in the several veins. The quartz is dark grey to white, with lustre glassy to dull, the latter probably a finely crystalline type. Sulphides are usually in evidence, confined for the most part to the quartz. Pyrite and pyrrhotite are the most common, each in sparing amount, and with them may be a little chalcopyrite and sphalerite. Occasional specks of tetradymite (bismuth telluride) occur in some of the veins. In the higher grade specimens, the native gold can be clearly seen along fractures in the quartz and was therefore emplaced after the quartz was fractured.

The three most important veins on the property are designated Nos. 1, 2, and 3. No. 1 was systematically sampled on the adit level in 1936 and over a length of 120 feet gold tenors averaged 0.45 oz. per ton across an average width of 2.3 feet. No. 2 vein assayed 1.37 oz. gold per ton for a drift length of 140 feet and an average width of 2.7 feet. These veins appeared to be stronger on the adit level than in their outcrops, where, however, they had about the same gold content. On the 250-foot level, in the winze, both veins are merely weak shears, containing little quartz. They have the same strike, N.80°W., and their dip, calculated from their position on surface and underground, is about 60° north. No. 3 vein was found underground, extending nearly due south from No. 2 vein at a point forty feet west of the adit and some distance east of the quartz diorite. For a length of sixty-two feet and a width of one foot, it contained an average of nearly four ounces of gold per ton. No vein having this strike has been found at surface.

On the shore of the lake, a short distance from the adit portal and not far from the granite-greenstone contact, a quartz vein, forty feet wide in places, has been followed for 400 feet. It occurs in drag-folded banded tuff and graphitic schist. The quartz is white and vitreous and is apparently devoid of gold or sulphides.

Another vein is exposed 4,500 feet west of the original discovery, on the central bay on the south shore of the lake. It has been followed for 200 feet from the lake shore in a direction S.45°E. and is from eight to ten feet wide. The quartz is glassy and it and the adjacent silicified volcanics are mineralized with pyrite. A sample from this vein was reported to carry gold.

Other Prospects in Currie Township

West of Large Bay on South Shore of Madeleine Lake

A considerable amount of exploratory work was carried out during 1934 and 1935 on the *Bush-Langevin* group of claims, which lie immediately west of the property of Lake Rose Mines (Taschereau, 1935, p. 131; MacKenzie, 1936, p. 104). The claims are underlain by volcanics, which are cut by a number of large dykes of feldspar porphyry. Four quartz veins and several shear-zones were uncovered by stripping. Three of the veins are of considerable size and in places they contain some pyrite and chalcopyrite. However, systematic sampling of the veins and shear zones failed to reveal the presence of gold in commercial amount and most of the assays gave negative results.

Between Madeleine Lake and East Boundary of Currie Township

Eastward from the property of Lake Rose Mines, surface work has been carried out on three groups of claims, one held by the *Engineers Exploration Company* and the others known respectively as the *Potter-Boulanger* group and the *Waite* group (MacKenzie, 1936, p. 104). Narrow quartz veins, some barren and others sparingly mineralized with pyrite, and less commonly with chalcopyrite, occur at a number of points in the volcanics or tuffs underlying these claims, but the owners of the properties have reported that assays for gold gave negligible or negative results.

Wedding River, North of Esther Lake

In 1935, *H. Boulanger* and associates did some work on a group of claims along the south bank of Wedding river, about a quarter of a mile north of Esther lake, where the volcanics are intruded by a small body of feldspar porphyry, exposed as a ridge (MacKenzie, 1936, pp. 104-105). Within the porphyry, near the east end of the ridge, is a quartz vein, two to four inches wide, heavily mineralized with galena and pyrite, and sparsely with chalcopyrite and sphalerite. A sample from this vein, assayed in the laboratories of the Quebec Department of Mines, gave: lead, 0.10 per cent; gold, 0.01 oz., and silver, 2.74 oz., per ton. About 500 feet west of this is a larger quartz vein, almost barren of sulphides, and, near the west end of the ridge, shears in the porphyry contain a little pyrite and arsenopyrite.

Southwest Part of Currie Township

Two occurrences of gold-bearing mineralization in the southwest part of Currie township are indicated on the Pusticamica Lake map-sheet (No. 570*A*) issued by the Geological Survey of Canada in 1940. Both are in volcanic rocks. One is about a mile and a half from the south boundary of the township and three-quarters of a mile from its west boundary; the other is two miles to the southeast of this. The eastern margin of the body of porphyritic quartz syenite north of Cameron lake follows approximately the Currie-Desjardins township-line and is thus not far distant from these occurrences.

In 1935, the *Prospectors Airways Company* reported gold-bearing quartz, well mineralized with pyrite, chalcopyrite, and galena, in shear zones in diorite near the west boundary of the township.

Franquet Township

There are but few exposures in the western part of Franquet township, but they are somewhat more frequent in the eastern part. However, sulphide mineralization has been uncovered in many localities, and two occurrences of gold have been recorded.

Gold-bearing quartz veins occur in the volcanics near the north-south centre-line of the township, less than a thousand feet south of the Desjardins-Franquet boundary (G.S.C. Map No. 570*A*). The locality is about two miles west-southwest of the Flordin shaft, on the west bank of a southerly flowing stream which, after a circuitous course, joins Florence river. Not far to the south and southeast is a body of intrusive rock, largely granitic in composition.

About two and a half miles farther northwest is a group of claims originally staked by *H. Bush* (Douglas, 1937, p. 55). In 1937 they were under option to the *Consolidated Mining and Smelting Company of Canada*, who carried out extensive surface exploration. Sulphide mineralization was found along a zone of shearing traceable for at least three-quarters of a mile in a northwest direction in silicified tuffs or sediments. More or less along the strike of the zone are several pink rhyolite dykes that are highly folded and sheared. Both the tuffs and dykes have been replaced by pyrite to a considerable extent over a width of, usually, a few feet, but up to as much as seventy-five feet. Some chalcopyrite accompanies the pyrite. Gold is present but has not been found in any important concentration.

Immediately northwest of the Bush claims, somewhat similar sulphide mineralization, as well as numerous quartz veins, have been uncovered. Assay of a sample from this locality gave little better than a 'trace' of gold.

A short distance south of Wedding river, about four miles west and three miles north of the southeast corner of the township, sheared amygdaloidal and other lavas are in places considerably carbonatized. They lie just off the west end of a long, narrow intrusive body of quartz porphyry which extends easterly for six miles and has a width of as much as a mile near its west end. Pyrite is abundant, and the whole zone is heavily iron-stained due to alteration of the pyrite to limonite (Longley, p. 74). No gold was reported.

Grevet Township

A considerable amount of surface exploration was done during 1935 and 1936 on various claims in the northwest section of Grevet township.

The occurrence of gold was reported at a number of places, but no deposits of commercial size or tenor were found (Taschereau, 1937, p. 115).

The most extensive work was on the *Cameron* property, which is about two miles east and a mile and a half south of the northwest corner of the township (MacKenzie, 1936, p. 106). The claims lie some five and a half miles S.65°E. of the Flordin shaft, along the continuation of the wide zone of shearing in which the Flordin deposits occur. On the north side of an east-west ridge, a zone of sulphide and gold mineralization in acidic tuffs and tufaceous sediments has been exposed in trenches over a length of 950 feet and a maximum width of 250 feet. Panning indicated the presence of gold at many places across and along the zone, but systematic sampling did not disclose ore zones. Maximum assays were 1.67 oz. gold per ton over widths up to six inches, and 0.31 oz. over widths up to one foot. Along one section of the large quartz vein, an assay of 0.23 oz. gold per ton was obtained across its width of 1.1 feet. In general, however, assays of the mineralized tuff ranged from *nil* to 0.05 per ton.

Fluorite was observed along one of the north-south cross-fractures, and tourmaline was noted in some thin sections of the tuffs. On the basis of the presence of these minerals, MacKenzie (1936, p. 107) concluded that the sulphide and gold mineralization is of pneumatolytic-hydrothermal type, associated with the injection of the aplite dykes and the albitization of the tuffs.

Gold has been reported about a mile and three-quarters southwest of the Cameron claims in a silicified shear zone in east-west trending lavas, adjacent to which is a feldspar porphyry dyke mineralized with sulphides.

Two occurrences of gold have been recorded on Wedding lake. One of these is in banded chert and volcanics on the island in the centre of the lake; the other is on the northwest shore of the lake, a little north of the west end of the island, where the gold occurs in a carbonatized quartz porphyry dyke. In both places, the gold is associated with pyrite.

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PUSTICAMICA LAKE AREA

The Pusticamica Lake area, immediately east of the Florence River-Wedding River area, comprises the townships of Duplessis and Benoît on the north and Mountain and Ruette on the south. Pusticamica lake is fifteen miles long and trends southwest from the northeast corner of Benoît township, across the southeast corner of Duplessis, and into the northeast corner of Mountain township.

Following the discoveries of gold in the Florence River-Wedding River area, a considerable amount of prospecting was carried out in these townships. The search was intensified when, in 1936, rich gold-bearing 'float' was found at one locality along the south shore of Pusticamica lake but, up to the present, no gold or other mineralization of value has been found 'in place'.

In this area, the belt of volcanic rocks, continuing eastward from the Florence River-Wedding River area, changes in trend from easterly to northeasterly, and at the same time it decreases in width from fifteen miles at the western boundary of the area to about six miles at the northeast.

Surface Exploration

The gold-bearing 'float' referred to above was found in an area of heavy drift on a point on the south shore of the lake, at the entrance to the more easterly of the two long, southwest trending bays. The boulders, which were angular, consisted of quartz and green schist. One contained some visible gold, and three others yielded assays of 0.9, 0.4, and 0.26 oz. gold per ton. The ground was staked by Thorne Exploration, Limited, who carried out a programme of trenching in the hope of discovering the bedrock source of the float. This work did not reveal material similar to the boulders. However, a wide mineralized zone was uncovered over an east-west length of 200 feet in a sheared, shattered, and kaolinized quartz porphyry and more massive dioritic rock, traversed by small stringers of quartz. The porphyry is probably related to a stock of granite that forms a high hill to the south. The mineralization consists of pyrite and a little chalcopyrite. Assays, as reported by the Company, did not exceed $1.20 in gold per ton (Taschereau, 1937, p. 109).

Duplessis township has been rather intensively prospected, particularly around Burge and Rochester lakes, and northeast of the latter lake near the south end of the northwest arm of Pusticamica lake. No mineralization of interest has so far been uncovered.

In the vicinity of Granite lake, in the southwest corner of Mountain township, the biotite granite — which occupies the whole of the southern part of the township — is traversed by several quartz veins, but all of those observed are barren looking (Longley, 1937, p. 75).

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THE OPAWICA-CAOPATINA BELT

Geology

The Opawica-Caopatina belt of Keewatin-like volcanic rocks, trending south of east between these lakes, has a length of fifty miles and a width of ten to fifteen miles. Flanking the belt on north and south are large granite batholiths. The following notes on the geology and mineral occurrences are based on the report by G. Shaw (1939).

Around and adjacent to the south shore of Caopatina lake, the rocks of the belt are mainly water-lain sediments. Elsewhere, throughout its length, they are 'greenstones', representing volcanic flows of composition ranging from andesite to rhyolite, with which minor amounts of tuffs are interbedded. Intruding these are a number of fairly large stocks or sills, some basic and others granitic.

In general, the rocks of the belt have an easterly strike paralleling its trend, and dips are usually steep. It is probable that the belt is a synclinal remnant whose flanks were engulfed by the batholithic intrusions.

Both to the north and south of Opawica lake, the volcanics are intensely sheared, contorted, and carbonatized. The shearing trends N.65°-70°E., and possibly a major fault with this trend extends along and eastward from the lake. North of the west end of Lewis lake, a fault with trend N.20°E. cuts the greenstone-granite contact, with displacement of the east side three-quarters of a mile to the north. Similar small faults north of Shortt lake offset east-west striking gold-bearing quartz veins.

Mineral Occurrences

There has been a certain amount of prospecting all along the belt, and gold and copper mineralization has been reported in several localities at its western end, in the vicinity of Opawica lake. Up to the present, however, no deposits of economic interest have been discovered.

Gold

Opawica Island.—This island is underlain by volcanics which, at its western side, are intruded by a small boss of syenite. Immediately east of the south end of this boss, the volcanics are, in places, highly silicified and carbonatized and contain disseminated pyrite. Panning of the weathered surface material yields gold 'colours', but sampling of fresh material blasted to a depth of six feet returned only low assays for gold.

North of Shortt Lake.—Gold was discovered in 1936 in two quartz veins near the north shore of Shortt lake, at a point about two miles north of Opawica lake and five miles eastward from Opawica island*. The veins, cutting gabbro, are two to nine inches wide and about six feet apart, and have been traced for nearly 100 feet along their easterly strike. The occurrence was explored by *Ceres Exploration, Limited,* from whose records the following data are summarized: Cutting the veins within a zone fifty feet wide there are twelve faults, with individual displacements from six inches

* The discovery was made by T. K. McDougall, of Ceres Exploration, Limited.

to eight feet. At about the centre of this zone, the south vein contains visible gold for a length of some seven feet, and assays as high as 146 oz. gold per ton were obtained across a width of four inches. Both eastward and westward of this high-grade section, the vein narrows, tailing out within twenty-five feet to the east and passing beneath drift some thirty-five feet to the west. The north vein is exposed for a longer distance, and a quartz vein in an outcrop 120 to 200 feet to the east may represent its continuation in that direction. In places, fine grained pyrite occurs in fractures in the vein quartz and adjacent gabbro, and also along the fault planes. Some assays of this pyritized material have yielded high returns for gold, others only a trace.

Copper

Gull Island.—About midway along the north shore of Gull island — which forms part of the south shore of the easterly trending north arm of Opawica lake and is some six miles east of Opawica island —a quartz vein containing ferruginous carbonate and chalcopyrite cuts intensely sheared acidic volcanics. The vein is four feet wide and can be traced under water for a distance of fifty feet. Panning of the vein material has yielded gold.

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LAFLAMME RIVER-PÉNACHE RIVER BELT

A belt of Keewatin-like rocks extends eastward from Bigniba river to beyond Eagle river (longitude 78° to 75°), a distance of about 130 miles. For the most part it lies between latitudes 49° and 50 °, the latter being near the boundary between Abitibi territory and Abitibi counties to the south.

Northerly flowing rivers cross the belt at intervals along its length and the country adjacent to these is comparatively easily accessible by canoe from points along the Canadian National railway, fifty to sixty miles to the south.

GEOLOGY

As in the other belts of Keewatin-like rocks in the region, volcanic flow rocks predominate. Interbedded with these in places are tuffs and other fragmental types, and along some sections there are, in addition, water-lain sedimentary rocks. The volcanic rocks have been converted to schists of various types — chlorite, hornblende, and sericite — but intimately associated with these in places are massive rocks of dioritic type. Several stocks and bosses, and numerous dykes, of granite and quartz porphyry have intruded the rocks of the belt near its western end.

The general strike of the schistosity and shearing, and of the bedding where this has been observed, is within a few degrees of east-west, paralleling the trend of the belt, and dips are steep to vertical. Adjacent to the flanking granite and to stocks of this rock, however, the strike tends to parallel the contact (Longley, 1939, p. 29; Milner, 1939, p. 5, 1943, p. 15; Freeman, 1939, p. 7, 1943, p. 11).

Mineral Occurrences

Numerous claims have been staked in the area, and surface work on some of these has revealed gold mineralization of interest, but to date no deposits of commercial size or grade have been developed. Following are brief descriptions of the principal known occurrences, taken in order from west to east along the belt.

Western Section of Belt

(Laflamme river to Wilson lake)

The western section of the belt, between Laflamme river and Wilson lake, has been mapped by Longley (1937, 1939, 1940). In several localities he observed sulphide mineralization in sheared volcanics, and in and adjacent to intrusive bodies, that appeared to merit further examination. Along the south bank of Wilson river, in the central part of Verneuil township, the greenstones, and also two acidic dykes that cut them, are extensively mineralized with pyrite, and, in the northwest corner of the township, the rocks of the belt are in places similarly mineralized along strong shears. In the adjacent township of Wilson, a zone of intense shearing in the greenstones exposed along the shore of Wilson lake at its northeastern end is silicified and mineralized with pyrite.

In the central zone of the western section of the belt, a number of claims have been staked, and on some of these a fair amount of surface work has been carried out. The following descriptions are summarized from Longley's 1939 report.

Léo Bomia Claims.—These claims are near the north boundary of Laas township, just east of the north-south centre line. They were explored by the Consolidated Mining and Smelting Company of Canada, Limited, who reported that assays of samples from the mineralized zones gave negligible returns for gold and silver.

Kiask Falls Mining Company, Limited.—The claims of this Company are in the northern part of Tonnancourt township, at Kiask falls on Bell river, six miles due east of the Léo Bomia claims. Two zones of rather strong shearing, trending respectively slightly north and slightly south of east, in the volcanics contain many quartz-carbonate lenses and stringers, poorly mineralized with pyrite. Apart from some surface stripping, there has been little work on the property.

G. R. Blais Claims.—A limited amount of stripping has been done on these claims, which are in the southeast corner of Fraser township, some twelve miles due north of the Léo Bomia property.

In the course of his work in this area, Longley observed pyrite mineralization in shear zones, quartz and quartz-tourmaline veins, and carbonatized zones in the volcanics at several localities, but assays of samples he collected from a number of these occurrences yielded negligible or negative results for gold.

There has been a considerable amount of prospecting along the south fringe of this western section of the belt, in Laas, Tonnancourt, Holmes, and Cuvillier townships, but it has failed to reveal gold or other mineralization of economic interest. Longley (1940) observed mineralized shear zones in the greenstones in several localities, and also a few quartz veins cutting them, but assays of samples he collected from the better looking occurrences were not encouraging, the highest being 0.03 oz. gold per ton.

Eastern Section of Belt
(Pénache river to Eagle river)

Barry Township

There has been much prospecting along this section of the belt and a considerable amount of surface work has been carried out on a number of the claims that have been staked. Up to the present, however, no gold or other deposits of commercial size have been found. The area was mapped in 1939 by Milner (1943), from whose report the descriptions that follow are summarized.

Barry Lake Mining Company, Limited.—The claims of this Company are in the north-central part of the township, at the west end of Barry lake. On one of the claims, a quartz body of irregular shape, from a few inches to fifteen feet wide, has been exposed for a length of fifty feet, and trenching on other claims has exposed sulphide mineralization, locally in fairly heavy concentration. According to Company reports, sampling of the several workings yielded only low assays for gold.

Mégiscane Mining Corporation.—Trenching on claims held by this Company on the north shore of Barry lake, at the northeast corner of the township, has exposed a narrow quartz vein in acidic schistose greenstone. Low assays in gold are reported.

Rouleau Mines, Limited.—This property is in township *118*, about three-quarters of a mile northeast of the Mégiscane holdings. Here, on the east shore of the small Rouleau lake, a mineralized zone in heavily sheared tuffs, striking N.70°E. and dipping steeply north, is highly silicified and carbonatized and contains much disseminated pyrite, with minor amounts of pyrrhotite, chalcopyrite, and magnetite. When seen by Milner, in 1939, it had been exposed by three cross-trenches over a length of three hundred and fifty feet, along which it has a maximum width of fifty feet. Cutting the zone are numerous tourmaline-bearing quartz stringers, with general north-south strike. The mineralization appears to be closely related to these stringers. The Company reports that sampling of two of the trenches over lengths of, respectively, 34 feet and 32.6 feet gave gold assays of $2.85 and $2.24 per ton, and that a number of higher assays were obtained from individual samples. The westward continuation of this zone of shearing has been exposed by several trenches at a point about half a mile to the southwest, on the east shore of Morissette lake, but sampling has indicated only 'traces' of gold.

Lac aux Loutres.—Stripping on claims at the north end of lac aux Loutres has exposed a band, fifty to one hundred feet wide, of fine grained schists carrying scattered pyrite and chalcopyrite. Assay of a grab sample taken by Milner near the east end of the workings gave only a 'trace' of gold.

Faessler (1936, p. 38) reported the occurrence of molybdenite in narrow quartz veinlets cutting porphyritic granite that forms a high cliff on the eastern shore along the southern part of the lake.

Lacroix Township

On the west shore of Chanceux lake, which lies immediately east of the north-south centre line of Lacroix township, about a mile south of its northern boundary, a cross-trench has exposed a carbonatized zone, ten feet wide, in well bedded tuffs which strike N.65°W. and dip vertically. A short distance to the south of this zone, the tuffs are cut by a quartz vein, three feet wide. Assays of samples from these workings are reported to have yielded negligible returns for gold (Freeman, 1939, p. 9). The work on these claims was carried out by the Gold Eagle Syndicate.

Buteux Township

The descriptions that follow are summarized from the report by Freeman (1943), who mapped the area in 1939.

Seguin-Griffith Claims.—These claims are near the west boundary of the township. At a point about one hundred feet south of Little Eagle river, a quartz vein, up to one foot wide, has been exposed for a length of thirty feet. The vein cuts gneissic diorite, and at its western end, where it abuts against a diabase dyke, it contains free gold in easily visible specks. North of the river, a few hundred feet northeast of this occurrence, a strongly silicified shear zone in the diorite is exposed for a length of forty-five feet, beyond which, both to east and west, it is concealed beneath overburden. A channel sample across a width of five feet is reported to have assayed $2.80 in gold per ton.

Golden Eagle Syndicate.—This property is about three miles east of the Seguin-Griffith claims. It lies just within the belt of volcanics, which are here light coloured, sheared tuffs, striking N.20°E. and dipping 60°S.E. Cutting them are two diabase dykes, about two feet wide and one foot apart. Quartz, calcite, and pyrite have been introduced along the shear and in lesser amount in the dykes. Grab samples are reported to have given low assays in gold.

Griffith Claims.—On these claims, about a mile west of those last mentioned, outcrops are limited to an area of about three hundred feet diameter. They are for the most part amphibolite, representing original basic lavas, but interbedded with them are a few bands of quartz-mica schist which is thought to be of sedimentary origin. The principal discovery to date is a quartz lens in the amphibolite, exposed for a length of fifteen feet and a width of five feet. Within the quartz are appreciable amounts of carbonate and pyrite, and gold can be panned from the crushed material. Assay of a two-pound sample taken by Freeman gave $11.79 in gold per ton.

Radio Prospectors, Limited.—This property is in the northeast quadrant of Buteux township, and just to the west of Claim lake. From the lake, a valley, some five hundred feet wide, extends westward. It is flanked on both sides by andesite, but the valley itself is underlain by quartzitic slates and acidic tuffs. These strike east-west and dip vertically or high to the south. In places within the curves of folds, the rock has been replaced by sulphides, which have the form of lenticular beds up to twenty-seven feet long and nine feet wide. Several such lenses were uncovered by trenching. They are of three types: pyrite, pyrrhotite with a little chalcopyrite, and mixed pyrite and pyrrhotite. Assays of five representative samples taken by W. N. Asbury in 1937 (Q.B.M., P.R. 120, p. 27) gave only a 'trace' in gold.

Tellurides have been reported in a small quartz vein near Schist lake, a mile and a half west of Claim lake (Q.B.M., P.R. 120, p. 27).

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LAC LA TRÊVE-OPÉMISCA-CHIBOUGAMAU REGION

INTRODUCTION

Location and Means of Access

The Lac La Trêve-Opémisca-Chibougamau region is a belt of country in Abitibi Territory extending from west to east for eighty miles and averaging twenty miles in width (Figure 7). It lies about midway between lac St-Jean and James bay and is from 100 to 130 miles north of the Canadian National railway. The area is included in maps 397*A* and 398*A*, the east half and the west half, respectively, of the Chibougamau sheet, issued by the Geological Survey of Canada in 1938.

Numerous lakes make all sections of the belt easily accessible by aeroplane. A winter road 137 miles long, built in 1935 from Rouleau siding, near Langlade, 65 miles east of Senneterre, leads to the property of Opemiska Copper Mines, Limited, in the central part of the belt. An older winter road, about 130 miles long, reaches Chibougamau lake, at the eastern end of the belt, from St-Félicien, on lac St-Jean. The St-Félicien end of this road has in recent years been improved for motor traffic.

History

The first systematic geological work in this district was carried out by James Richardson in 1870-71. He described occurrences of chalcopyrite and pyrite on Portage island, in Chibougamau lake. In subsequent years, chiefly between 1903 and 1907, similar mineralization, as well as occurrences of gold and asbestos, were reported at several other points. The interest aroused by these discoveries culminated in 1910, when the Quebec Department of Colonization, Mines and Fisheries appointed the Chibougamau Mining Commission to make a thorough examination of the geology and mineral resources of the Chibougamau region. The Commission reported (Barlow *et al.*, 1911) that the asbestos deposits were not of present economic interest and that, although further search might reveal gold and copper deposits of importance, the known occurrences were not of commercial value even if a railway were built into the district.

The opening of the Canadian National railway from Quebec city to Cochrane, in 1917, made access to the region somewhat easier than it had been, and, encouraged by the important discoveries being made in the Rouyn-Bell River area, prospectors once more turned their attention to the country adjacent to and westward from Chibougamau lake. Discoveries were made, some of considerable promise. On one of these, a copper-gold deposit in Lévy township, some four miles south of Opémisca lake and twenty miles west of Chibougamau lake, a considerable amount of surface exploration, diamond drilling, and underground work from a 545-foot shaft, was carried out by Opemiska Copper Mines, Limited, between the years 1930 and 1937. Further development of this and other deposits, however, awaits the provision of adequate transportation facilities.

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LAC LA TRÊVE AREA

The main feature of the geology of Lake La Trêve area is a synclinal belt, eight miles wide, of steeply-dipping sedimentary rocks, trending east-northeast between lac La Trêve and lac des Deux Orignaux. The beds exposed are feldspar-rich sediments, slates, banded chert, and conglomerate. These sediments are flanked by Keewatin-type lavas. They appear to be younger than the latter and are tentatively regarded as either late-Keewatin or equivalent to the Temiscamian of the Rouyn-Bell River area. Intruding these rocks are bodies of granite. Basic intrusives such as occur farther east and are particularly abundant on the north side of Chibougamau lake are not found in the vicinity of lac La Trêve.

Quartz veins carrying gold have been reported in the volcanics immediately north of the tip of the narrow northeast arm of lac La Trêve.

OPÉMISCA AREA

The Opémisca area, or central section of the region under discussion, may be considered as extending eastward from lac La Trêve to Chibougamau lake.

Opémisca lake, at the western end of this area, occupies a basin along the northern margin of a body of granite, the Opémisca batholith. This has a general trend somewhat south of east and is sixteen miles long by seven miles wide.

North of the lake is an easterly trending, synclinal belt of sedimentary rocks flanked on either side by Keewatin-like volcanics, and intruded by numerous sills. Few mineral deposits of interest have been found in this belt in the vicinity of Opémisca lake, but several have been reported farther east, about Chibougamau lake.

Immediately south of the Opémisca batholith is a closely similar synclinal structure, six to eight miles wide, trending east-southeast. The northern limb, which is composed to the extent of nearly 50 per cent of intrusive sills, is much thicker than the southern limb. Two of these sills, immediately north of Campbell lake, are 1,300 feet and 3,500 feet thick, separated by 500 to 2,000 feet of acidic lavas. Both have a fairly steep dip and are *Z*-shaped in outcrop, presumably as a result of drag folding. It is in the more easterly and thicker of these sills that the copper-gold deposits of Opemiska Copper Mines occur. The sedimentary rocks along the centre of the syncline are separated into two groups by an unconformity. The beds above this unconformity have been tentatively referred to the Temiscamian; those below, to the Keewatin (Norman, 1938, p. 3).

FIGURE 7 (folded insert)—*The northern part of Abitibi-East county from longitude 78° to 74°, including the Lac La Trêve-Opémisca-Chibougamau region.*

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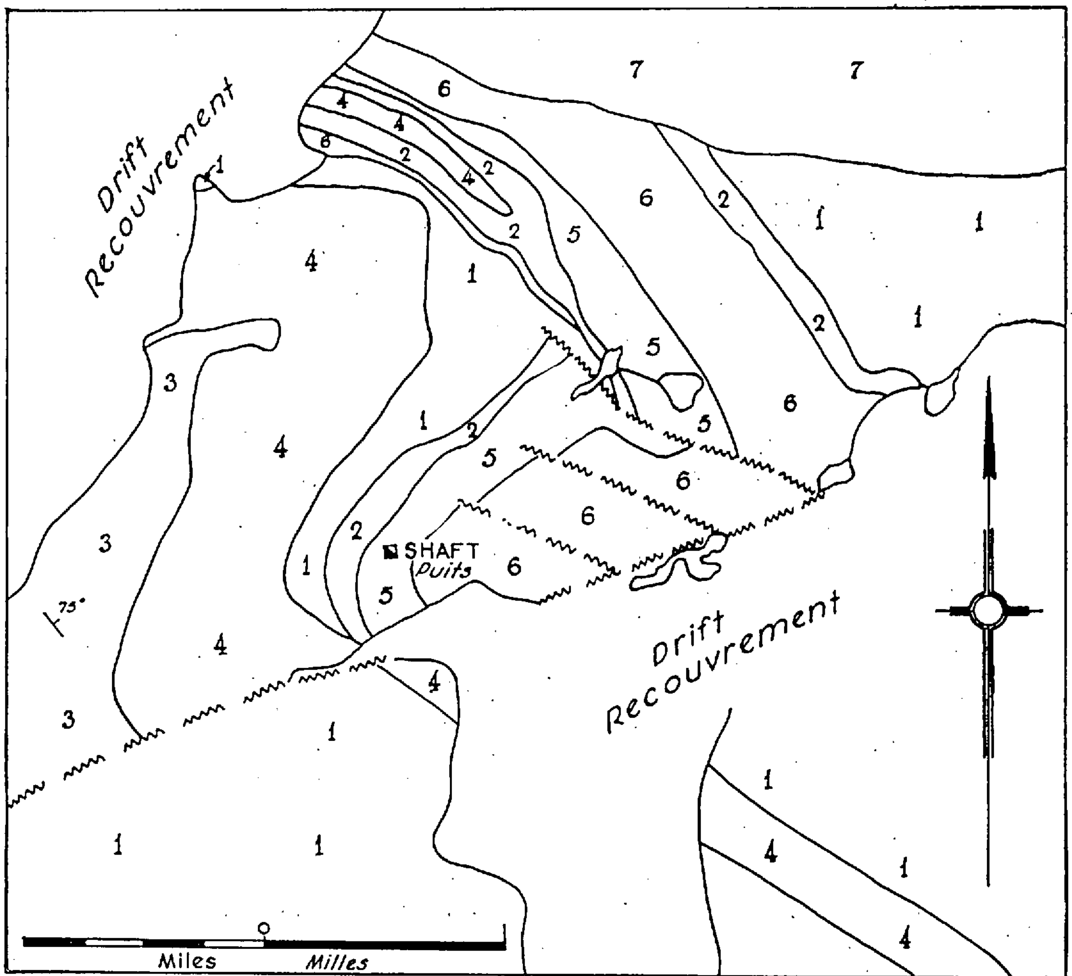
Mineral Deposits and Prospects

Opemiska Copper Mines, Limited

(Southwest quarter of Lévy township)

Opemiska Copper Mines, Limited, a subsidiary of Ventures, Limited, was organized in 1930 to develop the copper-gold veins which had been discovered the previous year in the basic intrusive rocks west of Campbell



M.M. Québec No, 707.

(1) Greenstones (2) Rhyolite (3) Sediments (4) Older gabbroidals-*Roches gabbroïdes anciennes* (5) Gabbro (6) Pyroxenite & peridotite (7) Granite

Figure 8.—*General geology, vicinity of Opemiska mine.*

lake. In addition to a very considerable amount of surface exploration, a shaft was sunk to a depth of 550 feet and a total of 5,700 feet of drifts and cross-cuts were driven on levels at 150, 275, and 525 feet. Also, about 22,000 feet of diamond drilling was completed from surface and underground. This work indicated some 300,000 tons of good grade copper ore, carrying some gold, to the depth explored. However, transportation facilities were not adequate for profitable operation of the mine, and all work was suspended in the fall of 1937 (MacKenzie, 1935, pp. 141-145; Norman, 1938, pp. 7-11).

In the vicinity of the shaft, the gabbro sill is cut by three easterly trending chalcopyrite-pyrrhotite veins which contain also minor amounts of sphalerite, galena, specularite, and gold. They are 150 to 300 feet apart and, from north to south, they have the following dimensions and grade at surface:

	Length	Width	Copper	Gold
North vein.......	201 ft.	6.9 ft.	16.87%	0.20 oz./ton
No. 1 vein.......	509 "	8.4 "	7.90%	0.10 "
No. 2 vein.......	701 "	7.9 "	6.54%	0.12 "

A fourth deposit, known as No. 3 vein, 300 feet south of No. 2, is irregularly distributed over an area some 700 feet by 100 feet. These veins are cut by a northwesterly striking quartz-arsenopyrite vein which has been traced for a length of 900 feet, with an average width between one and two feet. It is reported to assay 0.52 oz. gold per ton over a length of 80 feet. Some surface work has been done on other copper-gold veins cutting basic intrusive rocks half a mile east, and one mile east-northeast, of the shaft.

Other Mineral Deposits in the Opémisca Area

Besides the Opemiska Copper Mines' deposits, numerous other occurrences of copper and gold mineralization are known in the Opémisca area, but such investigation — limited to surface work — as has been made of these has failed to reveal any deposits of commercial size or grade. Following are brief descriptions of some of these occurrences (Norman, 1937, 1938).

West of Opemiska Mine (Lévy township, S.W. ¼)

About a mile and a quarter west of the Opemiska shaft is a low, isolated, outcrop of fine grained sedimentary rock, rising from an extensive sand plain. The beds are contorted and are traversed by southeast shears and east-west fractures which are mineralized sparingly with chalcopyrite, pyrrhotite, and — in the case of the shears — a little arsenopyrite.

North of Cavan Lake (Daubrée township, S.W. ¼)

In 1935, some work was done on a gold-bearing quartz vein or lens in a rusty-weathering, carbonatized zone in andesitic lavas one mile north of Cavan lake. It has a length of twenty feet, striking northwest. Assays of 0.28 to 0.34 oz. gold per ton are reported, with no gold in the adjacent rock. The locality is about five miles west of the Opemiska shaft.

Near Laura Lake (Lévy township, S.E. ¼)

In the vicinity of Laura lake, about five miles east of the Opemiska shaft, sporadic work has unearthed a number of mineralized showings of

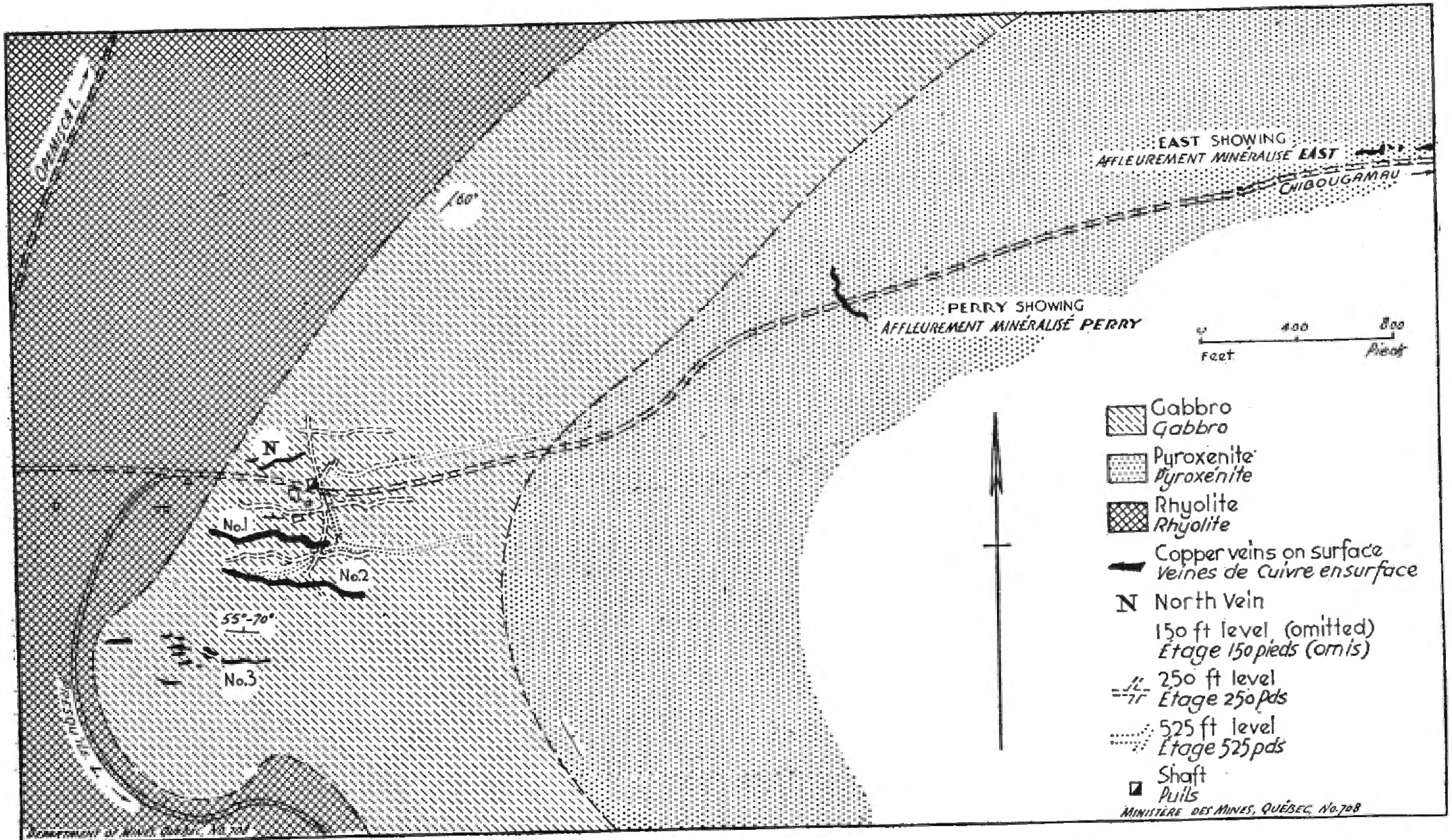


FIGURE 9.—*Opemiska mine, surface exposures and mine development.*

some interest, but of no appreciable size. Extensive drift and sand cover has greatly hampered prospecting.

Western Part of the Chibougamau Batholith

The Chibougamau batholith is a complex of anorthosite, gabbro, diorite, and granite. Gold and sulphide mineralization have been reported in these intrusive rocks at many localities (Norman, 1937). Some of these occurrences are described below.

Outlet Rapids, Simon Lake (Scott township)

In 1935, some trenching was done along a quartz vein cutting granite at the foot of Outlet rapids, the channel through which the waters of Simon lake pass into Scott lake. The vein, striking southeast and dipping 40° southwest, varies from two to six inches in width along its exposed length of forty-five feet. The granite on the footwall side is altered over a width of four feet and is cut by stringers of quartz and carbonate. Nearly one-third of the material of the vein is pyrite with a little associated chalcopyrite and pale yellowish-green sphalerite. Assay of a sample is reported to have shown about one ounce gold per ton. A drill hole was put down at a point 100 feet south of the vein but, at the depth where it was estimated the vein should be intersected, only a few narrow veinlets of quartz and carbonate, mineralized with a little pyrite, were encountered, although the granite at that depth exhibits the same type of alteration as seen in the footwall granite at surface.

Ceres Island, East Side of Simon Lake (Scott township)

Stripping along a shear zone in granite on the west side of Ceres island has exposed a quartz vein, three to six inches wide, with adjacent narrow veinlets, some containing black tourmaline. Two samples of the vein material from points five feet apart are reported to have assayed 3.58 oz. and 0.88 oz. gold per ton, but the sheared granite carries only a 'trace' of gold.

Deschênes Island (Scott township)

During 1935 and 1936, McKay (Quebec) Exploration, Limited, completed 1,400 feet of trenching and 1,000 feet of diamond drilling in the exploration of quartz veins which cut granite and related rocks on Deschênes island, in the northeast arm of Simon lake. Two of these veins were traced for lengths of 100 feet and 250 feet, respectively. They are of irregular width, from a few inches up to three feet, and contain pyrite in solid masses that range from an inch or two in diameter and up to more than a foot long. Assays are reported to have yielded the following results, in gold per ton (Canadian funds): general sample, $14.35; sulphide-rich sample, $7.70; carbonate-rich sample, $1.75; quartz-tourmaline-carbonate material, $1.05.

Quartz veins containing pyrite, similar to those on Deschênes island, have been found cutting the intrusive rocks of the batholith at several localities on the peninsula between this island and Dulieux bay, and on the lake shore east of the bay. Such assays as have been made, however, have failed to reveal the presence of gold in commercial amount (Taschereau, 1937, p. 102).

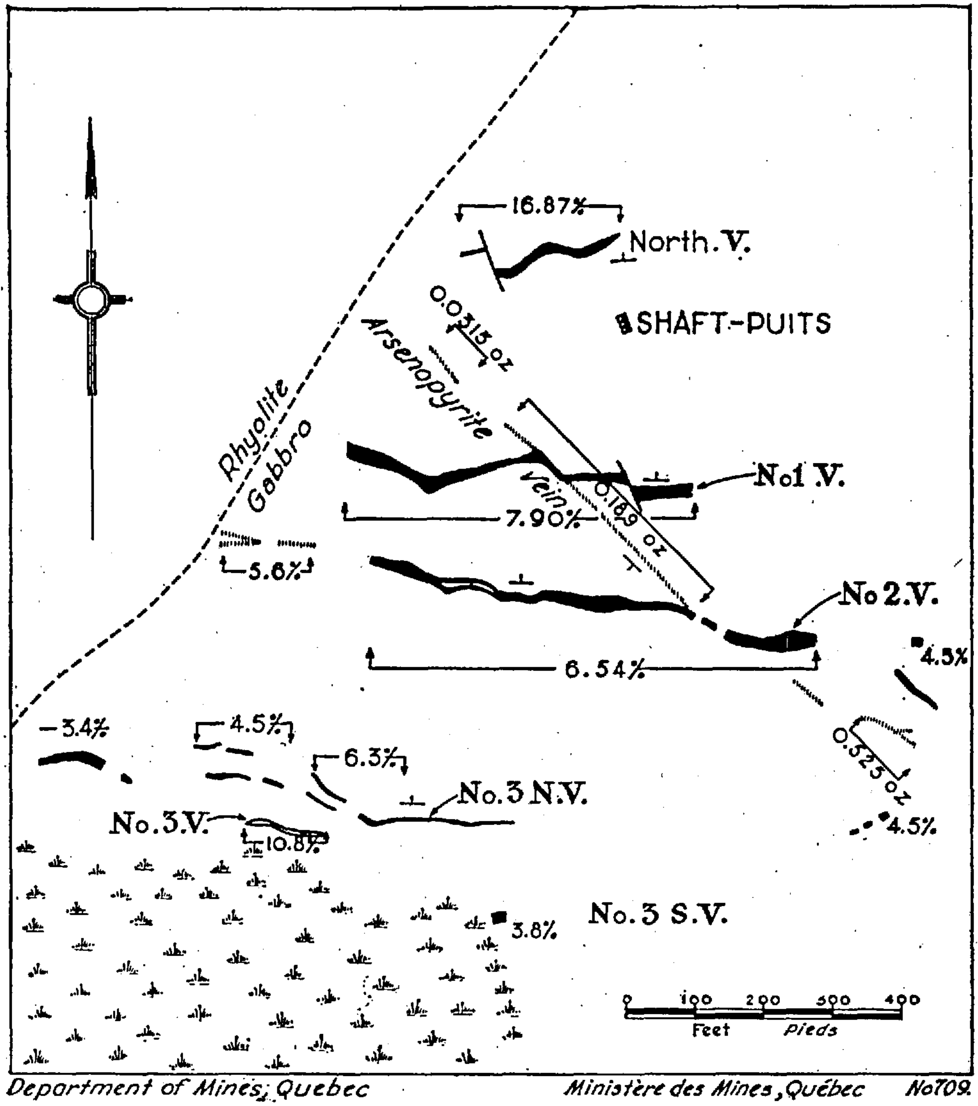


FIGURE 10.—*Opemiska mine veins exposed at surface in vicinity of shaft:* Copper veins black with percentage of copper shown. Gold assay in ounces.

Buckell Lake (Scott township)

Coarse gold was discovered in 1936 in a quartz vein at the northeast end of Buckell lake, which lies midway between Dulieux bay (Simon lake) and the south end of David lake. The original discovery was in a 20-foot section of a narrow vein in which, for a length of two inches, coarse gold was abundant. However, assays of material from the veins and stringers on either side of this, and in nearby shears, are reported to have shown little or no gold.

Northwest of David Lake (Scott township)

Three mineralized zones have been well exposed by trenching on claims near the northwest end of David lake. The most northerly zone consists of irregular stringers of fine grained pyrite, with a little chalcopyrite and sphalerite, in fractured, massive granite. It strikes about S.70°E. and dips 65°N. The sulphide stringers, up to an inch or so wide, in places make up from 25 to 50 per cent of the material of the zone. This zone has been stripped for a length of 375 feet, along which its width varies from three feet or less to four feet. Sampling over a length of 180 feet where the width is about four feet, and over an additional length of 90 feet where the width is less than this, is reported to have indicated 0.1 to 1.0 oz. gold per ton.

Some 100 to 150 feet south of this zone, and roughly parallel to it, is a second zone along which the granite contains lenses of quartz and also a sheared lamprophyre dyke, with accompanying pyrite mineralization. A sample from an 18-inch section across the dyke, taken about 150 feet south of the west end of the north zone, is reported to have assayed $21 in gold per ton, but, apart from this, assays were erratic and low.

Some 485 feet south-southwest of the north zone, a third mineralized zone, parallel to the others, has been exposed for a length of 65 feet. Moderate to low gold assays are reported across widths of twenty-seven inches in the western part of the zone, and 'traces' only on the eastern part.

Williams Lake (Scott township)

Occurrences of pyrite and chalcopyrite mineralization in Keewatin-like schists along the south shore of Williams lake were investigated in 1935 and 1936 by McKay (Quebec) Exploration, Limited, who put down eight diamond drill holes aggregating 1,000 feet. The south shore of the lake parallels, and for most of its length is a few hundred feet north of, the westerly-trending contact between the intrusive rocks of the Chibougamau batholith and the extensive area of Keewatin-like rocks to the north. The schists, which include chloritic, sericitic, and carbonate-rich types, contain a little pyrite and are cut by a few stringers and small veins of quartz and carbonate, some of which contain an abundance of pyrite and chalcopyrite. The shear zone in which these occur is largely drift covered, but it probably extends westward for two and a half miles to Scott lake, on the east shore of which the rocks adjacent to the granite-greenstone contact are strongly sheared.

North of David Lake (Scott township)

Sphalerite and other sulphide mineralization was discovered in 1926 at a point one mile north of David lake and about the same distance from the northeast corner of Scott township (Mawdsley and Norman, 1935, p. 69). The country rock here is granite which, about a quarter of a mile to the north, is in contact with the southern margin of the greenstone belt.

Within the granite, stripping has exposed an altered, dark, fine grained quartz-bearing rock, followed on the north by serpentine schist. The granite to north and south of these rocks is more or less sheared and carbonatized, and narrow dykes of such granite cut the dark, quartz-bearing rock. Traversing the latter is a shear zone, two feet wide, striking slightly north of west and dipping 72°N. It is highly carbonatized and contains four stringers rich in sphalerite. Their total width is six inches, with the widest two and a half inches. There are also a few narrow veinlets in the adjacent uncarbonatized rocks. These strike N.50°E. and dip 80°N.W. and are apparently later than the main shearing and carbonatization. It is estimated that, as an average, the veins have the following composition: light coloured sphalerite, containing minute particles of chalcopyrite, 70 per cent; pyrite, usually in crystals and in greater amount near the vein walls, 5 per cent; and white granular quartz, 25 per cent. The gold content, if any, has not been determined.

North of Opémisca Lake (Opémisca and Cuvier townships)

As already noted, the country immediately north of Opémisca lake is underlain by volcanic rocks which form the southern flank of a wide, easterly trending synclinal structure and are succeeded northward by overlying sedimentary rocks. Cutting these rocks are intrusive sills. In this section of the area, however, drift and sand deposits, and muskeg, are widespread. Prospecting is greatly hampered by these conditions and few mineral deposits of note have so far been discovered.

Gladstone Falls (Opémisca township)

Pyrite, with a little chalcopyrite, occurs here in a shear zone at the contact between altered volcanics and siliceous sediments to the north of them. Assays are reported to have given low results for both copper and gold.

Dadson Lake (Opémisca township)

Pyrite and chalcopyrite occur in a series of parallel quartz veins, a few inches to two feet wide, at a point 500 feet west of the north end of Dadson lake, which is three and a half miles north of the west end of Opémisca lake. Sampling has indicated that their gold content is negligible.

Leclerc Creek (Cuvier township)

A short distance west of Leclerc creek, a quartz vein one to three feet wide, in conglomerate, has been exposed by stripping and trenching for a length of 200 feet. It contains a small amount of pyrite and chalcopyrite, particularly near its south wall, and at one or two points there is fairly coarse free gold. The highest assays of parts of the vein in which gold is not visible are reported to have shown only about 0.1 oz. gold per ton. Commenting on this occurrence, Norman (1938, p. 13) says: "A sample taken from a few of the rusty outcrops was assayed by the Bureau of Mines, Ottawa, and contained only 'traces' of gold and silver. The locality, however, does not seem to have been prospected, and the sample taken may not be representative".

Barlow Lake to Gwillim Lake (Barlow township)

Rock outcrops are numerous in the country between Barlow and Gwillim lakes and they have received some attention from prospectors. Up to the present, no discoveries of importance have been made, but possibilities for the occurrence of mineral deposits are considered favourable.

Little Rush Lake to Rush Lake (Barlow township)

Quartz veins with a low gold content were discovered in 1935 at two localities south of Chibougamau river, between Little Rush lake and Rush lake. They are known as the 'Croteau showings'. At each locality, the principal vein is seven to eight feet wide and contains pyrite, which is present also in the adjacent wall rocks. Assays are reported to have indicated a low and somewhat erratic gold content.

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CHIBOUGAMAU AREA

General Geology

Lithologically and structurally, the Chibougamau area is essentially the eastward continuation of the Opémisca area. The synclinal belt of sills which, in the latter area, is cut off by the Gwillim Lake fault, appears again at Gwillim lake to the east of that fault and, with its included bands of Keewatin-like volcanics and, more rarely, sediments, continues in a direction slightly north of east for thirty miles. At Gwillim lake, the belt has a width of four miles, but farther east it narrows to about two miles, and eleven miles east of McKenzie and Rapid bays, which project northward from Chibougamau lake, it terminates against a mass of later granite. The sills are mainly of ultrabasic composition — serpentinized peridotite, pyroxenite, and gabbro — but dioritic types or facies are represented. Topographically, the belt is characterized by high hills and east-west ridges, some rising to between 200 and 300 feet above Chibougamau lake, in marked contrast to the generally low relief of the surrounding country. Capping some of these hills in the country between Gwillim and Bourbeau lakes are gently dipping sedimentary rocks, chiefly conglomerate and arkose, which have been designated the Chibougamau series. They are the youngest rocks in the area and are possibly equivalent to the Cobalt series in the Rouyn area (see p. 19). These rocks are also well exposed in a down-faulted block about one mile wide that extends for six miles in a northeasterly direction immediately east of McKenzie bay, and they occupy a much larger area along and near the shore of Waconichi lake, whose south end is four miles north of McKenzie bay.

The country to the north of the belt of sills is generally low and, over extensive tracts, bed-rock is covered by overburden. For a width of about four miles, the rocks are mainly volcanics, but dioritic and gabbroic intrusives are locally important. The northern limit of this belt of volcanics follows approximately the north boundary of McKenzie township, beyond which it continues with a trend slightly north of east.

Following the volcanics on the north is a belt, about four miles wide in its eastern part, of overlying Keewatin-like sediments. These extend west and northwest from the margin of the granite mass to and beyond Waconichi lake, where they are in contact with the southern margin of a great batholith of granite that extends far to the north. This granite borders the northern half of the west shore of Waconichi lake and then leaves the lake to continue with southwest trend to the northern part of Rush lake, eighteen miles distant. The sediments include feldspathic types, fine-grained tuffs, and conglomerates. Adjacent to the granite, for a width of two miles, they have been converted to a well foliated quartz-amphibole-epidote rock.

The belt of sills is flanked on its southern side by a narrow band of volcanics which is bounded on the south by the composite Chibougamau batholith. From west to east, the northern margin of this batholith extends across the area, with a general trend somewhat north of east, from the northern end of Simon and David lakes, across the central part of Doré lake, to the northeast end of Chibougamau lake, a distance of nearly thirty miles. At the central part of Chibougamau lake, it has a width of fifteen miles, but it narrows both to west and east. The batholith is a composite of anorthosite, gabbro, diorite, and granite. Anorthosite and gabbroic rocks predominate in the northern part, over a width of one to two miles, and also in the southeastern part, southeast of Chibougamau lake. Elsewhere, the prevailing rock is granite, which cuts all the other facies.

Structure

Like the Opémisca batholith, which lies immediately to the west, the Chibougamau batholith presumably occupies an anticlinal structure. It is inferred that the syncline south of the Opémisca batholith extends eastward along the south side of the Chibougamau batholith, at least in its western part.

Several major faults with northeasterly trend are known in the area. Other faults, north and east of McKenzie bay, have a north-northeasterly trend. Northwesterly shearing is common in the rocks along the north part of Doré lake.

Copper and gold have been discovered at numerous points in shear zones in the intrusive rocks of the batholith, on and near the shores of Chibougamau and Doré lakes, and also associated with the basic sills south of Bourbeau lake. At several localities, also, sulphide replacement deposits occur in the 'greenstones', tuffs, and sedimentary rocks, particularly at their contact with basic intrusives.

Mineral Occurrences

Vicinity of Bourbeau Lake, McKenzie Township

Berrigan Lake.—Along the north shore of Berrigan lake, cross-trenching over a length of 1,200 feet and a width of 80 feet has revealed a shear zone, trending N.70°E., in serpentinized peridotite with alternating narrow bands of volcanics, both in places highly carbonatized and silicified. Sparsely distributed along the zone are quartz veins, some of which contain carbonate and sphalerite, and also narrow stringers and lenses of pyrrhotite, sphalerite, and chalcopyrite. Certain bands of dark schist, possibly sheared peridotite, are mineralized with pyrite (Mem. 185, pp. 62-63).

Southwest Bay, Bourbeau Lake

An open-cut near the head of the southwest bay (Cran Penché bay) of Bourbeau lake has exposed a lens of massive sulphides, chiefly pyrrhotite but with some pyrite, chalcopyrite, and sphalerite, in the serpentine country rock. The lens has an average width of eighteen inches, widening to three feet at one point, and it wedges out four feet from the face of the cut. A sample taken across an 18-inch width was assayed in the laboratories of the Mines Branch, Department of Mines, Ottawa, and yielded 1.15 oz. gold and 0.82 oz. silver per ton. Similar high assays are reported to have been obtained from other samples (Mem. 185, p. 64).

Three-quarters of a mile farther east, near the south shore of the bay, quartz veins cutting pyroxenite, serpentine, and associated feldspar and quartz porphyry dykes, are mineralized with pyrite, pyrrhotite, chalcopyrite, and, in some places, molybdenite, but their gold content is reported to be unimportant. Sphalerite and galena have also been reported at this locality.

South Shore of Bourbeau lake

In 1930, a gold discovery of considerable promise was made on the south shore of Bourbeau lake, near the eastern entrance to Cran Penché bay. From the lake shore southward, the rocks exposed here are sill-like bands of 'diorite' (800 to 900 ft.), gabbro (750+ ft.), and serpentine and pyroxenite. A shear zone in these rocks, striking S.30°W., contains a gold-bearing quartz vein or vein system. It has been explored by cross-trenching over a length of 1,300 feet, with closely spaced trenches in the northerly 700-foot section to and including the more northerly of the two schist bands, and again for 120 feet southward from the southerly schist band. A total of 15,000 feet of diamond drilling has also been done, in forty-five holes, almost all of it along the northern 700 feet of the vein. The work on this property was carried out in 1933 and 1934 by *Noranda Mines, Limited,* and its subsidiary, *Norbeau Mines (Quebec), Limited.* According to the report of the Company, an ore-shoot 800 feet long and averaging 4½ feet wide was outlined to a depth of 500 feet, with an average gold content of 0.35 oz. per ton. Additional diamond drilling was done in 1939 but the Company reported that the results were disappointing (Taschereau and Herring, 1940, p. 73).

In 1934, another vein was discovered, 1,500 feet east of the main vein and 900 feet south of the lake shore. Free gold has been reported in this vein.

In a shear zone in the same band of diorite, 3,000 feet farther east, three quartz veins aligned in a westerly direction have been exposed by cross-trenching over a length of 750 feet.

In all the veins, the quartz is mottled grey and white and contains smears of fine grained tourmaline and chlorite and scattered crystals of pyrite, with, in places, a little chalcopyrite. Arsenopyrite also is present, particularly in the western vein, as narrow bands near the walls and more rarely distributed through the quartz in well formed crystals up to a quarter of an inch long. The wall-rocks are pyritized, in places heavily so, as in the stockworks, in which, also, the dioritic blocks are apt to be more carbonatized and chloritized than the wall-rock elsewhere.

Where exposed in the most westerly trench, the vein contains visible gold. Under the microscope, it is seen to occur chiefly along fractures in arsenopyrite, which, in turn, fills narrow fissures in the quartz. Mawdsley and Norman (1935, p. 68) report that, in one of the specimens they examined, a veinlet of arsenopyrite was seen to traverse a crystal of pyrite and that gold is present in the veinlet but not in the adjacent pyrite.

Vicinity of Doré Lake

There are numerous occurrences of sulphide and gold mineralization in the vicinity of Doré lake, especially along and near its northwest shore, and some of these are distinctly attractive. The lake trends northeast and it is believed that a fault zone traverses it in this direction, possibly passing under the channel on the western side of Merrill island.

North of Cachée Bay

A considerable amount of work has been done on claims to the north of Cachée bay, an almost land-locked body of water opening from the west side of Doré lake, about four miles from the western, and one mile from the northern, boundary of Obalski township. In addition to much surface trenching and the sinking of a prospect shaft to a depth of 70 feet, this work included diamond drilling aggregating more than 15,000 feet. It revealed a number of long and relatively narrow gold-bearing vein zones which in places carry appreciable amounts of copper.

In a belt 3,700 feet long and 500 to 900 feet wide there are at least five main shear zones (designated by the letters *A* to *E*) and other minor ones. The easternmost of the main shears trends northwest from a point 500 feet north of the east end of Cachée bay. Of the others, two strike about N.70°W., and two slightly south of west. They all dip vertically or steeply to the south. The granitic and related batholithic rocks are cut by 'greenstone' dykes. The quartz and sulphide mineralization is later than these (Mem. 185, pp. 70-74).

The individual main shears have been traced for lengths of 600 feet to more than 2,000 feet, and their widths range from one foot to as much as five feet.

As reported by the *Obalski Mining Corporation*, the average gold content of samples from *C* and *D* zones, taken over a total length of 713 feet and an average width of 38 inches, was 0.05 oz. per ton. Chalcopyrite occurs in relatively negligible amount. In 1939, the Company reported that the surface work and drilling indicated, in *C* and *D* zones, a total of 107,300 tons of ore averaging 0.5 oz. gold per ton, and in *A* zone, to a depth of 350 feet, 66,000 tons averaging 2.76 per cent copper and 0.028 oz. gold per ton (Canadian Mining Handbook 1940, p. 153).

Merrill Island and Vicinity

Merrill island is underlain by altered anorthosite, but the part of Gouin peninsula that forms the lake shore immediately south of the island is occupied by granite.

On the island, a mineralized zone, striking southeastward, has been exposed from the lake shore inland by nine rock trenches spaced at intervals of 100 feet along the strike of the zone, which they expose at these intervals for a width of 100 to 180 feet. In the trenches at 200, 400 and 600 feet from the lake shore, fresh-looking quartz porphyry is exposed. Its greatest width is five feet and it probably represents an irregular or faulted dyke.

The trench on the shore of the island discloses anorthosite heavily sheared over a width of about forty-five feet and mineralized with pyrrhotite, pyrite, and chalcopyrite. Across the full width of forty-five feet, the sulphide content of the rock is about 10 per cent. The sulphides occur in solid masses, some of them as much as three feet in diameter, in veinlets, and disseminated. The gold content is apparently low, rarely exceeding 0.1 oz per ton.

Diamond drilling beyond the limit of the trenching has indicated that the mineralized zone extends for 2,000 feet southeastward from the shore, and drilling from the ice has shown that it continues for 500 feet northwestward, beneath the waters of the lake (MacKenzie, 1937*a*, p. 16). The drilling to the southeast intersected widths of mineralization that were nearly all greater than ten feet and in two holes were about sixty feet. The gold content over these widths was below 0.1 oz. per ton, and in most cases below 0.05 oz. Copper is consistently present, usually between 1 and 2 per cent; rarely it is above 5.0 per cent.

The *Northern Investment and Mining Company* did some surface work in 1929 on claims on the northwestern shore of Doré lake. Here, nearly along the projected strike of the mineralized zone on Merrill island, irregular calcite veinlets carrying some chalcopyrite were found filling fractures in the anorthosite. This ground appears to have been first prospected by John Kokko in 1906-7. A general sample taken by the Chibougamau Mining Commission from the dump at his workings assayed 0.31 oz. gold and 4.03 oz. silver per ton, and 6.72 per cent copper (Barlow *et al.*, 1911, p. 207).

The somewhat sheared and chloritized granite on Knoll (or Noll) island, which lies off the southwest end of Merrill island, is cut by an irregular mass of quartz, fifty feet long and up to twelve feet wide, containing a little pyrite and chalcopyrite, with associated tourmaline. Two samples taken here by the Chibougamau Mining Commission assayed 2.31 oz. and 0.75 oz. gold per ton (Barlow *et al.*, 1911, pp. 209-10). However, the results obtained from a diamond-drill hole put down into the mass by *Prospectors Airways, Limited*, in 1933 were disappointing. The island is only about fifty feet in diameter and is awash when the lake level is high. It and other islets to the south are formed of granite; those to the north are anorthosite.

Kokko Creek

A mineralized shear zone in chloritized anorthosite, very similar to that on Merrill island, occurs along Kokko creek, which flows into a small bay on the western side of Doré lake, immediately north of Merrill island. It strikes N.41°W. and has been exposed in cross-trenches spaced at intervals over a length of 550 feet, and in two pits.

The Report of the Chibougamau Commission (1911, p. 208) gives the following results of assays of samples from Kokko creek:

	Gold	Silver	Copper
General sample from dump.......	0.04 oz./ton	2.10 oz./ton	4.82%
Selected pyritic material.........	1.03 "	5.16 "	10.44%

It is reported that more recent assays of material from certain parts of the zone have shown an appreciable gold content.

Cedar Bay (McKenzie township)

The most extensive mining operations in the Chibougamau district were carried out between the years 1934 and 1937 on the Cedar Bay property of *Consolidated Chibougamau Goldfields, Limited.* Cedar bay is on the northwest shore of Doré lake, north of Merrill island, and the main workings are on an easterly projecting point at the southern entrance to the bay, about

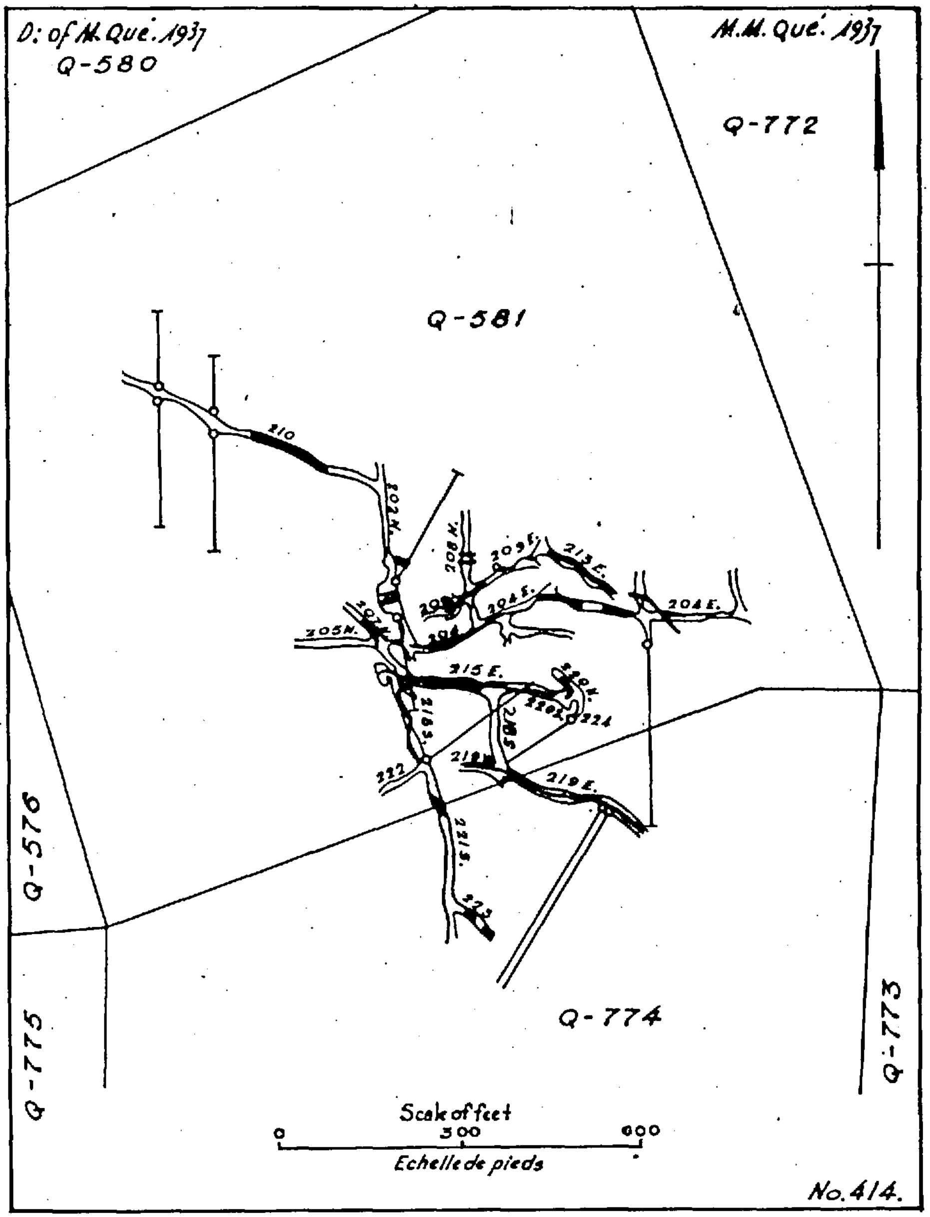

FIGURE 11.—*Consolidated Chibougamau Goldfields, Cedar bay; plan of 250-foot level.* (Fig. 1), Que. Bur. Mines, P.R. 120.

one mile north of the south boundary of McKenzie township and two and three-quarter miles from its eastern boundary (MacKenzie, 1935, p. 135, 1937*a*, p. 3, 1937*b*, p. 83; Mawdsley and Norman, 1935, p. 78; Ross *et al.*, 1938, p. 30).

This part of the shore of Doré lake is underlain by anorthosite, which, on the point referred to, is extensively sheared and chloritized. What is known as the *major shear zone* trends northwesterly and has been traced on the surface for a length of 1,300 feet. At its southeastern end, the shearing is quite intense over a width of forty-five feet, within which are lenses and

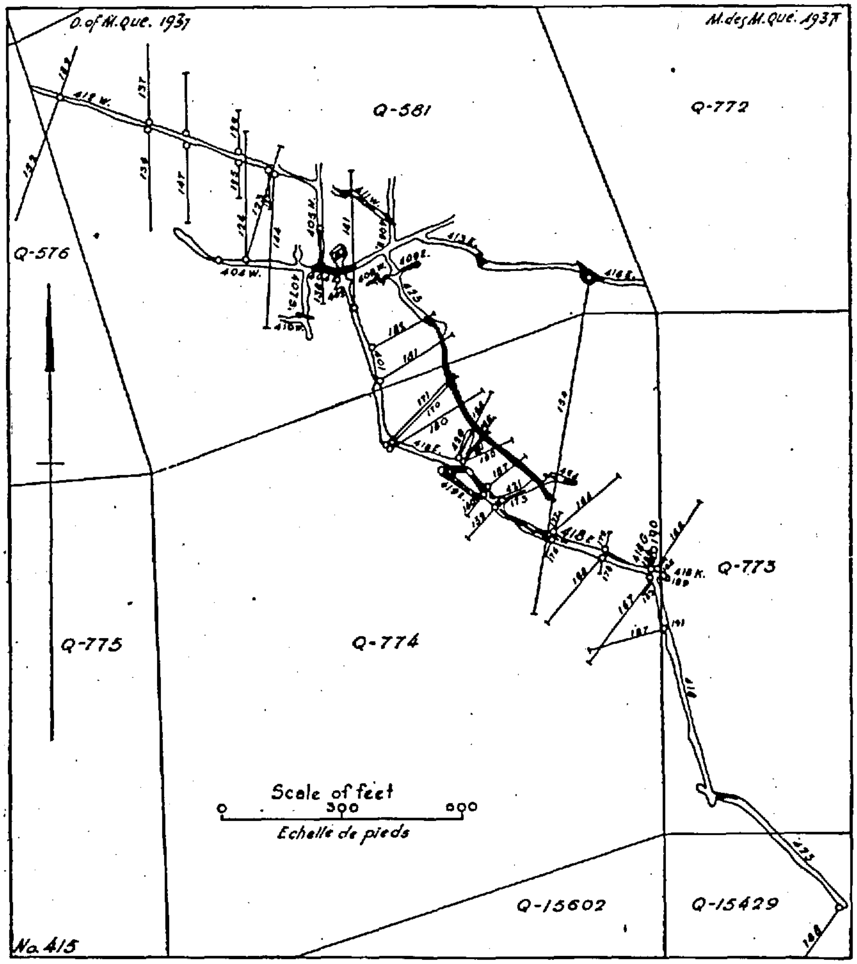

FIGURE 12.—*Consolidated Chibougamau Goldfields, Cedar bay; plan of 500-foot level.* (Fig. 2), Que. Bur. Mines, P.R. 120.

veins of quartz, some of them as much as seven feet wide, well mineralized with pyrite and lesser chalcopyrite. The northwestern part of the zone is not exposed, but drilling has revealed alternating bands of massive and sheared anorthosite over a horizontal width up to one hundred feet. The sheared bands, which range from a few inches to fifteen feet wide, are mineralized chiefly with pyrite, but quartz and chalcopyrite are present in places. This zone has been explored underground by drifts on the 250-foot and 500-foot levels for lengths of 1,100 feet and 1,600 feet, respectively (Figures 11 and 12).

From the southeastern end of this major shear, another zone of shearing extends for 700 feet with a general westerly trend. This is known as the *main mineralized zone*. It has been exposed for its entire length by drifts on the 250-foot and 500-foot levels. Shearing is less intense than in the major sheared zone, but sulphide mineralization is heavier, over a width of forty feet in places but elsewhere almost or quite pinching out. It is most regular and persistent in the section for 200 feet westward from the junction of the two zones.

From near the western end of this zone, a third zone of shearing extends northwestward for about 700 feet, paralleling and about 100 feet south of the major zone. This was revealed mainly by diamond drilling, which indicated persistent mineralization along the zone over horizontal widths up to forty feet.

There are several smaller zones of shearing, either exposed at the surface or encountered by diamond drilling, as for example just west of the point of intersection of the two main zones, where a shear up to six feet wide has been traced for a length of ninety feet. The 'shaft' vein outcrops in this shear.

Farther southeast, toward and beneath the lake, the anorthosite encountered in the mine workings is massive though in general highly chloritized, and within it were found the two largest ore shoots, or 'veins'.

Cutting the anorthosite are dyke-like and irregular masses of rock of intermediate to basic composition, referred to as andesite and gabbro. One such dyke, striking northwest, is well exposed on the 250-foot and 500-foot levels in the mine workings southeast of the shaft. The major sheared zone is bounded on its northern side by a sheared dyke of quartz porphyry, fifteen feet wide, which is exposed at the surface and also in a drift on the 250-foot level, where it forms the wall of an ore shoot. These dykes are believed to be genetically related to the anorthosite.

Post-ore faults strike both along and across the shearing but, so far as observed, on none of these does the horizontal or vertical displacement exceed two feet.

According to MacKenzie (1937*b*, p. 87) "there is evidence of more than one stage of mineralization. Siderite, accompanied by some sulphides, would appear to be an early stage, lacking important associated gold values. The best gold tenors seem to occur in massive sulphides, mostly pyrite with some quartz present. One vein carrying good gold values consists largely of grey quartz, shattered and cemented by veinlets of white quartz, with pyrite and chalcopyrite occurring in both. Minor amounts of pyrite and chalcopyrite also occur in the later quartz and calcite veins along the fractures and fault planes crossing the strike or dip of the earlier shearing and mineralization. Gold values along these latter veins are unimportant". The chloritization of the anorthosite is attributed to solutions that accompanied the introduction of the quartz and sulphides.

A limited amount of surface work was done on the property by *Chibougamau McKenzie Mines, Limited,* at various times between 1922 and 1933, in which year it was taken over by *Consolidated Chibougamau Goldfields, Limited.* In 1934, control of the property was acquired by the *Consolidated Mining and Smelting Company of Canada, Limited,* who, in that and the three following years, carried out an intensive development programme. In addition to surface work, a shaft was sunk to a depth of 522 feet, and some 12,000 feet of lateral work was completed on two levels at 250 feet and 500 feet. Diamond drilling aggregating more than 33,000 feet was also carried out from the surface and underground.

In the fall of 1937, all operations were suspended as it was not considered that ore shoots of the size and tenor indicated could be profitably mined under prevailing conditions, particularly as regards transportation facilities.

A number of other occurrences of sulphide mineralization in the anorthosite surrounding Cedar bay have been investigated (Mem. 185, pp. 81-83). Trenching and stripping by *Chibougamau Prospectors, Limited,* in 1929 on claims half a mile west of the bay exposed a series of wedge-shaped masses of sulphides at intervals over a length of 120 feet in a direction 10° to 18° east of north. Individually, they are from eight to thirty-five feet long and up to three feet wide and they appear in large measure to be bounded by fault planes, suggesting the possibility that they are faulted sections of one original body. The sulphides present are pyrite and chalcopyrite, the former predominating.

About midway along the west shore of the bay, trenching by the Consolidated Mining and Smelting Company of Canada, Limited, in 1930 revealed a zone, striking S.65°E., in a gabbroic facies of the anorthosite in which there is much carbonate and occasional narrow veinlets rich in chalcopyrite. On the east shore of the bay, slightly north of the projected extension of this showing, a trench along the water's edge has exposed chloritized anorthosite which, over a width of six feet, contains an average of 20 per cent pyrite and chalcopyrite. On the northern side of this, the rock for a similar width is traversed by quartz-sulphide veinlets, beyond which it is cut by a 'greenstone' (diorite) dyke, twenty-seven feet wide. This occurrence is known as the 'Dumonde showing'.

On Machin point, which is on the east shore of Doré lake, directly east of Cedar bay, stripping and trenching has uncovered narrow bands of schist containing chalcopyrite and pyrite, as well as quartz veins, along what is believed to be a continuous zone of mineralization.

Proulx Bay and Vicinity

There has been a considerable amount of prospecting at various times in the country east and west of Proulx bay, adjacent to the McKenzie-Roy township line, at the extreme north of Doré lake.

In 1906-7, Captain H. A. C. Machin did some stripping, and sank two pits, on claims on the west side of Machin bay (Barlow *et al.*, 1911, p. 204). Assays of the material indicated that the gold content is negligible.

Portage Island (Roy township)

Portage island, extending northeastward from Gouin peninsula, forms the northeastern shore of Doré lake. The first recorded gold discovery in the Chibougamau district was made on this island in 1903, by Peter McKenzie.

The north shore for its entire length is occupied by Keewatin-like volcanic rocks, except near the centre where, for a distance of half a mile, the shore is bordered by granite. The remainder of the island is underlain by anorthosite and its gabbroic facies.

At Copper point, stripping over an area some thirty feet in diameter has exposed shattered anorthosite veined by chalcopyrite, pyrrhotite, and pyrite, which also are disseminated through the adjacent rock. Samples of 'selected' chalcopyrite and pyrrhotite, taken by the Chibougamau Mining Commission (Barlow *et al.*, 1911, p. 203) assayed, respectively, 0.12 oz. gold and 1.34 oz. silver per ton, and 0.06 oz. gold and 0.33 oz. silver per ton. The pyrrhotite sample also contained 0.48 per cent nickel.

The original gold discovery on the island is on the side of a hill about 1,500 feet inland from Copper point, in a direction a little north of west. The rocks in the vicinity are schists and are thought to represent the gabbroic facies of the anorthosite, but they may be highly altered volcanic rocks.

A considerable amount of work was done on this property, known as the *McKenzie mine*, prior to 1910. The workings are described in detail in the report of the Chibougamau Mining Commission (1911, pp. 193-203), which gives also the results of numerous assays of samples taken from various parts of the property. Assay of a general sample from seventeen individual samples gave 0.07 oz. gold per ton.

In 1935, *Consolidated Chibougamau Goldfields* did some additional trenching on the property and put down eighteen diamond-drill holes to explore the mineralization at depth.

Bear Bay (Roy township)

During 1929-30, *Dome Mines, Limited*, explored an easterly trending zone of sulphide mineralization along the contact between volcanics and serpentine south of Bear bay, which is on the north shore of Chibougamau lake, a mile and a half due east of Northeast point, Portage island.

The rocks surrounding and eastward from Bear bay are Keewatin-like volcanics, chiefly 'greenstone' but with included bands of silicified rhyolite, highly altered diabase, and, more rarely, fragmental rock. One-third of a mile south of the bay they are in contact with an east-west belt, about 1,000 feet wide, of serpentine, the marginal facies of the anorthosite. On the west, both the volcanics and the serpentine are in contact with granite, which occupies a width of 500 feet along the lake shore for 2,000 feet southward from Bear bay. The zone of sulphide mineralization extends eastward from this granite.

Assays indicate that, over any appreciable width, the sulphide replacement zone rarely contains as much as one per cent copper, and the gold content is reported to be negligible.

Taché Lake (Roy township)

A zone of sulphide replacement very similar to that at Bear lake occurs immediately south of Taché lake, which lies across the east-west centre-line of Roy township, at its eastern boundary. The locality is about four miles east-northeast of Bear lake. Trenching has exposed a zone at least twenty-five feet wide, across which pyrrhotite, with some chalcopyrite, forms from 25 to 50 per cent of the rock. In other trenches, the sulphides are less abundant than this.

Three miles due north of the Taché Lake occurrence, some stripping has been done along a zone of sulphide mineralization in volcanics on the north shore of Rapid river, but has failed to reveal deposits of economic value.

Asbestos Island, McKenzie Bay (Roy township)

The shores of McKenzie bay, and Asbestos island within the bay, are underlain by serpentine and related ultrabasic facies of the anorthosite. Some veins of chrysotile-asbestos were discovered in the serpentine on the island in 1903, but the Chibougamau Mining Commission, who made a careful examination of the workings, reported that "the veins are narrow, irregular, infrequent, and not continuous over any great distance. The occurrences are not, therefore, of economic importance as far as present development has shown "(Barlow *et al.*, 1911, p. 54).

McCorkill Township and Waconichi Lake

There has been very little prospecting, and no sulphide or other mineralization of economic interest has yet been reported, in McCorkill township, immediately east of Roy, or in Richardson and Bignell townships, which adjoin Roy and McCorkill, respectively, on the north.

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ROUYN-BELL RIVER AREA

Introduction

With the exception of the Belleterre mine, in the Ville Marie-Guillet Lake area (see p. 314), all the producing gold and copper mines of Western Quebec are in the Rouyn-Bell River area, which extends from the Quebec-Ontario boundary eastward for one hundred and thirty miles to or beyond Bell river, with a north-south width of about seventy miles and an area of close to 10,000 square miles (Figure 13). An outline of the geology and structure of the area, and a brief account of the mining development, has been given in the introduction to this section of the volume (pp. 18-22).

Three more or less well defined belts or zones of shearing traverse the area from west to east. Of these, the most persistent, as well as the most important as regards known occurrences of gold and copper deposits, is the Noranda belt; it follows the southern margin of the area and is the eastward continuation of the Kirkland Lake gold belt of Ontario. Some twenty miles to the north of this, another belt of shearing, the McIntyre belt, passes eastward through Duparquet township and is probably the eastward continuation of the Porcupine belt. Thirty-five miles still farther north, a producing mine, the Normetal, has been developed in a less well defined zone of shearing near the northern margin of the area.

In the pages that follow, the gold mines and important occurrences of gold along each of the three belts are briefly described.

NORTHWEST PART OF ROUYN-BELL RIVER AREA

General Note

The block of seventeen townships, each ten miles square, in the extreme northwest of the Rouyn-Bell River area, adjoining the Quebec-Ontario boundary, may be conveniently considered together. Geographically, they are situated as follows:

Perron	Rousseau			
Desmeloizes	Clermont	Chazel	Disson	Ligneris
La Reine	La Sarre	Royal Rousillon	Languedoc	Guyenne
Roquemaure	Palmarolle	Poulariès	Privat	Launay

The Canadian National railway crosses the block obliquely from central Launay to northwestern La Reine. Taschereau station, in Privat township, is the point of junction with a branch line to Noranda, some forty miles to the south, and from Dupuy station, in La Reine township, a branch line ten miles in length leads northward to the Normetal mine, in Desmeloizes township.

Except for occasional hills, which are generally of intrusive rocks, the area is fairly flat and covered by drift or swamp deposits, with large tracts devoid of rock exposures.

The western half of the area was mapped by Mawdsley in 1928 (1930). The underlying rocks over at least three-quarters of the area are Keewatin-like volcanics, basic to acidic in composition, which are in places schistose

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Figure 13 (folded insert)—*Rouyn-Bell River area.*

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and have a general northwesterly strike. Closely associated with these are varying amounts of tuffs, breccias, and sediments.

Intruding the volcanics and sediments are bodies, some of batholithic proportions, of granite and related rock types, granodiorite and syenite. One large body occupies almost the whole of Palmarolle township and the western half of Poulariès and extends into the townships north of these. Another underlies the northern half of Perron and nearly the whole of Rousseau and extends northward beyond the limits of the area. A third large body, of very irregular shape, spreads over parts of the four townships in the southeast corner of the area, and several smaller masses occur to the north of this and in the western part of the area. It is probable that these intrusive bodies are not all of the same age.

Gold and other metallic mineralization has been found at a number of localities in the area, but up to the present only one producing mine has been developed. This is the Normetal, in Desmeloizes township, where a sulphide orebody carries copper and zinc together with small amounts of gold and silver (see p. 439).

The principal known occurrences of gold, with or without appreciable amounts of sulphides, are in the northwest part of the area, in the five townships adjoining Desmeloizes, and in Privat and Launay, at the southeast corner. Molybdenite also has been found in the last named townships, and in La Reine and Perron, in each case associated with granite.

Perron Township

A considerable amount of exploration, including geophysical surveys, was carried out in the southern part of Perron township in the years immediately following the discovery of the Normetal deposit, in 1925. Gold, copper, and other mineralization was found in several localities, but none of the occurrences investigated proved of commercial importance. There has been very little prospecting in the township since 1929. The township was geologically mapped by Flaherty in 1936 (1939).

Mineral Occurrences

(Mawdsley, 1930 pp. 79-82)

Southern Part of Lots 27 and 28, Range V.—Altura Mines, Limited, did some trenching, sank a prospect shaft, and put down diamond-drill holes aggregating some 4,000 feet, along a zone of weak shearing in highly altered andesitic lavas and tuffs near their contact with granite. Small amounts of disseminated pyrite and pyrrhotite, with lesser chalcopyrite and magnetite, occur in the andesite over a maximum width of six feet.

3 to 3½ Miles from West Boundary of Township, along Range Line II-III.—Arno Mines, Limited, did some trenching here in 1927 to check ore 'indications' obtained in a geophysical survey. The locality is a short distance southeast of a circular granite boss and covers the contact between andesitic lavas and rhyolites to the south of them. Trenching has exposed shears mineralized over widths of a few inches to ten feet with disseminated pyrite, which varies in amount up to 20 per cent of the rock. Very minor amounts of pyrrhotite and chalcopyrite are also present.

Southern Part of Lots 29 and 30, Range II.—*Arno Mines, Limited,* also carried out work on claims about a mile and a half southeast of those referred to above. The rock here is rhyolite, much of it sheared. Diamond drilling disclosed zones, two to thirty feet wide, containing disseminated pyrite and pyrrhotite with a little associated chalcopyrite.

Molybdenite has been reported in a quartz vein, twelve to fifteen feet wide, in lot 26, range VII.

Desmeloizes Township

The eastern end of a large body of granite (the La Reine batholith) crosses the Ontario-Quebec boundary and occupies the western one-third of Desmeloizes township, except for the northwest corner. The remainder of the township is underlain by steeply-dipping volcanics — dominantly of intermediate to basic composition but rhyolitic in the northeast — with some bands of interbedded tuffs and sediments. Four small masses of granite intrude the volcanics south of the main band of sediments, and later gabbro or diabase dykes, striking north or northeast, cut all the other rock types.

Mineral Occurrences

Normetal Mine.—This is the only producing mine in the area. The orebody, consisting predominantly of pyrite, with important amounts of chalcopyrite and sphalerite, is a replacement deposit in the rhyolite and rhyolite tuffs in the northeastern part of the township. It is described on page 439, in the section dealing with zinc and lead deposits.

Following are brief descriptions of other deposits in the township on which surface work and diamond drilling have been done. Unless otherwise indicated, the descriptions are summarized from Mawdsley's report (1930, pp. 71-76).

Lot 29, Range X.—The *Midland Mining Corporation, Limited,* reported low gold assays from quartz lenses and stringers in carbonatized rhyolitic tuffs and quartz-feldspar porphyry at this locality, which is within a few hundred feet of the north boundary of the township, two and a half miles west of the Normetal shaft (Bell, 1937, p. 4).

North Half of Lots 38 to 43, Range X.—*Abbey Mines, Limited,* did 9,200 feet of diamond drilling on this property in 1927-28, on the strike of the ore zone on Normetal ground, which adjoins on the east. The property is drift covered. Some well mineralized zones containing pyrite with negligible amounts of copper and zinc were encountered (Taschereau, 1929, p. 108).

South Half of Lots 46 to 53, Range X, and Lots 48 to 51, Range IX.— These claims, which are immediately east of the Normetal property, were investigated in 1927. The work included an electrical survey, a considerable amount of trenching, and some diamond drilling, and was chiefly on the south half of lot 46, range X, on the strike of the Normetal ore zone. The results were reported as disappointing.

North Half of Lots 42 to 45, Range IX.—These claims are due south of the Normetal workings. They were electrically surveyed in 1927 and in the following year were explored by stripping and trenching and 2,500 feet of diamond drilling. No mineralization of interest was encountered in the course of this work.

Northern part of Lots 40 and 41, Range IX.—Demara Mines, Limited, completed about 5,000 feet of trenching and 2,000 feet of diamond drilling here in 1927 and 1928, and also made a magnetometric survey of the greater part of the property. This work revealed two zones of sulphide mineralization. One of these, near the east boundary of lot 41, 600 feet south of range line IX-X, is in a strongly sheared band, eight feet wide, in fine grained rock that appears to be a tuff. The other, in the centre of lot 40, is 800 feet farther south. Two trenches have exposed shattered rhyolite containing, over a width of two feet, up to 5 per cent of pyrrhotite in paper-thin streaks, as disseminated grains.

South of the two zones of sulphide mineralization, a band of magnetite-bearing iron formation crosses the centre of lot-line 38-39, range IX, and continues in both directions, with trend S.63°E., for a length of 3¼ miles and possibly 5½ miles. It parallels, and is about 2¼ miles northeast of, the band of tuffs and sediments that crosses the township diagonally.

South Half of Lots 25 to 28, Range VI.—Some diamond drilling and several thousand feet of stripping and trenching was done on these lots in 1928 by *La Reine Mine, Limited.* The claims are close to the eastern margin of the La Reine batholith. Sparse sulphide mineralization, consisting of pyrite with a little chalcopyrite, and in places galena and sphalerite, occurs in banded hornblende and biotite schists.

Vicinity of Lots 25 and 26, Ranges II and III.—This property is not far east of the La Reine granite batholith. Stripping and trenching over a length of 4,000 feet has exposed northwesterly striking biotite schist and quartzose greywacke, mineralized in places with lenses of magnetite and small amounts of pyrite, pyrrhotite, and chalcopyrite (Taschereau, 1929, p. 111).

Near Lot-Line 34-35, Range I.—At this locality, about 200 feet north of the south boundary of the township, a pit has exposed sheared greenstone, silicified and containing much epidote, cut by quartz stringers and mineralized with pyrite, pyrrhotite, and chalcopyrite. Assay of a chip sample taken by S. H. Ross gave 35 cents in gold per ton (Ross, 1940, p. 19).

La Reine Township

Most of the western one-third of the township is occupied by granite, the eastern portion of La Reine batholith, and what is probably an eastern outlier of this body lies across the southern boundary of the township into which it extends northward as far as range IV. There is also a small boss of granite in the northwest quarter, about a mile and a half northwest of the village of Dupuy. The remainder of the township is underlain by volcanics, with some associated sediments. As in Desmeloizes, these are dominantly of intermediate to basic composition and have a general southeasterly strike. Cutting these rocks are gabbro or diabase dykes. The northern bay of Abitibi lake projects into the southwest corner of the township. Mineral occurrences include both gold and molybdenite. The latter are described on page 419.

Mineral Occurrences

Lots 28 to 30, Range IV, and Lots 30 and 31, Range V.—This property is about four miles southwest of Dupuy village and half a mile north of the south body of granite. It is underlain by volcanics which are intruded by granite, the latter forming a bare ridge 2,000 feet long and 800 feet wide, trending north and south. Cutting the granite, but so far as observed not the volcanics, are numerous quartz and quartz-feldspar veins, which have an average strike of N.35°E. and a dip of 50° to 75° southeast. Of the seven principal veins, one is from 4¾ to 8¾ feet wide and the others range in width from 7 to 19 inches. These veins have been exposed in trenches for lengths of 70 to 425 feet. Some are barren, but others are mineralized with well crystallized pyrite (cubes up to an inch and a half in diameter) and a small amount of chalcopyrite. One of the veins averages 10 per cent pyrite over a width of 7 inches for an explored length of 425 feet. Gold assays ranging from 0.04 to 0.31 oz. per ton are reported.

Two shafts have been put down on the property, both in the ridge of granite. One, sunk in 1927-28, has a depth of 128 feet, with 245 feet of lateral work on the 100-foot horizon. The other, put down in 1934, is 170 feet deep, with some workings on the 150-foot level. In 1937, *True Fissure Mines, Limited,* did 3,280 feet of diamond drilling in seven holes. Each hole is reported to have given one or more intersections with assays ranging from $1.40 to $10.85 in gold per ton over widths of one to three feet (Ross, 1938, p. 3).

Rousseau and Clermont Townships

Granite occupies the whole of Rousseau township except the south-west corner, and it extends southward for one to two miles into Clermont. Elsewhere, the rocks underlying these townships are, as far as known, Kee-watin-like volcanics with, particularly in Clermont, some sediments.

Mineral Occurrences

Southeast Corner of Rousseau Township.—On the *Champeau and Doire claims,* just east of the southward-flowing section of Turgeon river, free gold was found in a narrow quartz vein in sheared granite. Pyrite occurs in the vein and also in the wall-rock, which, over narrow widths, is reported to contain some gold. The occurrence has been explored by trenching and a prospect shaft, forty feet deep (G.S.C. Map 482*A*, 1939).

Lots 29 to 31, 200 to 700 Feet North of Range Line VII-VIII, Clermont Township.—On these lots, in the north-central part of the township, a number of shear zones mineralized with sulphides have been explored by stripping and trenching and by more than 3,000 feet of diamond drilling.

The rocks underlying this part of the township are chiefly andesitic and rhyolitic lavas, and these are cut in places by quartz-feldspar porphyry and gabbro dykes, the former evidently related to the granite mass, a mile and a half distant, which occupies the northern part of the township. Minor amounts of tuffs and conglomerate, in beds five to thirty feet thick, are interbedded with the volcanics. The sulphide mineralization consists of pyrite, with galena, sphalerite, and chalcopyrite. In places, the adjacent rock is much carbonatized over a considerable width.

Most of the mineralized zones are distributed over an area about 800 feet long by 250 feet wide in lot 30. They have a northwesterly strike, with high dip, usually to the southwest. Seven of them, some in conglomerate, have been partially exposed by trenching over individual lengths of as much as 250 feet, with the sulphides extending over widths from a foot or so up to twelve feet. Appreciable assays for gold and silver have been reported, but grab samples taken from some of the zones by S. H. Ross (1939, p. 9) and assayed in the laboratory of the Quebec Department of Mines, gave only \$0.24 to \$0.84 in gold, and \$0.38 to \$0.63 in silver, per ton.

Chazel, Disson, and Ligneris Townships

The easterly-trending band, three to four miles wide, of Temiscamian-like sediments previously referred to extends across the southern part of Chazel and Disson townships and the central part of Ligneris. A stock of granite crosses the boundary between Chazel and Disson; another occupies the northeast quarter of the latter township and extends beyond into the three adjoining townships; and the western end of a smaller body projects into the southeast corner of Disson. Elsewhere, the underlying rocks are Keewatin-like volcanics.

Although a fair amount of prospecting has been done in these townships, no metallic mineralization of interest has been reported. Lithologically, it may be considered favourable country, but the all-important structural characteristics necessary to guide and control mineral deposition are apparently lacking.

La Sarre Township

The northerly lobe of the Palmarolle-Poulariès granitic batholith extends northwesterly across the southeastern and central part of La Sarre township, occupying about one-third of the area of the township. To west and north of this the rocks are Keewatin-type volcanics with some associated tuffs and sediments, except at the northern boundary, where they are intruded by a small stock of quartz diorite. Dykes that are presumably related to this body, and also granitic and later gabbro or diabase dykes, cut the volcanics in some places.

Mineral Occurrences

Lot 52, Range II.—Pyrite mineralization occurs in the southern part of this lot in two northwesterly striking zones of strong shearing in lavas, carbonaceous tuffs, and graphitic schists. The northeasterly shear zone has been explored over a length of 200 feet. It is eight to nine feet wide and is heavily mineralized with disseminated and massive pyrite over a width of three to four feet. The other shear zone, 175 feet to the southwest, has also been investigated over a length of 200 feet. Pyrite mineralization extends over a width up to two and a half feet, and assays are reported to have shown the presence of gold.

Lot 50, Range IX.—Sulphide mineralization occurs in Keewatin-like volcanics and tuffs on both sides of a dyke of granodiorite, 160 feet wide, that crosses this lot in a northwesterly direction, closely paralleling the strike of the volcanics which, in places, are strongly sheared (Mawdsley, 1930, p. 78). On the south side of the dyke, trenching has exposed a lens-shaped sulphide zone, 90 feet long, which tapers out at both ends from a width of seven feet in its central part. Over most of this length, sulphides make up about 60 per cent of the material, and in places they form nearly solid masses. Some samples of this massive material from near the central part of the lens were estimated to contain 70 per cent pyrrhotite, 20 per cent chalcopyrite, 5 per cent pyrite, and 5 per cent sphalerite, but in general pyrite is the most abundant sulphide. On the north side of the dyke, similar mineralization occurs in a strong shear zone over a length of about 100 feet and a width of ten feet.

During 1928 and 1929, *Windsor Mines, Limited,* who owned a group of claims in lots 44 to 51, range IX, did a considerable amount of trenching on these occurrences. They also made a magnetometer survey, and put down eight diamond-drill holes aggregating 1,100 feet. In December, 1929, they shipped about 25 tons of ore containing 3.44 per cent copper to the Noranda smelter.

Royal Roussillon Township

Macamic lake is situated centrally in this township and occupies about one-fifth of its area. Along the south shore of the lake, and extending some four miles southeasterly from it, is a narrow body of granitic rock. Elsewhere in the township, the rocks are Keewatin-like volcanics with associated tuffs and sediments.

Mineral Occurrences

North Half of Lots 5 and 6, Range IV.—On these lots, which are directly north of the village of Macamic and three-quarters of a mile north of the Canadian National railway, a shear zone in the volcanics at their contact with the granitic rocks of the Palmarolle-Poularies batholith is heavily mineralized with sulphides over a length of 600 feet and a width varying from four to forty-five feet. The sulphides occur as lenses, and also disseminated, in the schists, which they have replaced. Pyrite predominates and is accompanied by pyrrhotite and some chalcopyrite.

Surface exploration of these occurrences was carried out by *Quebec United Mines, Limited,* Samples taken from a pit at the western end of the shear zone are reported to have assayed 3.6 per cent copper and better than \$2.50 in gold per ton. The greatest width of ore is at the eastern end of the zone, where a pit has exposed a width of ten feet of practically massive pyrite and a total width of sulphide replacement of about forty-five feet (Ross, 1938, p. 5).

Languedoc and Guyenne Townships

The only recorded occurrence of sulphide mineralization in these townships is in lots 39 and 40, range II, of Languedoc, where highly sheared and altered volcanics are irregularly replaced by pyrite with some associated chalcopyrite (Lang, 1933, p. 35).

Roquemaure, Palmarolle, and Poulariès Townships

The greater part of Palmarolle township and the western half or more of Poulariès is underlain by granitic rocks of the Palmarolle-Poulariès batholith, and the southern part of a body of granite extends into northern Roquemaure from La Reine township. Elsewhere, the rocks are the usual Keewatin-like volcanics with some interbedded tuffs and sediments.

No metallic mineralization of commercial interest has been reported in these townships.

Privat and Launay Townships

Granite occupies most of the northeastern quarter of Privat township and the west-central part of Launay. The Canadian National railway, crossing the townships in a direction north of west, passes across this granitic mass at its widest part. Keewatin-type rocks occupy the remainder of the townships. In general, they are volcanics, but in places tuffs and sediments are associated with these, particularly in a band about a mile wide which passes diagonally across Privat township, about two miles southwest of the margin of the granite batholith.

Gold and sulphide mineralization has been found in shear zones in the volcanics at several localities in these townships. Molybdenite also occurs in both townships, within the granitic rocks. The occurrences of this mineral are described on page 419.

Mineral Occurrences

Lots 52 and 53, at Range-Line II-III, Privat Township (Isbell Claims).—At this locality, at the south end of Genest lake, a shear zone, 1,200 feet long and 75 feet wide, in altered tuffs and lavas, contains a series of parallel veins of ferruginous quartz, up to ten feet wide. The volcanics are chiefly micaceous and chloritic schists, but over a width of forty feet they have been highly carbonatized. Trenching at right angles to the strike has indicated that the vein system has a length of about 400 feet, with maximum width of ten feet. The veins contain some tourmaline and are mineralized with pyrite and chalcopyrite. Assays of $3 to $4 in gold per ton have been reported (Ross, 1938, p. 7).

Lot 55, Range II, Privat Township (Bussières Claims).—On this property, immediately east of that just described, stripping and trenching have exposed what appears to be the continuation of the shear zone on the Isbell claims. For widths up to twenty-five feet it contains quartz stringers and veins, and inclusions of chloritic schists in the veins are well mineralized with pyrite (Ross, 1938, p. 7).

South Half of Lots 8 and 9, Range II, Launay Township (Freegold Mines, Limited).—Sheared and carbonatized volcanics on these lots are cut by numerous quartz veins. Schist inclusions in the veins are heavily mineralized with finely disseminated pyrite, which, also, is irregularly dispersed through the quartz.

These occurrences were investigated by *Freegold Mines, Limited,* in 1936 and 1937. They put down eight diamond-drill holes aggregating 3,000 feet, sank a shaft on the main vein to a depth of 125 feet and did about 125 feet of lateral work at that horizon.

The main vein has an indicated length of 400 feet and is five feet wide on surface at the shaft. In addition to pyrite, it contains a small amount of arsenopyrite, and free gold in very minute specks is associated with the sulphides. Assays ranging from $0.70 to $15.40 in gold per ton are reported by the Company, but channel samples taken by S. H. Ross (1938, p. 8) at surface and underground on the 125-foot level yielded only $0.98 and *trace* in gold per ton. It would appear that the distribution of the gold is very erratic.

Lots 25 to 27, Range II, Launay Township (Quebec Consolidated Gold Mines, Limited).—Some three miles east of the Freegold holdings, a shear zone in the volcanics, striking N.80°W., has been traced for a length of 1,500 feet, with average width of 150 feet. The rocks for a width of thirty feet along the zone are highly carbonatized, ferruginous, and rusty weathering, and are cut by stringers and veins of quartz, which make up between 10 and 20 per cent of the material in the shear. Fine grained pyrite is disseminated through the quartz, and visible gold has been reported. A 20-foot channel sample taken by S. H. Ross across a zone of the carbonatized andesite with 10 per cent quartz assayed $1.82 in gold per ton.

The zone has been explored by 2,200 feet of trenching, several test pits, and a prospect shaft 35 feet deep. The *American Smelting and Refining Company* did some work on this property in the spring of 1936 (Ross, 1938, p. 9).

Lot 10, Range IV, Launay Township (Rochette Gold Mines Company, Limited).—Trenching along a shear zone in Keewatin-like volcanics has exposed a quartz vein for a length of 340 feet, over which it varies in width from six inches to two feet. It is scantily mineralized with pyrite and chalcopyrite, chiefly near the walls and in schist inclusions and in places it contains finely disseminated free gold. Assay of a grab sample taken by S. H. Ross gave only a trace of gold. Diamond drilling in ten holes totalling about 2,000 feet was carried out to explore the vein at depth.

References

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TASCHEREAU, R. H., *Progress in the Development of the Mineral Deposits of Western Quebec in 1928;* Que. Bur. Mines, Ann. Rept., 1928, pp. 64-131 (1929).

EASTWARD FROM DESBOUES TO VASSAL TOWNSHIP

Continuing eastward along the belt, the country is relatively flat. Deposits of lake clays are widespread, and rock outcrops are infrequent. The townships concerned are as follows, from west to east:

Desboues	Miniac	Coigny	Bernetz
Berry	Béarn	Castagnier	Vassal

Granitic rocks occupy close to 70 per cent of the area of these townships. A body with north-south width of some fourteen miles extends from the western part of Desboues completely across the four townships in a direction slightly south of east, and an irregular mass occupies the southeast quarter of Berry and much of the southern half of Béarn. Smaller bodies intrude and lie within the Keewatin-type rocks that underlie the remainder of the area.

The Keewatin-type rocks have a general strike somewhat north of west, with steep dip. They are chiefly 'greenstones' or, along contacts with the granite, amphibolite and quartz-hornblende schists, but they include interbedded tuffs and sediments, as for example along the south boundary of Vassal township, where a band of greywacke and conglomerate extends eastward from Castagnier lake. No strong zones of shearing have been observed in the Keewatin-type rocks.

Several types, and ages, of granite are represented. That of the main mass is for the most part a medium grained, grey, biotite granite with gneissic structure, though in places this is not pronounced. It is cut by numerous narrow dykes of pegmatite and aplite. Also, within the area of outcrop of this gneissoid granite there are, in places, exposures of coarse, pink, hornblende granite and large dykes of fine grained granite, and elsewhere there are intrusive masses of medium to coarse grained hornblende-biotite granite and of syenite. A later gabbro dyke is exposed on the west shore of Obalski lake, in the southeast corner of Béarn township.

There has been a limited amount of prospecting in these townships, more particularly along the southern part of the area, but no metallic mineralization of economic interest has been reported. Small quartz veins are fairly common in the Keewatin-type rocks, and occasional 'pockets' of pyrite and pyrrhotite may be seen. Assays of twelve samples taken by Longley from the better mineralized zones and quartz veins at various localities in Castagnier and Vassal townships gave negligible or negative results for gold.

Reference

Longley, W. W., *Preliminary Report on Castagnier Lake Area, Abitibi County;* Que. Dept Mines, P.R. No. 167 (1942).

DESPINASSY-SENNETERRE DISTRICT

The belt of volcanics and sediments, bounded on the north by granitic rocks, has been traced eastward from Vassal township, across Despinassy to about the centre-line of Bartouille, and Keewatin-type rocks that occupy almost the whole of the adjoining township of Josselin (see p. 81) possibly represent its continuation. In that township, a narrow neck of the volcanics extends northward to join the easterly trending Laflamme River-Pénache River belt, immediately to the north (see p. 42).

Southward from Bartouille, however, the rocks of the belt terminate against the western margin of a granite batholith which extends far to the east, the irregular contact passing southward close to the western boundary of Ducros township, and then southeastward from the northwest corner of Montgay to the eastern boundary of Senneterre, just below its centre line. Two granitic stocks lie within the volcanics in Montgay and Senneterre townships, and the northwest end of the Pascalis-Tiblemont batholith extends into southern Courville. A small boss of diorite intrudes the volcanics in the northwest quarter of Carpentier, and a narrow body of rhyolite and dacite porphyry, believed to be intrusive, extends southeastward across the southwestern part of the township. The relative positions of the townships concerned are as follows:

Despinassy	Bartouille
Rochebaucourt	Ducros
Carpentier	Montgay
Courville	Senneterre

Deposits of lake clays and sand are widespread in these townships, particularly in Despinassy and Rochebaucourt, and rock outcrops are nowhere plentiful. Gold mineralization has been reported at several localities in Carpentier, Montgay, and Senneterre townships.

CARPENTIER TOWNSHIP

Lots 31 to 34, Range I.—In the northern part of these lots, two aplite dykes, five feet wide, cutting schistose rhyolite porphyry are traversed by quartz veinlets sparingly mineralized with pyrite. A sample of the quartz from one of the veins, taken by Bell (p. 64), assayed $6.61 in gold per ton. A short distance to the west, in the same outcrop of porphyry, a 10-inch vein of quartz is heavily mineralized in places with pyrite and chalcopyrite. A sample taken by Bell (p. 64) assayed $22.45 in gold per ton. Some surface work, chiefly trenching and sampling, was carried out on this property in 1932 by Dubuisson Mines, Limited.

Lot 20, Range V.—Gold is reported to have been panned from quartz that occurs in short lenses and stringers cutting sheared rhyolite porphyry near its contact with the volcanics. Heavily pyritized material occurs a short distance to the north of the quartz lenses.

A limited amount of prospecting has been done on lot 31, range V, lots 31 to 34, range IV, and lot 60, range I, where quartz lenses and stringers, sparsely mineralized with pyrite and some of them containing tourmaline, cut sheared and carbonatized lavas and tuffs. It is reported that gold may be panned from the quartz on lot 31, range V.

Montgay Township

Lot 6, Ranges V and VI (Dik Dik Exploration Company, Limited).—Trenching on these lots has exposed strongly sheared tuffs and flow-rocks, with northwesterly strike, which locally are silicified and replaced to a considerable extent by sulphides—chiefly pyrite but with some chalcopyrite, sphalerite, and stibnite—over a width varying from six feet to thirty feet. Interesting assays in gold and silver have been reported by the Company. Assays of four samples taken by Longley (p. 29) gave *trace* to 0.056 oz. gold per ton, and one of the samples assayed 10.872 oz. silver per ton. In the summer of 1937, a geophysical survey was made of the property.

Lots 1 to 6, Range VI (Hennessy claims).—Similar mineralization has been found on these claims, which adjoin the Dik Dik property on the northwest. It is reported that the highest assay obtained from fifty grab samples was $5.90 in gold per ton.

Lots 12 to 15, Ranges VII and VIII (Taylor claims).—Massive coarse grained granodiorite on these claims is cut along a zone of shearing by a rhyolite or aplite dyke which also is sheared and traversed by numerous quartz stringers. The rock is silicified and to some extent replaced by pyrite. The maximum width of the entire zone is about twenty feet, and of the quartz zone ten feet. The latter has been exposed in a series of trenches for a length of 300 feet. A sample taken by Longley (p. 30) assayed 0.036 oz. gold per ton.

Senneterre Township

Lots 7 and 8, Ranges VI and VII.—Quartz lenses and stringers carrying a little pyrite, and in one instance some chalcopyrite, have been found at several points in shear and fault zones in the volcanics underlying these lots, which are not far north of the west end of a stock of granite. Granite or porphyry dykes, presumably genetically related to this stock, are closely associated with the quartz. These occurrences have been explored by trenching and test pits, and from all of them low gold assays have been reported.

Lot 4, Range V.—At this locality, which is just within the granite stock, at its western end, some work has been done along a narrow shear which contains a quartz vein. Bell (p. 70) reports that material from a test pit blasted in the vein contains massive sulphides and fine grained magnetite.

Lots 30 to 34, Range V.—A garnetiferous band in tuffaceous rocks at the east margin of the granite stock is mineralized over a width of three to six feet with massive pyrite and pyrrhotite. It is reported that this material gave low assays for gold, but a sample taken by Bell contained no gold.

Lot 23, Range II.—Trenching has exposed a rusty-weathering band, twenty to fifty feet wide, in sheared greenstone, which is silicified and mineralized with pyrite and some sphalerite. The gold content of a sample taken by Bell (p. 70) was found to be negligible, but the owners of the claims reported visible gold in a sample from one of the trenches. These claims are a mile or so south of the granite stock.

Lot 62, Range III.—This lot is at the eastern boundary of the township and is close to the margin of the granite batholith that extends from here far to the east. Irregular lenses of quartz, well mineralized with chalcopyrite and some pyrite, occur here along either side of an acidic dyke, two to eight feet wide, which intrudes basic volcanics. The gold content of the mineralized material appears to be low.

References

Bell, L. V., and Bell, A.M., *Senneterre Map-Area, Abitibi District;* Que. Bur. Mines, Ann. Rept., 1933, Pt. *B* (1934).

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VICINITY OF PARENT LAKE

Immediately east of the village of Senneterre, Bell river widens to form Parent lake, which continues in a direction somewhat east of north for a distance of some thirty miles, to about the centre of the east boundary of Josselin township. Bell river leaves the western shore of the lake some miles from its northern end. This northern stretch of the river and lake forms the north-south boundary between the following townships:

Bartouille	Josselin
Ducros	Delestre
Montgay	Brassier

At the northern boundary of this group of townships, Keewatin-type rocks extend from eastern Bartouille completely across Josselin, but southward their width narrows and, crossing Parent lake, they continue as a narrow belt which enters Brassier at its north-south centre-line. Gneissic granite surrounds the Keewatin-type rocks on the west, south, and east, but northward they continue as a narrow neck to merge with the easterly trending Laflamme River-Pénache River belt. As has been noted earlier, it is possible that the Keewatin-type rocks in Josselin township are the eastward continuation of those in the townships to the west, and mark the termination of this particular belt of volcanics and associated sediments.

The Keewatin-type rocks are chiefly lavas of intermediate composition, but in places there are interbedded tuffs and sediments, notably in northern Josselin and southern Delestre. In general, they have pronounced schistose structure.

Quartz veins are common in the schists and gneisses, and carbonate veins occur here and there within the lavas. The carbonate veins usually contain some pyrite, but the quartz veins in general are devoid of sulphide mineralization. In the few assays that have been reported, gold is absent or in negligible amount. Lenses of pyrite and pyrrhotite have been found in several places, chiefly in the schistose sediments, and some of these occurrences have been explored by stripping and trenching.

Bartouille Township

Lot 65, Range III.—At several points adjacent to the western boundary of this lot, lenticular masses of pyrite and pyrrhotite, in about equal amount, have been found replacing rusty-weathering quartzite, which contains also much magnetite. Half a dozen such bodies are exposed over a north-south distance of 1,000 feet and two others occur 1,000 and 1,500 feet farther south, near the southwest corner of the lot. In one trench, the total mineralized width is 55 feet, of which 40 feet averages 20 to 25 per cent sulphides, with some lenses as high as 60 per cent, and the other occurrences have dimensions and sulphide content of about the same order. One body can be traced on the surface for a length of 250 feet. Some diamond drilling was done here by the *Mining Corporation of Canada*, but the results of this work are not available.

Lots 74 and 75, Range II.—Sulphide mineralization with similar associations occurs about a mile and a half southeast of that described above. The sulphides, here chiefly pyrite, are scattered sparsely through a belt 400 to 500 feet wide but only in three zones do they attain a concentration as high as 10 per cent of the rock. At one place, a four-foot section of silicified tuff is intricately veined by stringers of quartz containing a little chalcopyrite.

Josselin Township

Portage between Josselin Lake and Bell River.—Trenching has exposed pyrite in crushed and heavily sheared andesite, striking N.45°E. The mineralization extends sporadically over a width of 75 feet and is traceable for upwards of 300 feet along the strike. The pyrite content of the rock exposed averages 3 to 5 per cent, but locally is much higher than this. Samples are reported to have given low assays for gold.

Ducros Township

In Ducros township, Bannerman observed pyrite and pyrrhotite mineralization on lots 71 and 72, range VIII, and on lot 58, range IX, and, judging by the amount of rusty gossan and siliceous limonitic material exposed, he concluded that the sulphide bodies are of considerable size. The geological relationships are essentially the same as in the occurrences in Bartouille township except that here the hanging-wall is banded iron formation. Some chalcopyrite is reported in a vein on lot 71, range VIII.

Delestre Township

Prospect Island, Range V.—In the central part of the east lobe of the island, stripping has exposed two bodies of heavy sulphide mineralization, one 12 to 15 feet wide, the other 2 to 3 feet, separated by about 20 feet of barren rock. The wall-rocks are tuffaceous sediments, with northwesterly strike. Assays of samples yielded only a 'trace' of gold. Outcrops of rusty siliceous schists in the western part of the island suggest that sulphides may be found there also.

Lots 25 and 26, Range V.—On the mainland, about half a mile east of the above occurrence, trenches have been opened across a sulphide zone in the siliceous tuffs. The mineralization is sparsely scattered across a width of a hundred feet or so, but, as exposed, the greatest width of massive sulphides is only 27 inches, and such concentrations appear to have the form of discontinuous lenses. Strong magnetic attraction along a depression to the north of the trenches suggests that the mineralization there may be heavier than that now exposed. Only a 'trace' of gold is reported from assays of the sulphides.

Bannerman reported similar pyrite and pyrrhotite mineralization on the Delestre-Brassier township line, about 2¾ miles east of Brassier (Jackpine) river.

Reference

Bannerman, H. M., *Josselin-Delestre Map-Area, Abitibi-East County;* Que. Bur. Mines, Ann. Rept., 1935, Pt. *C*, pp. 3-26 (1936).

HÉBÉCOURT-DUPARQUET-DESTOR TOWNSHIPS

General Note

Hébécourt township adjoins the Quebec-Ontario boundary and is followed on the east by Duparquet. Both townships are underlain almost entirely by Keewatin-type rocks, but along a narrow, easterly trending belt in central Duparquet these are overlain by Temiscamian-like sediments which lie along the axis of a major syncline. Eastward, this belt continues half way across the adjoining Destor township, but westward it noses out before reaching Hébécourt, in which township no Temiscamian-type sediments have been found. The syncline, however, is known to extend for more than twenty miles east of Destor township, and there are grounds for believing that it continues westward for at least eighty miles, to the Porcupine district, Ontario.

At the east boundary of Duparquet township, the belt of sediments has a north-south width of about one mile. Westward, it gradually narrows to terminate at a point 2,500 feet southeast of the Beattie mine shaft, or nearly a mile and three-quarters west of the centre-line of the township. The rocks of the belt are chiefly conglomerate and greywacke, with slate near both north and south margins, and, in contrast with the flanking Keewatin-type rocks, they are in general relatively fresh looking. They occupy the centre of the syncline, which pitches eastward.

The Keewatin-type rocks adjacent to the northern margin of the belt, at its western end, are intruded by a series of interlocking syenite porphyry, bostonite porphyry, and quartz porphyry bodies (O'Neill, 1933, 1934), which extend eastward for a distance of some three miles with a general width of about 2,000 feet. The main Beattie orebodies lie at or adjacent to the northern margin of the most westerly of these intrusive bodies. An east-west trending stock, mapped by O'Neill (1934) as quartz porphyry, intrudes the sedimentary-volcanic contact at the south margin of the belt near the Duparquet-Destor boundary, and smaller bodies of similar porphyry occur elsewhere, for the most part at the margin of the belt, but some of them well within it.

The Keewatin-type rocks to north and south of the sedimentary belt are chiefly volcanic flows of intermediate composition. Of special interest, however, is a belt of sedimentary rocks, chiefly sericitic schists, tuffs, and agglomerates, about 2,000 feet wide, that strikes N.65°E. from the north shore of Duparquet lake toward the syenite porphyry mass of the Beattie mine. These highly altered sediments are believed to be Keewatin. At the west end of the village of Duparquet they come in contact with the west end of the belt of comparatively fresh Temiscamian-like sediments, the two formations meeting at an angle of about 15° (O'Neill, 1934, p. 85). In the Beattie mine workings, also, an angular unconformity of about 20° in strike between the two series of sediments is evident (Banfield). Nowhere else in Western Quebec has any evidence been found suggesting an unconformity between the Keewatin and Temiscamian.

Another interesting feature of the geology here is the occurrence in some places of an apparent 'conglomerate' at or near the contact between the Temiscamian and Keewatin-type rocks, as for example near the syenite porphyry mass on the north side of the belt of Temiscamian-type sediments, and near the quartz porphyry body at the south margin of the belt at the Duparquet-Destor boundary (see Vol. II, pp. 80-81, 87-88, 105). The striking feature of this 'conglomerate' is the presence of large numbers of what appear to be 'boulders' of porphyry, thought by some (Buffam, p. 96; Bannerman, p. 14) to be derived from the porphyry masses in the vicinity. If this interpretation were correct, it would of course follow that some, at least, of the porphyry intrusions are pre-Temiscamian. From various considerations, however, it would appear beyond question that the porphyry intrusions are all post-Temiscamian. Concerning the 'conglomerate', O'Neill (1934, p. 87) says: "Some of these occurrences are clearly breccias; some are due to lenticular injections of porphyry into conglomerate and later shearing; but some are apparently true conglomerates. In the case of the latter, however, there is no evidence to show that the porphyry boulders are from neighbouring bodies of porphyry. In fact, there are dykes of quartz porphyry cutting the Temiscamian, and the emplacement of the main bodies of porphyry is definitely controlled by the structure, which is post-Temiscamian. Further, the porphyry conglomerates were nowhere found to rest directly against any feldspar porphyry, and relatively thin beds of conglomerate of this type were found underlain by beds of greywacke and of the normal-type conglomerate some distance above the contact. Whatever the origin of these peculiar conglomerates, they are definitely older than the porphyries which are exposed in this area; but they may, in some cases, have been modified by the intrusion of those porphyries". O'Neill is supported in this view by Lang (p. 30) and also by Banfield. Lang found a porphyry dyke cutting the porphyry 'conglomerate'.

Hébécourt township is for the most part blanketed with superficial deposits of drift and glacial-lake clays. The relatively small areas of rock outcrop, particularly along the westward strike of the Beattie orebodies, have been prospected fairly thoroughly, but no gold or other metallic mineralization of interest has been discovered.

In Duparquet, also, it is only locally that rock outcrops are numerous, but intensive exploration along and adjacent to the belt of sediments has led to the discovery of gold mineralization in several localities, most notable up to the present being the Beattie orebodies. These and other deposits in the township are described in the following pages.

Beattie Gold Mines (Quebec), Limited

History

The Beattie mine, near the northeast shore of Duparquet lake, is about twenty miles north-northwest of the town of Noranda. A railway runs eastward from the property to Davangus, on the Rouyn-Taschereau branch of the Canadian National railway, and is closely paralleled by a road, about nine miles long, which meets the Macamic highway in the western part of Destor township.

The ground in which the chief orebodies occur was staked by John Beattie in 1923 and in the following year the *Victoria Syndicate*, under an option arrangement, did a considerable amount of trenching on the property. The results of this work were not encouraging, but further prospecting by Beattie in the succeeding years led to new discoveries and in 1927 the *Consolidated Mining and Smelting Company of Canada* took an option on the property. Besides extensive trenching, they put down diamond-drill holes aggregating several thousand feet before relinquishing their option in 1930. All of this work had been along and near the northern margin of the syenite porphyry stock, in an area some 2,000 feet east of the present main shaft. In the fall of 1930, in the course of prospecting toward the western end of the stock, Beattie discovered what is now known as the Main, or North, orebody, about 400 feet directly north of the point selected later for the sinking of the shaft. *Ventures, Limited,* then took on option on the property, and were joined later by the *Nipissing Mining Company.* The new discoveries were thoroughly diamond-drilled, a shaft was sunk in the ore to a depth of 220 feet, and the orebody was cross-cut at that level. This work indicated 5,000,000 tons of ore assaying 0.15 oz. gold per ton above the 500-foot level. In 1932, *Beattie Gold Mines, Limited,* was organized to develop the property, and in 1937 the Company obtained a Provincial charter and became *Beattie Gold Mines (Quebec), Limited.*

A flotation plant for concentration of the ore was erected, and production commenced in May, 1933. During that and the following year, the concentrates were shipped for further treatment to the smelter of the American Smelting and Refining Company, at Tacoma, Wash., but in 1934 a cyanide plant was added to the mill and from 1935 until the end of 1937 only the concentrates from re-flotation of the cyanide residue were sent to Tacoma. Late in 1937, a plant was installed for roasting the primary flotation concentrate prior to cyanidation, and since that time all milling operations have been carried out at the Beattie property. Gold recovery steadily improved from 81.9 per cent in 1938 to 89.95 per cent in 1942. Arsenic oxide is recovered in the roasting plant*.

From the start of production in 1933 until the end of 1940, the mill treated 3,921,281 tons of ore and recovered 471,085 ounces of gold and 73,214 ounces of silver, an average of 0.120 oz. gold and 0.019 oz. silver per ton. At the end of 1940, ore reserves were estimated at 4,243,520 tons, averaging 0.136 oz. gold per ton. This represented a seven years' supply of ore at the current milling rate of about 1,700 tons per day.

The following outline of the geology and description of the ore and orebodies is based on an unpublished doctorate thesis by A. F. Banfield (see references), geologist for Beattie Gold Mines, a copy of which was made available through the courtesy of the Company and the author.

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*For a description of mining and milling operations at the Beattie property, reference may be made to the following papers:

TUTTLE, Jay, *The Spiral Stoping System as Applied at the Beattie Mine;* Can. Inst. Min. & Met., Trans., Vol. XLII, pp. 95-122 (1939).

ARCHIBALD, F. R., MARTIN, F. J. and KOENEN, A. T., *Roasting of Beattie Concentrate;* Can. Inst. Min. & Met., Vol. XLII, pp. 608-631 (1939).

ARCHIBALD, F. R. and HARRIS, W. A., *The Importance of Temperature, and of Sulphur Dioxide Concentration, in Roasting Arsenopyritic Concentrate;* Can. Inst. Min. & Met., Vol. XLIII, pp. 757-761 (1940).

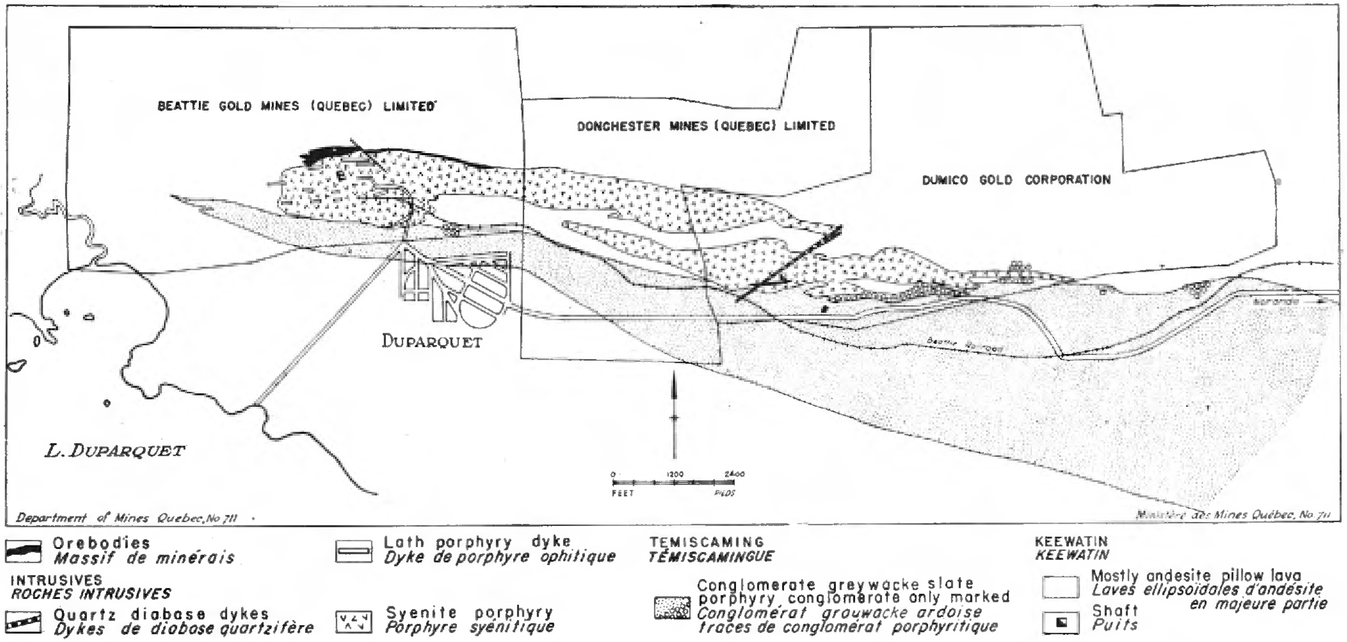


FIGURE 14.—*Geological map of surface at Beattie mine and neighbouring properties.*

General Geology

The orebodies occur at and within the northwest margin of a stock of syenite porphyry which intrudes the Keewatin-type rocks north of, and very close to, the western end of the belt of Temiscamian-type sediments. The stock rises to 150 to 175 feet above the level of Duparquet lake, half a mile to the southwest, and extends eastward for about three miles. On the west, for a length of 1,800 feet, it has a north-south width of 1,500 feet, but there it narrows abruptly and continues eastward with only about one-quarter of that width. Immediately south of this narrow part of the stock is another body of syenite porphyry, which also extends eastward for about three miles, and there are other bodies of similar rock still farther east. These latter bodies were described by O'Neill (1933, p. 16; 1934, p. 91) as 'bostonite porphyry' and were regarded by him as later than the most westerly syenite porphyry stock. He also mapped as bostonite porphyry a narrow zone of rock bordering the north side of the syenite porphyry stock. Banfield, however, considers this to be merely a marginal facies of the syenite porphyry, more or less altered by mineralizing solutions. It is in this rock that the main Beattie orebodies occur.

Structural evidence indicates that the porphyry was intruded into the Keewatin-type rocks as a sill which now, like the containing rocks, has an east-west trend and nearly vertical attitude, and pitches eastward. Although not actually seen in contact with the Temiscamian-type sediments, it is believed to be post-Temiscamian. Porphyries of this age are common in other parts of western Quebec, as for example in Beauchastel and Dasserat townships.

On both the north and south side of the stock or sill, the contact between the porphyry and Keewatin-type rocks is sharp, and in places the intrusive is very fine grained at the contact, due to chilling, but there is no evidence of contact metamorphism of the adjacent volcanics. At the western end of the stock, however, there is interfingering of porphyry and volcanics over a distance of 50 to 100 feet. In this zone, there is considerable development of sericite, chlorite, and carbonate until, with increase in the amount of chlorite, the rock finally passes into the normal dark, chlorite-rich Keewatin rock. There is an absence of porphyry dykes cutting the neighbouring volcanics, and inclusions of these in the porphyry, though rare, invariably have the same east-west trend as the main body of volcanics, which are little if at all contorted in the vicinity of the intrusive body. On the basis of these features, and on other evidence, Banfield concludes that the porphyry was intruded into the Keewatin-type rocks by replacement.

The massive, unaltered syenite porphyry, as seen in the underground workings of the mine, is light grey in colour, but adjacent to joint planes and in surface outcrops it is red. In general, it is medium grained, with abundant phenocrysts of feldspar, up to a quarter of an inch in diameter. These are albite, orthoclase, anorthoclase, and a perthitic intergrowth of albite and orthoclase. The groundmass consists of soda-rich anorthosite and hornblende, the latter, with minor amounts of accessory apatite, sphene, magnetite, and ilmenite, making up about 15 per cent of the rock.

Usually there has been partial, and in sheared rock almost complete, alteration of the feldspar and hornblende to white mica, chlorite, and other secondary minerals. Quartz veinlets, some containing also calcite, are common filling tension fractures in the syenite. An analysis of the rock gave: K_2O, 4.33 per cent; Na_2O, 5.31 per cent.

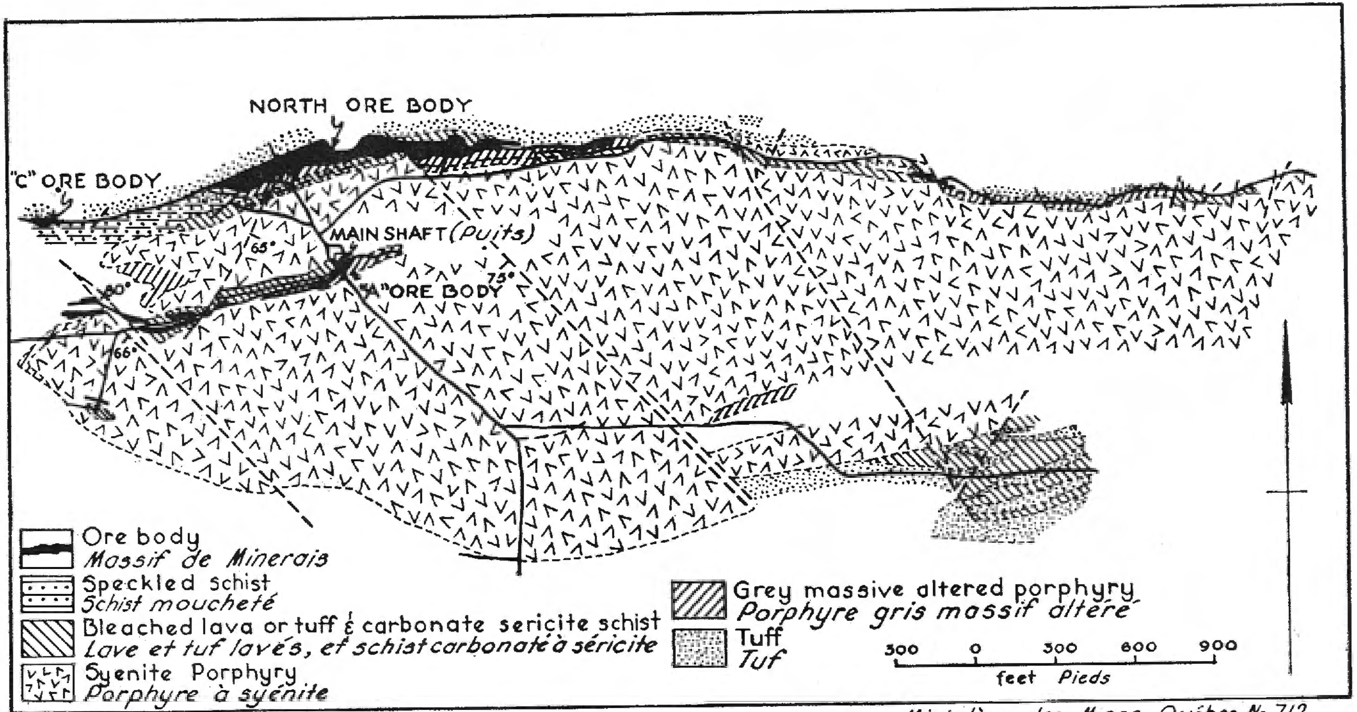
Cutting the syenite porphyry and Keewatin-type rocks, and particularly numerous in the ore zones, are dykes that are known locally as 'lath porphyry'. These, like the rocks they invade, have an easterly strike, and they appear to have been injected along shear zones. The majority are about ten feet wide but some are much narrower than this and others have a width of as much as fifty feet. A feature of these dykes is an abundance of lath-shaped phenocrysts of orthoclase, which may make up as much as 75 per cent of the rock. Generally, they are a quarter to half an inch long—rarely, up to two inches—with the length five times the width, and, particularly in the narrower dykes, they are oriented with their length parallel to the dyke walls. The groundmass consists of a felt of lath-shaped crystals of orthoclase. It contains no hornblende, but magnetite and ilmenite are prominent as accessory minerals. These dykes are usually bright red in colour. In marked contrast to the syenite porphyry, they contain 13.44 per cent K_2O and only 0.20 per cent Na_2O.

The lath porphyry dykes contain varying amounts—up to 5 per cent—of sulphides, chiefly pyrite and arsenopyrite, with which gold is associated. In some of them, the gold concentration is of ore grade, and widths up to fifty feet assaying 0.20 oz. gold per ton have been encountered. Being more brittle than the syenite porphyry and Keewatin-type rocks, the tendency has been for these dykes to break into rectangular blocks under the late shearing stresses to which the rocks in the ore zones were subjected, and the openings thus formed afforded a passage for the mineralizing solutions.

Numerous narrow dykes and stringers cut, and closely parallel the bedding of, the Keewatin-type tuffs in the North orebody. They are very fine grained, light coloured rocks whose dominant feldspar is orthoclase. These dykes are coarsely brecciated and have been much altered by mineralizing solutions.

Structure

The most prominent shear zone in the mine, known as the East-West shear, lies along the north margin of the syenite porphyry stock and is about 400 feet north of the shaft. It has been traced in the mine workings for a length of more than 5,000 feet and has been probed to a depth of 1,200 feet. Its dip is vertical and it has a width of from ten to as much as fifty feet, averaging probably twenty feet. In the main, the shear is close to the porphyry-Keewatin contact. It has been the locus of recurrent movement, but, as it parallels the general strike of the formations, it is difficult to determine how much displacement there has been. Banfield considers that. possibly, the total movement has not been more than a few tens of feet, The shear is still present, but is apparently dying out, in the most easterly workings of the mine. To the west, it terminates 200 feet west of the porphyry.



Department of Mines, Quebec, No. 712. Ministère des Mines, Québec, No. 712.

FIGURE 15.—*Geological plan of third level, Beattie mine.*

Along some sections of the zone, the rock consists chiefly of sericite and carbonate; along others, it is highly silicified. In these latter sections, the rock is of ore grade; elsewhere, this is rarely the case. Calcite bands or veinlets are not uncommon in the shear zone, and a central band of calcite from an inch to two feet wide is present through most of its length. Two ages of calcite are recognized, the earlier possibly closely related to the period of silicification.

The North orebody is closely related to this shear zone. There is no comparable shear near the *A* orebody.

Faults are not numerous and have not complicated the problem of mining. They fall into two sets, striking, respectively, northwest and northeast. Five northwesterly striking faults, spaced at wide intervals, have been encountered in the mine. The most important is the Main fault, which dips at 75 degrees to the southwest and at the surface passes 600 feet northeast of the shaft. It cuts the two main orebodies, displacing them so that the northeast side has been moved south about 70 feet and down about 100 feet. The northeasterly striking faults, with steep dip to the northwest, are less important. The most prominent of them would outcrop at the surface 450 feet northwest of the shaft. The horizontal movement on this fault is of the northwest side ten to fifty feet south; the vertical component of movement is not known. Gouge or calcite occurs along the plane of nearly all the faults.

There is a noticeable widening of the North orebody in the vicinity of the Main fault, and the walls of the calcite-filled faults traversing this ore zone are generally highly silicified and high grade. Some of the smaller faults contain silicified gouge and breccia.

Narrow, flat tension cracks filled with white quartz and white calcite are common in the syenite porphyry near its margins. They strike east-west and dip 20 degrees to the north. They contain no gold or sulphides.

The Orebodies

Two main orebodies are being mined on the Beattie property. A third body has been partially developed and a number of other gold-bearing sections have been encountered in the mine workings or in diamond drilling.

The North Orebody, or ore zone, is the largest and, before extraction started, was estimated to contain 7,000,000 tons of ore carrying about 0.15 oz. gold per ton. At the surface, it has an east-west length of 5,000 feet and a width which gradually decreases from 250 feet at its western end to ten feet at the east boundary of the property. It lies along the contact of the syenite porphyry stock with the Keewatin rocks to the north. The East-West shear is almost wholly in the ore zone or close to its southern margin and generally is of ore grade. The ore zone dips within a few degrees of vertical. Its western end in general is blunt, but in detail it fingers out into the Keewatin rocks. At the surface, this western end is about 200 feet north and 900 feet west of the main shaft, and is just north of the western end of the syenite porphyry mass and like the latter it pitches eastward at about 45 degrees. The ore zone decreases both in length and width at depth and on the 6th level, or 950-foot horizon, it has a length of about

700 feet and a maximum width of possibly 100 feet. In 1940, a winze was being sunk from this level to investigate ore conditions at greater depth.

Of the ore produced from this zone to date, about 70 per cent has consisted of mineralized Keewatin rocks and associated small dykes, and the balance of mineralized syenite porphyry.

The bulk of the Keewatin ore is 'breccia ore'— highly mineralized and silicified, brecciated, grey, bleached lava or tuff — and averages about 0.15 oz. gold per ton. About one-seventh of it is 'buff breccia ore', in which the mineralization and alteration are less intense and the gold tenor is only 0.05 oz. gold per ton. As a consequence of the ore zone crossing the Keewatin beds at an angle to their strike, some of the richer sections of the ore in these rocks have a flat eastward pitch. Along the northern contact and base of the orebody a tendency to have downward projections is marked.

The 'porphyry ore' consists of highly altered and mineralized porphyry which, as it is followed northward, is seen to grade into the normal syenite porphyry of the body of the stock. Where the alteration is intense, the rock is grey-coloured, fine-grained, very hard, and well mineralized with sulphides. It is ore of good grade, some sections averaging 0.22 oz. gold per ton. Microscopic quartz-calcite stringers are numerous in the contact zone. Chemical analysis indicates that the alteration of the syenite porphyry involved the introduction of much calcium carbonate and potash, and the removal of soda. The total silica content is lower, if anything, than in the unaltered rock, but, in the microscopically veined contact zone, the percentage of alumina and of alkalies is markedly lower, indicating a replacement of feldspar by calcite and quartz. Instead of the anorthoclase of the syenite porphyry, orthoclase and albite are present. The essential processes involved in the formation of the porphyry ore have been brecciation, microscopic veining by quartz-calcite stringers, and the introduction of carbonate, sericite, sulphides, and gold. Porphyritic facies are not common and, if present, the phenocrysts are small.

This altered syenite porphyry, referred to at the mine as the 'grey massive porphyry', is presumably the fine grained 'bostonite porphyry' of O'Neill (1933, p. 16; 1934, p. 91), who considered it a younger intrusive than the syenite porphyry. The mine staff do not now recognize such a later intrusive within the mine workings, but consider that this rock is a marginal facies of the syenite porphyry, more or less altered by mineralizing solutions.

The A Orebody was unexpectedly encountered at a depth of 450 feet during the sinking of the Main shaft in the syenite porphyry, at a point 400 feet south of the North orebody. Subsequent work has indicated an orebody containing over a million tons of ore with an average gold content of about 0.13 oz. gold per ton, and an additional million tons assaying 0.06 oz. gold per ton. Its greatest dimension is on the third, or 500-foot, level, where it extends for 1,000 feet west and 300 feet east of the shaft, its actual trend being about N.75°E. The average width on this level is 50 feet. The body has a northerly dip at about 75 degrees and an easterly pitch at 45 degrees and less. Its greatest vertical extent is 400 feet.

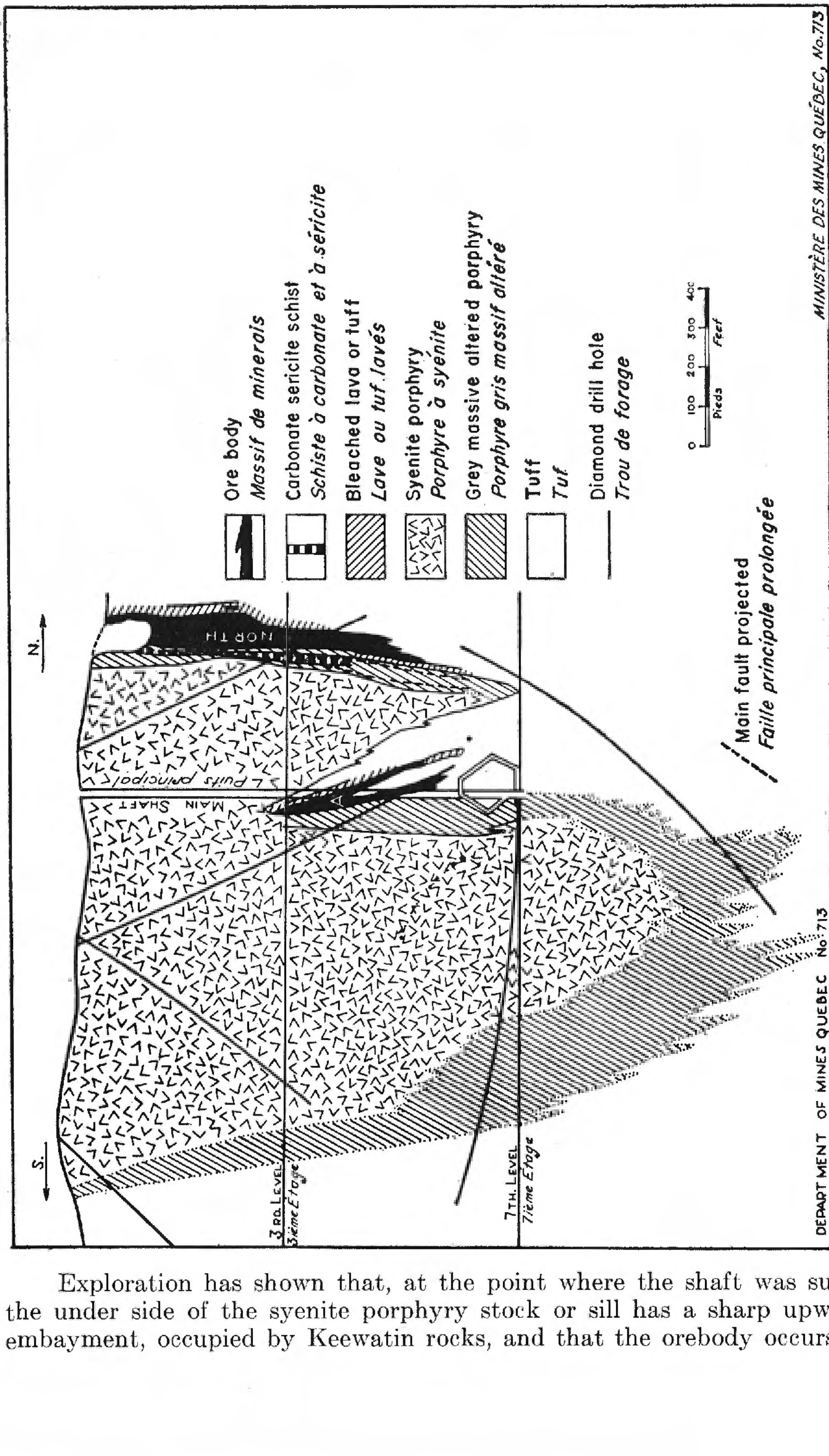


FIGURE 16.—*Geological section through shaft, Beattie mine.*

Exploration has shown that, at the point where the shaft was sunk, the under side of the syenite porphyry stock or sill has a sharp upward embayment, occupied by Keewatin rocks, and that the orebody occurs at the Keewatin-porphyry contact on the south side of this embayment, apexing at the under side of the syenite porphyry. The mineralized rock composing the ore is in nature and proportion closely similar to that of the North orebody. The selective replacement of certain rock types by the mineralizing solutions is more clearly shown in this body than in the North orebody; a tuff bed has proved to be particularly favourable, whereas massive pillow lavas are quite unfavourable. Bleaching such as is characteristic of the 'breccia ore' of the North orebody is common. Although some of the ore exhibits brecciation and shearing, there is no strong shear zone here comparable to the marked East-West shear. The orebody is, however, cut by three of the later cross-faults.

The C Orebody lies just west of the North orebody and is estimated to contain 70,000 tons of ore assaying 0.12 oz. gold per ton. At surface, the two bodies are joined, but as the *C* orebody dips vertically and the North orebody has a pitch of 45 degrees to the east, they rapidly diverge with depth and, on the third level, are 500 feet apart. The *C* body is wedge-shaped and extends from the surface to a short distance below the third, or 500-foot, horizon. It is 300 feet long on the first level and only 50 feet long on the third. Its average maximum width on the three levels is about 20 feet.

This orebody lies entirely within the Keewatin rocks. On the first level it is composed of 'breccia ore' formed from tuffs, while on the third level the ore is mineralized carbonate-sericite schist. On the second level it is connected with the North orebody by a highly bleached and mineralized band of fine tuffs, which in places is only a few inches wide.

Other gold-bearing bodies of interest have been encountered in the mine workings and by diamond drilling. On the third level, 1,100 feet southwest of the shaft, a mineralized lath porphyry dyke, cutting the syenite porphyry mass, has been explored for 100 feet, and a diamond-drill hole intersecting it above and to the west of this section assayed 0.10 oz. gold per ton over a core length of 50 feet. Exploration has been started also along the south margin of the syenite porphyry mass, which has an easterly trend and is about 1,000 feet south of the shaft. Encouraging diamond-drill intersections have been obtained here.

Mineralogy

The mineral composition of the ore varies with that of the original rock type that has been mineralized, but for average run-of-mine ore it is approximately as follows:

Feldspar.............	45 per cent	Sericite................	5 per cent
Quartz..............	25 " "	Chlorite...............	1 " "
Calcite..............	15 " "	Others.................	1 " "
Sulphides...........	8 " "		

The processes of mineralization have, in general, markedly reduced the proportion of feldspar and have relatively enriched the resulting rock in the potash variety, orthoclase, albite being present in only minor amount. The feldspars occur generally in a fine mosaic, but there is a tendency for some of the apparently secondary crystals to have a lath-like shape. The grains are much fractured and veined and are more or less altered to secondary minerals, such as sericite and kaolin. They are often rimmed by porcelain-like kaolin.

The quartz is of several ages. Most important is that which was responsible for the intense silicification of the rocks following their brecciation. It veins and replaces all the original rock-forming minerals except apatite. The grains average about 0.01 millimeters in diameter and have interfingering contacts. In extreme cases, this quartz forms 50 per cent of the rock mass. These highly silicified rocks are grey or black in colour. The latest quartz to be introduced is probably that seen in narrow, flat, tension cracks, associated with calcite and containing neither sulphides nor gold.

Calcite, also, was formed at several stages during the mineralization of the ore zones, but chiefly, it is believed, immediately following the period of silicification, though some calcite is intimately associated with the quartz introduced at that time. The calcite occurs in both coarse and very fine aggregates. The latest was deposited — at more than one time — in the late cross-faults.

Sericite, as an alteration product of feldspar, is common in all parts of the orebodies and its development is believed to be closely contemporaneous with the period of silicification. Where silicification is extreme, however, sericite is almost absent. The flakes are generally arranged in parallel and give the ore a somewhat schistose appearance. Narrow bands of the material are often arranged about the sulphides.

Chlorite is not abundant in the ore of better grade, having been removed in the process that bleached the Keewatin rocks.

Leucoxene, ilmenite, and magnetite are present in the ore in small amount. Fluorite, in quartz-calcite stringers, has been observed in some of the mine workings. Tourmaline has been found at only one place in the mine, in the form of fine crystal aggregates in a barren, white quartz vein which cuts unaltered Keewatin rocks. Both the fluorite and the tourmaline are believed to have been introduced late.

Sulphides form 8 per cent by weight of the Beattie ore and, with the exception of extremely minor amounts of chalcopyrite, galena, sphalerite, and molybdenite, are almost wholly pyrite and arsenopyrite. On the average, pyrite forms 6½ per cent of the ore and arsenopyrite 1½ per cent.

Pyrite is much more abundant in the altered minerals of the original rock than in the introduced quartz and calcite. It occurs as very uniformly scattered cubes having diameters of from 0.001 to 0.3 mm., and for the most part about 0.025 mm. Only about one in ten shows fracturing. Rarely, the crystals are skeletal. All the pyrite in the ore zones is gold-bearing, but similar pyrite away from these zones is not auriferous. Along the south margin of the syenite porphyry mass, zones showing marked silicification and pyritization contain no gold.

The distribution of the arsenopyrite is much the same as that of the pyrite. Except for the very rare occurrence of rosettes of prismatic crystals, the mineral is in diamond-shaped, skeletal, or dendritic crystals, the proportion of the three types being approximately 40, 30, and 30. Mill tests show that the average diameter of 98 per cent of the arsenopyrite in the ore is 0.003 mm. Some of the diamond-shaped and dendritic crystals are as much as 1.0 mm. in diameter. The skeletal crystals have an average diameter of 0.001 mm. and are more abundant in high-grade than in low-grade ore. As inclusions of pyrite have been noted in arsenopyrite, the latter is believed to be somewhat later than the pyrite. Mill tests have shown that 30 per cent of the arsenopyrite can be removed by flotation without reducing the gold content of the ore, but the arsenopyrite remaining in the concentrate is auriferous. Outside the ore zones, arsenopyrite that is not gold bearing has been encountered, as, for example, in workings on the 500-foot level, near the east boundary of the property, and here the associated pyrite also is non-auriferous.

Beattie ore averages 0.12 to 0.16 oz. gold per ton, but some of the rock mined contains as little as 0.07 oz. The gold is very finely and evenly distributed through the ore; very rarely is it coarse enough to be seen by the naked eye. Mill tests show that 35 per cent of it is in the free state and 65 per cent is intimately associated with the pyrite and arsenopyrite. As already noted, however, at least 30 per cent of the arsenopyrite is not gold-bearing. Microscopic study of table concentrate shows the free gold to range in size from 0.002 to 0.05 mm., with 80 per cent about 0.015 mm. Particles of smaller size than 0.002 mm. could have been recognized but none were seen. This absence, however, may be due to loss of the very fine gold during tabling. No gold has been seen in pyrite, and only an occasional grain in arsenopyrite, from which it is concluded that the gold recovered with the sulphides is of sub-microscopic size and is admixed with the sulphides. Mill tests indicate mechanical mixture rather than solid solution.

Visible free gold in noticeable amount — and then not more than about 2.0 oz. per ton — has been found at only two places in the mine: in strongly mineralized syenite porphyry in the shaft, and along the wall of a narrow east-west calcite slip in the ore above the fourth level in 406 stope. This calcite veinlet also contained a little sphalerite. The bulk of the ore occurs in strongly silicified rocks but some is found in unsilicified rocks, as for example in the mineralized tuffs. The close association of the gold with the sulphides has been emphasized, but it should be pointed out that there are zones containing sulphides, identical with those in the ore, that are not gold-bearing. This might suggest that the introduction of the gold was a late, but related, event.

The ratio, by weight, of silver to gold in the Beattie ore is generally 1 : 3.5, and most of the silver is closely bound up with the gold. As the ratio is not constant, however, it has been suggested that an unrecognized silver mineral, probably an arsenide, is present in the ore.

The ore contains about 0.03 per cent of chalcopyrite in grains, about one millimeter in diameter, which have irregular distribution. They are fractured, and contain inclusions of pyrite. Nests of chalcopyrite weighing up to a few ounces are also found in the late calcite-filled faults.

Flotation concentrate of the sulphides contain as much as 0.15 per cent of zinc, probably as sphalerite, and this mineral may be rather widely distributed, although, so far, it has only been recognized in veinlets of quartz and calcite cutting the ore. A few small crystals of galena have been found with some of the sphalerite. The concentrate also contains 0.02 per cent of cobalt, but no nickel. The source of the cobalt has not as yet been recognized.

Molybdenite has been noted as very thin films along small fault planes in the ore.

Four hundred feet north of the North orebody, at the contact between fine-grained slaty tuffs and coarse-grained tuffs or sediments, is a highly contorted band, three feet wide, of friable calcite and graphitic material. It forms an easy passage-way for surface water. For forty feet north of this band, the slaty, sheared, carbonaceous tuff contains much graphite and about 30 per cent of marcasite, and in one place a solid body of marcasite nine feet wide. The mineral is in coarse, globular or botryoidal masses, contains no copper or gold, and has no connection with the mineralization that formed the Beattie orebodies.

Other Deposits in Duparquet Township

Donchester Mines, Limited

Donchester Mines, Limited, owns a large, irregular group of claims adjoining the property of Beattie Gold Mines on the east. Up to the present, there has been no extensive exploration of the Donchester ground, but diamond drilling carried out in 1929 and 1931 just east of the Beattie boundary intersected the narrow eastward continuation of Beattie's North orebody (O'Neill, 1934, p. 100).

Central Duparquet Mining Company, Limited

The property of the *Central Duparquet Mining Company* adjoins that of Donchester Mines on the east. It was operated by the *Duparquet Mining Company* until 1936 and by the *Dumico Gold Corporation* until 1940. No. 3 shaft, from which most of the development has been carried out, is about 1⅔ miles a little south of east of the Beattie main shaft, and 2,000 feet west-northwest of the centre point of Duparquet township (O'Neill, 1934, pp. 101-104; Banfield; Ross, 1939, pp. 10-11).

No. 3 shaft is sunk in a body of syenite porphyry that lies at the north margin of the belt of Temiscamian-type sediments. Actually, there are two or more types of porphyry here, which Banfield distinguishes as: 'old porphyry', equivalent to the Beattie syenite porphyry; dykes of porphyry with large plum-like phenocrysts of feldspar; and a still younger 'porphyritic porphyry', which is closely similar to the Beattie 'lath porphyry'. There is a marked progressive increase in total alkalies, and a relative increase of potash over soda, from oldest to youngest of these three porphyries.

Four hundred feet northwest of the shaft is a quartz diabase dyke, forty feet wide, which strikes northeasterly. This is the youngest rock type in the district.

The bulk of the ore occurs in a shear one to five feet wide in silicified porphyry containing fine grained, disseminated pyrite and arsenopyrite. Mill tests show that the ore is almost identical with the Beattie ore. The zone has been explored for a length of 1,200 feet and has been opened by extensive workings on the 300-, 450-, and 750-foot levels, with some work on the 600-foot level.

In 1939, it was reported that this work had indicated approximately 135,000 tons of ore averaging 0.19 oz. gold per ton. On the 750-foot level, over 400 feet of the explored part of the zone is ore.

Vaughan Claims

The *Nipissing Mining Company* did a considerable amount of trenching and sank many pits to bed-rock on these claims at a point about one mile east of the centre-line of Duparquet township, where a small boss of quartz porphyry intrudes the Temiscamian-type beds at the south margin of the belt of these rocks. No gold assays of commercial grade were reported (O'Neill, 1934, p. 105).

Ottman Gold Mines, Limited

The claims of *Ottman Gold Mines, Limited,* formerly known as the Macdonald group, are immediately east of the property of the Central Duparquet Mining Company. Up to 1939 much surface work and about 8,000 feet of diamond drilling had been carried out to investigate gold occurrences in a feldspar porphyry boss and associated dykes which intrude Keewatin-type greenstones. The mineralization of interest resembles somewhat that of the Beattie mine, but, so far, no commercial orebodies have been found (O'Neill, 1934, pp. 104-105).

Duquesne Mining Company, Limited

The *Duquesne Mining Company, Limited,* controls a large block of ground having an east-west length of approximately six miles astride the Duparquet-Destor township-line. This ground is the consolidation of groups which formerly were owned by *Fleming Thompson Gold Mines, Limited, Galatea Gold Mines, Limited,* and the *Del Rio Mining Company, Limited* (Buffam, pp. 102-104).

Up to the end of 1939, upwards of eight miles of trenching and stripping, and over 60,000 feet of diamond drilling, were reported to have been done on the property. Heavy overburden has hampered exploration considerably.

The east-west contact between Temiscamian-type sediments and Keewatin-type rocks to the south of them lies within these claims, and bodies of quartz porphyry are intruded along this contact. The porphyry is sheared, and gold-bearing shoots of possible ore grade have been reported along three of the shears. The mineralization on the Galatea fraction is of the Beattie type.

DESTOR TOWNSHIP

As already noted, the ground held by the Duquesne Mining Company extends eastward from Duparquet into Destor township. Elsewhere in Destor, exploration has revealed the presence of gold mineralization in a number of places, but, up to the present, no commercial concentration of the metal has been discovered. In general, the mineralization occurs in shear zones in Keewatin-type volcanics and in and along the margins of fine grained porphyry dykes that cut them, and consists of sparsely distributed, very fine pyrite, chalcopyrite, arsenopyrite, and a little gold. In a few places, gold has been reported in quartz veins carrying a sprinkling of pyrite and chalcopyrite. Following are some of the occurrences that have been explored to some extent by surface work or diamond drilling (O'Neill, 1934, map No. 280; Bannerman, map No. 401).

Range VII, 3,000-4,000 feet east of the west boundary of the township. Sparse mineralization in quartz porphyry dykes that intrude older gabbro.

Range V, three to five miles east of the west boundary of the township.

About a mile and a quarter south of Lépine lake, near Macamic road and Beattie railway. Pyrite, enclosing specks of chalcopyrite and arsenopyrite, occurs in silicified and carbonatized shear zones at and near contacts between porphyry and Keewatin-type volcanics.

Range IV, lot 42. Gold-bearing quartz veins, 15 inches or less in width, fill tension fractures in quartz diabase which intrudes Keewatin-type lavas. The veins contain pyrite, minor chalcopyrite, and, locally, a little galena and sphalerite.

Range III, south part of lots 41 and 42. Shear zones up to 50 feet in width in andesitic lavas contain fine-grained sulphides, chiefly pyrite. Assays are reported to have shown the presence of gold.

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THE FOUR TOWNSHIPS EAST OF THE DUPARQUET BELT

Geology

Very little mineralization of interest and none of economic importance has been uncovered in the townships of Aiguebelle, Manneville, Villemontel, and Figuery, which lie successively east of Destor. There are extensive areas of outcrop in Aiguebelle (except in its northern part) and in the adjacent west part of Manneville. In west-central Aiguebelle and eastern Destor, the rocky Abjévis hills rise to heights of 500 feet above the main rivers of the district. Gravel beaches high on the slopes of these bare, wave-washed hills mark the shore line at various stages in the life of post-glacial lake Barlow-Ojibway. At lower levels are extensive plains mantled by the sands and clays that formed the bed of this now extinct lake.

Aiguebelle and Manneville townships are almost wholly underlain by volcanics, predominantly of andesitic type. Despite close folding, the rock is remarkably massive. Along the south boundary of these townships, however, the volcanics are flanked by older, conformable sediments. Similar sediments, striking southeasterly, cross the northeast corner of Manneville and some are exposed farther east in the township, near Villemontel.

These two townships are almost devoid of intrusive rocks, with the exception of a very occasional dyke. There is, however, a small boss of granite in southeastern Manneville, and two large 'later diabase' dykes, with northeasterly strike, cross the township. A small boss of quartz diorite intrudes the volcanics in the northwest part of Villemontel, and there is a small granite mass in the southeast part of this township and others in Figuery. A mass of serpentinized peridotite, containing in places the usual small veinlets of asbestos, crosses the north boundary of Villemontel.

There is very little shearing in the rocks of this region.

Mineral Deposits

Along the shore of Loïs lake, at the north boundary of Aiguebelle township, some rusty weathering carbonatized bands in the volcanics contain sparse sulphide mineralization, but, so far as is known, there is no accompanying gold.

In the southwest corner of Aiguebelle, near the westerly flowing Paré creek and presumably close to the Destor fault, a little disseminated pyrite occurs in a feldspar porphyry dyke cutting coarse conglomerate. Assays have shown only a negligible content of gold (James and Mawdsley, p. 123).

In Manneville township, on lots 23 to 25, range II, some surface work has been done on a ridge of strongly carbonatized volcanic rock north of Kinojévis river, but nothing of economic importance was found (Cooke *et al*, pp. 276-278; Ambrose, p. 45). The ridge is some 400 feet wide and strong shearing is evident along its flanks. The altered rock is now a mass of iron-magnesium-lime carbonate (ankerite), coloured green in places by flakes of chrome mica (fuchsite), and cut by numerous irregular veinlets of quartz. Small quantities of pyrite are present and low assays for gold are reported.

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AMOS-DUVERNY-BARRAUTE DISTRICT

The district here considered consists of the six townships whose relative positions are as shown below. The Canadian National railway crosses the area from the southeastern corner of Barraute to central Trécesson, and the town of Amos is in Figuery township, just south of Dalquier.

Trécesson	Dalquier	Duverny	Lamorandière
[Villemontel]	[Figuery]	Landrienne	Barraute

These townships are underlain by Keewatin-type volcanics, chiefly 'greenstones' but with some associated tuffs and flow breccias. Bounding these in the extreme north of Lamorandière township, eastward from Castagnier lake, are Temiscamian-type sediments. Intruding the volcanics in various places are olivine gabbro and quartz gabbro dykes, and in two places they are cut by stocks of granite. One of these trends southward on either side of the Trécesson-Dalquier boundary, being the narrow southern lobe of a mass which is much wider to the north of these townships. The other is a smaller body which occupies much of the southwestern quarter of Duverny and extends westward for a short distance into Dalquier. Gold-bearing mineralization is associated with both stocks, and particularly with the smaller one.

In Duverny township, shearing with a northwesterly trend and steep dip is a marked structural feature. North-northeast faults are prominent in the southern part of the township, and shears having this or a more north-easterly direction are common in the northern part. On the other hand, in eastern Landrienne and in Barraute, there are two prominent shear zones which have a west-northwest trend but dip in opposite directions. Northerly striking tension fractures with steep dip are prominent in eastern Trécesson, Dalquier, and Duverny, while in Landrienne and Barraute the fractures of this type are flat lying. The structural features in Lamorandière township are as yet unknown, owing to lack of outcrops.

The shear zones and fractures have afforded passageways for mineralizing solutions, and in places they contain quartz veins, which are not all of the same age. In some of these, pyrite or chalcopyrite, or both sulphides, fill fractures in the quartz. Where gold is present it is, in general, irregularly distributed, and in many occurrences it is seen clearly to be later than both the quartz and the pyrite. That the copper and gold have been emplaced separately is evident from the fact that the copper deposits in Dalquier township contain no gold and, conversely, the gold deposits in this and the other townships contain little or no copper.

No sulphide or other deposits of interest have been found in Lamorandière township, which is almost wholly covered by drift and clay deposits.

Trécesson Township

(See Geol. Surv. Can. Map No. 327*A*)

In the eastern part of Trécesson township, a number of quartz veins, some of them large, occur in north striking fractures in the western part of the stock of granite already referred to that follows the Trécesson-Dalquier boundary line. They have been found at various points between the north part of range III and the north part of range VI. Most of the veins look barren, but gold has been reported in some of them. Similar gold-bearing quartz veins occur on the eastern side of the stock, in Dalquier township.

Dalquier Township

Gold Occurrences

The *Nortrac Mining Company, Limited,* has done a considerable amount of work on a number of gold-bearing quartz veins on lots 12 and 13, range VI, about seven miles north of Amos (Ross, 1938, pp. 9-11). Besides numerous test-pits and trenches, this work included 12,000 feet of diamond drilling in twenty-six holes and the sinking, on one of the veins, of a shaft to a depth of 112 feet with 1,000 feet of drifting and cross-cutting at the 100-foot level.

The four most important veins, known as the Gold Star, Shaft, Goyette, and No. 9, have surface widths of, respectively, 26 feet, 4 to 5 feet, 5 feet, and 4 to 20 feet, and are exposed for lengths of 300 to 900 feet, and there are several others of lesser width and length. In general, they strike within 30 degrees east or west of north, and they all have steep dip.

The Gold Star vein cuts silicified greenstone, but all the others are in, and within half a mile of the margin of, the granite stock that occupies the western part of the township. The vein material is quartz, usually milky, through which pyrite is disseminated. Tellurides have been reported in some of the veins, and No. 9 contains a little scheelite. Where free gold occurs, it is usually high in silver content. The best assays are reported from sections of the veins where the rock is highly epidotized.

About a mile and a half southeast of the shaft, sheared chloritic volcanics are replaced over a width of four to six feet by massive sulphides, chiefly pyrite, and are cut by several veins of smoky quartz. Pyrite with some associated sphalerite lines fractures in the quartz and is disseminated through the schists over a zone that has been exposed in a few trenches for a length of 250 feet and a width of 200 feet. Assays of material containing about 12 per cent pyrite are reported to have yielded 0.1402 oz. gold per ton.

Colonial Mines, Limited, whose property comprises lots 10 and 11, ranges VI and VII, adjoining Nortrac on the east, have explored several gold-bearing quartz veins, including the eastward continuation of the Nortrac No. 9 vein, in test-pits and by diamond-drill intersections (Ross, 1938, p. 11).

The *Kongor Mining Corporation* has done some surface exploration on lots 7 and 8, range VI, west of the Colonial property. A brecciated, drusy quartz vein cutting the granite has been exposed in four test-pits over a length of 1,500 feet. The vein varies in width from eighteen inches to six feet and in general appears barren, but in three of the pits the quartz contains occasional grains of pyrite (Ross, 1938, p. 11).

On the *Arthur Lake (Loring) Group* of claims, in the north part of lots 14 and 15, range III, a quartz vein in fine grained, basic, volcanic rock has been explored over a length of 400 feet. The vein, which averages two feet in width, strikes N.80°W. and dips at about 75° to the south, and is bounded on its northern side by a basic dyke. It is mineralized with chalcopyrite, and assays from a 'trace' to 0.04 oz. gold per ton are reported (Ross, 1938, p. 11).

Copper Occurrences

Oremont Mines, Incorporated, acquired, in 1937, a group of claims in range I, immediately northwest of the town of Amos, which had originally been staked in 1924. The claims cover the contact between the granite stock and Keewatin-type greenstones, the latter chiefly andesite. Outcrops of both granite and greenstone are plentiful on the higher ground, but contacts are usually obscured by drift. The work done on these claims has exposed some twenty quartz veins occupying fractures in the granite and sparsely mineralized in places with chalcopyrite (Ross and Asbury, 1939, pp. 28-29).

Jay Copper-Gold Mines, Limited, did a considerable amount of underground work on their property in range II during the years 1926-28, and in 1927 made a test shipment of thirty-two tons of ore containing 5 per cent copper and 4 oz. silver per ton. The shaft is in the centre of lot 44 and has a depth of 518 feet, with levels at 100 foot-intervals. At the time operations were suspended early in 1929, more than 3,000 feet of drifting and crosscutting had been completed, chiefly on the 200- and 500-foot levels, as well as 2,000 feet of diamond drilling from the 500-foot level.

The mineralization of interest is in a shear zone striking N.50°W. and dipping 85 degrees northeast. The quartz porphyry wall-rock is converted to a sericite schist in the more intensely sheared sections, and along these are narrow, irregular bodies of white quartz, with more or less scattered filaments and bunches of chalcopyrite distributed over a maximum width of eight feet. At the surface, the ore shoot was seven feet wide and seventy feet long. It was encountered on all the levels, but on the 500-foot level it was found to be very narrow (Dufresne and Taschereau, p. 152; Taschereau, p. 129).

North Country Mines, Limited, have investigated copper mineralization of the same type as that on the Jay Copper property on their claims half a mile west of the latter's shaft (G.S.C. map 327*A*).

Duverny Township

General Note

Although occurrences of gold had been reported in Duverny prior to 1934, it was not until that year, when the Fontana and Claverny deposits were discovered, that general interest in the township was aroused and systematic prospecting commenced. This resulted in numerous discoveries being made, particularly in the western part of the township, and a great deal of money and effort was expended in their development. However, the results, on the whole, proved disappointing and, by 1938, exploration had practically ceased. Extensive areas of muskeg, drift, and sand made prospecting, and also geological mapping, difficult. Such outcrops as occur are localized and not numerous.

For the most part, the township is underlain by steeply dipping Keewatin-type volcanics of intermediate to acidic composition, with some associated fragmental equivalents. Two axes of folding have been inferred: an anticline striking east-southeast across range-line VIII-IX at lot 45; and a syncline striking east-west in range III from lot 35 to the east boundary of the township. A stock of granite, which occupies most of the southwest quarter of the township, is intruded across the synclinal axis. The granite is in places much carbonatized, as also are the sparse outcrops of volcanics for three miles north of the stock. Such structural determinations as have been possible indicate the presence of faults and shear zones trending 20° east of north, and 25° to 70° west of north, and some tension fractures striking 15° east of north (G.S.C. map No. 530*A*).

Most of the deposits of interest appear to be associated with the northwest shearing, in which, however, much of the gold may be present in the closely associated northerly striking tension fractures.

The dissimilar trends of the quartz veins may indicate that they are not all of the same age. The sulphides, at least in part, are later than some, if not all, of the quartz. The gold is very definitely later and, in high-grade specimens, can be seen in fractures in the quartz.

The widespread occurrence of metallic mineralization, often in spectacular though, as presently known, small concentrations, will continue to attract attention to this township.

Mineral Occurrences

Reynolds Quebec Gold Mines, Limited.—This property, which was formerly operated by Grenadier Gold Mines, Limited, is in the northwest quarter of the township. Gold-bearing quartz veins occur in an east-west shear zone and in related north-south tension fractures in the granite, chiefly on lots 18 and 19 in the vicinity of range-line VII-VIII. The occurrences have been explored by trenching and by 5,000 feet of diamond drilling. Free gold, erratically distributed, is common, and interesting gold assays are reported, but all the veins so far found are narrow and short (Bell, p. 75).

Central Duverny Gold Mines, Limited.—Work on this property has been confined chiefly to lot 27, range VII, where extensive trenching has exposed a series of quartz veinlets occupying tension fractures in the granite. Some diamond drilling also has been carried out. The fractures strike N.15°-25°E. and occur in three zones which, at the south, are separated by about 50 feet of granite, but tend to merge toward the north, in which direction they persist for 600 feet. Individually, the zones have widths of 5 to 15 feet and average more than 10 feet. The quartz veinlets are commonly less than one inch, and rarely as much as six inches, wide, and comprise 10 to 20 per cent of the zone as a whole. Pyrite, in disseminated crystals and filling fractures, forms up to 15 per cent of each zone. Gold, and a little sphalerite, are often visible in the vein quartz. A bulk sample of the ore, assayed in the ore dressing laboratories of the Bureau of Mines, Ottawa, gave gold 0.125 oz., and silver 0.04 oz., per ton. Assays reported by the Company of 2.5- to 3.1-foot lengths of drill core ranged from 0.12 to 0.18 oz. gold per ton (Ross and Asbury, pp. 36-37).

Duverny Consolidated Gold Mines, Incorporated, have explored, by trenching and some diamond drilling, a number of mineralized quartz veins on their property in ranges V and VI. The claims are underlain by volcanics of intermediate to acidic composition which are intruded by small porphyritic granite dykes. Carbonatization of all the rocks is locally intense and they are generally sheared.

About 2,000 feet south of range-line VI-VII and near the west boundary of lot 11, a northwesterly striking shear zone in the volcanics contains several veins and stringers of quartz, mineralized with pyrite and a little chalcopyrite. It has been exposed in cross trenches over a length of 300 feet and has been explored at depth by two diamond-drill holes. A grab sample from one of these veins gave a high assay for gold.

About 1,000 feet to the southwest, on lot-line 9-10, a shear zone in the volcanics, striking N.72°E., has been exposed at intervals over a length of 110 feet. It is thirty feet wide and is well mineralized with pyrite and pyrrhotite, with which is associated a little chalcopyrite. A grab sample yielded a 'trace' in gold and 0.2 per cent copper. Other occurrences, of varied gold tenor, have been found 1,500 feet farther south (Ross, 1940, p. 27).

Similar mineralization in sheared and carbonatized volcanics on lot 40, range VII, and on lot 53, range VIII, has been investigated by, respectively, *Duverny Gold Fields, Limited,* and *Sonia Duverny Gold Mines, Limited.*

Fontana Gold Mines, Limited.—This property, comprising parts of lots 12 to 21, ranges V and VI, Duverny township, is about ten miles northeast of Amos. It is underlain by rocks of the granitic stock, which border the volcanics on the south. Extensive trenching and test-pitting has exposed several silicified and carbonatized shear zones in the intrusive rock, and, in these, numerous milky and ferruginous quartz veins and stringers mineralized with pyrite and minor amounts of chalcopyrite, galena, sphalerite, and, rarely, arsenopyrite. Visible gold is present in much of the vein material and is reported also in the mineralized wall-rock. One or two of the veins are in places as much as five feet wide, but in general their width is less than one foot, and many of them are mere stringers. Some have been exposed for lengths up to 200 feet. Many of the veins occupy tension fractures which are more or less at right angles to the trend of the shearing. The mainshear zone strikes N.52°W. and dips steeply to the northeast. It has a width of 38 feet and, on the Fontana property, a length of 590 feet. Four other zones of shearing, two of which have a northeasterly trend, have been exposed by trenching. These, also, contain narrow mineralized quartz veins or groups of stringers (Ross and Asbury, pp. 34-35).

Besides the extensive surface exploration, work on the property has included more than 5,000 feet of diamond drilling and the sinking of a shaft to a depth of 300 feet, with 1,200 feet of lateral work on two levels. The underground work is reported to have yielded disappointing results, and operations were suspended late in 1939.

Claverny Gold Mines, Limited.—This property lies immediately east of Fontana and has a similar geological setting. Four prominent shear zones, trending N.70°W., cross the property. One is in the Keewatin-type rocks. The others are in granodiorite, one of them being the continuation of the main shear zone on Fontana ground. These zones are 500 to 1,000 feet apart, range in width from 7 to 15 feet, and are traceable along their trend for 1,000 to 1,300 feet. They contain quartz veins, some of them gold-bearing and mineralized with pyrite (chiefly) and chalcopyrite, and, more rarely, sphalerite and galena. The majority of these veins, which for the most part are one to three inches wide, occupy tension cracks or subsidiary fractures whose trend is approximately at right angles to that of the shearing. In addition, upwards of two dozen quartz stringers, one to two inches wide, have been found cutting the granodiorite elsewhere. Besides stripping and trenching, several of the veins have been explored by diamond drilling, and on one of them an inclined shaft has been sunk to a depth of 320 feet (Ross and Asbury, p. 35). A 50-ton mill was installed early in 1939 and by September of that year it had treated about 700 tons of ore and concentrates for a recovery of 162.5 oz. gold (Taschereau and Herring, pp. 71-72).

Duver Creek Gold Mines, Limited, have investigated a number of gold-bearing veins on their property, which lies east of the northern part of Claverny. The veins cut sheared and carbonatized granodiorite and have been found principally in lots 27 and 28, range V.

About three-quarters of a mile east of the Claverny shaft, near lot-line 28-29, one thousand feet south of range-line V-VI, trenching has exposed nine or more north-south quartz veins for lengths of 40 to 450 feet. They range in width from a few inches to three feet and are sparsely mineralized with fine grained pyrite. The widest of these veins has been traced for 130 feet and a chip sample across a 2-foot width assayed 0.14 oz. gold per ton.

About 400 feet west of this vein, several quartz stringers occur in a shear zone which strikes N.50°W. and dips 65 degrees northeast. They are exposed over a length of 35 feet across a width of 5 feet and are mineralized with pyrite, some chalcopyrite, and occasional grains of sphalerite.

West Duverny Gold Mines, Limited, whose property lies immediately south of Fontana ground, has explored a shear zone in granodiorite on the south part of lots 15 and 16, range V, about a mile southwest of the Fontana shaft. The work completed to the end of 1938 included extensive surface trenching, a geophysical survey, and over 6,000 feet of diamond drilling.

Fifteen veins are reported to have been uncovered in the granite or granodiorite near its contact with Keewatin-type volcanics. The shear zone, which has a northwesterly trend, has been traced for a length of 1,000 feet across the south part of lot 15 and, following 1,000 feet of muskeg, what is probably the same shear continues for 400 feet across the south part of lot 16. Mineralized quartz veins of interest have been found in the shear in both lots. A gold-bearing vein is reported in the granodiorite about 1,000 feet northeast of this zone.

La Compagnie Minière Franco-Canadienne, Ltée.—The property of this Company is in range II, near the southwest corner of the township. A gold-bearing quartz vein cutting granite near the southern margin of the stock has been explored by surface work, 3,000 feet of diamond drilling, and, underground, from an inclined shaft sunk on lot 8 to a depth of 110 feet. The vein or series of lenses, striking north-south and dipping 70 degrees east, has been exposed on surface for a length of 100 feet, where it has a width of two feet. The mineralization, including the gold, is very patchy. Other quartz veins or lenses with the same strike have been found on the property (Taschereau, 1936, p. 63; Bell, pp. 75-76).

Ranic Mines, Limited, whose property adjoins, on the north, the western half of the Franco-Canadienne holdings, has done some surface work in lots 3 to 5, range III, where veins, reported to be gold-bearing, cut the granite approximately two miles from the south margin of the stock.

Landrienne Township

South Part of Lots 8 and 9, Range IV.—On these claims, known locally as *La Mine d'Or Abitibi,* forest fires and some stripping have exposed Keewatin-type volcanics, chiefly andesite, which are slightly sheared in a direction N.80°E., with dip 60° north. Along two zones about fifty feet apart, the rocks are much carbonatized. The southern zone has a width of 300 feet, and in its northern part, over a width of 80 feet, it is cut by quartz veins which make up 7 to 15 per cent of the rock of the zone. There are three sets, or systems, of these veins. Two sets have a northeasterly strike; the third, which is cut by the others, strikes N.37°W. The veins of this older set are contorted, half an inch to twelve inches wide, and, in addition to quartz, contain 20 to 30 per cent chlorite, 6 per cent reddish carbonate, 2 per cent tourmaline, and 1 per cent pyrite (chiefly) and chalcopyrite. The later veins are similar but contain less chlorite and tourmaline and have a maximum observed width of five inches. The carbonatized wall-rock in the vicinity of the veins contains about 5 per cent pyrite. Results of any assays that may have been made of the material are not available. No body of intrusive rock has been noted in the vicinity of the mineralized zone (Cooke *et al.,* pp. 282-283).

Randall Mines Corporation (Mines Development Corporation, Limited).—The Randall property is adjacent to the east boundary of the township, in ranges IV and V, and is crossed by the line of the Canadian National railway. The discovery, in 1924, of large boulders of quartz carrying visible gold led to intensive prospecting in that and succeeding years, and lenses and irregular masses of quartz containing chalcopyrite and pyrite were discovered in strongly sheared and carbonatized volcanics (dacite) on lots 59 and 60, range V, about a mile eastward from Fisher station. These occurrences were explored by *Fisher-Quebec Gold Mines, Limited,* who reported high assays for gold in both the chalcopyrite and adjacent schist (Cooke *et al*, pp. 284-286).

Later work was carried out by the *Randall Mines Corporation* and the *Mines Development Corporation* on deposits which had been discovered in the northern part of lots 55 and 56, range IV, about half a mile south of Fisher. A number of gold-bearing veins were found here in sheared, carbonatized, and chloritized volcanics, chiefly of andesitic composition, which are intruded by dykes of diorite, porphyry, and aplite. These occurrences have been explored by trenching, prospect pits, and diamond drilling, and in 1933 a shaft was sunk on the main vein. It was eventually deepened to 600 feet, with four levels at 125-foot intervals, the first at 200 feet. Some 3,000 feet of lateral work was completed on these levels, This vein, which, like the shearing, has a northwesterly trend and a steep dip to the northeast, varies in width from two to six feet and consists of white quartz mineralized with scattered pyrite crystals, which also are present in the chloritic wall-rock. Free gold, and also tellurides, have been reported. In the mine workings, the vein has been found to be lenticular in habit, and to the northwest of the shaft its continuity is interrupted by a number of faults. It has been stoped for 125-foot lengths on the 200- and 325-foot levels, and on the former horizon it was reported to contain an average of $6.00 in gold per ton across a width of twenty inches over a length of 100 feet. At a depth of 360 feet in the shaft, the andesite is in contact with diorite, and below that depth both rocks are encountered in the lateral workings, with diorite predominating at the lowest, 575-foot, level. The diorite is cut by porphyry and aplite dykes. Other quartz veins and lenses were encountered in the mine workings.

In 1936, a mill with a rated capacity of 50 tons per day was installed. It was operated intermittently until the end of 1937, when all operations at the property were suspended (Ross and Asbury, pp. 37-38).

Lot 35, Range II.—In the northern part of this lot, northwesterly trending shear zones in a large outcrop of rhyolite are heavily mineralized with fine grained pyrite. No assays of the material are available. There are four zones of shearing, which, from north to south, have widths of 20, 5, 20, and 40 feet, and they have a known length of upwards of 200 feet. No intrusive rocks are exposed in the immediate vicinity, but the northern margin of the large body of granite which occupies almost the whole of LaCorne township is about two miles to the south (Cooke *et al.*, p. 284).

Barraute Township

South Half of Lot 46, Range VI (*Groslouis claims*).—These claims are underlain by tuffs, volcanic breccias, and flow rocks of both intermediate and acidic composition which strike N.65°W. and have steep dip. Intruding these, with northerly strike, is a dyke of olivine gabbro, 200 feet wide.

Trenches have exposed two shear zones, 300 feet apart, in the volcanics. They strike east-west and dip steeply to the north. Over a width of 70 feet in the north zone and of 30 feet in the other, the greenstones are carbonatized and silicified and contain veins of quartz, and both the quartz and the schist are mineralized with pyrite (chiefly) and chalcopyrite. A chip sample across two feet of quartz and schist in the south shear zone assayed $5.00 in gold per ton (Ross, 1940, p. 3).

Similar mineralized shear zones have been exposed in trenches in the south part of lots 48 and 49, range VI. Chip samples from a pit on lot 49 gave negligible assays for gold, and the highest of several assays for copper was 0.23 per cent (Ross, 1940, pp. 3-4).

La Mine d'Or Vénus, Consolidée.—This property is in the southwest quarter of the township, about twenty-five miles southeast of Amos. The Canadian National railway passes through the central group of claims.

A number of gold-bearing quartz veins have been exposed in trenches and test-pits, and some of them have been explored by diamond drilling and, more extensively, by underground workings from two shafts—the South shaft, on lot 14, range II, and, three-quarters of a mile to the north-east, the North shaft, in lot 17, range III, about 100 feet south of the railway. Both are 200 feet deep, with lateral workings at that level. From the bottom of the North shaft, an inclined winze was sunk to the 300-foot level. In 1930, a 25-ton test-mill was installed and was in operation for several months. All work at the property was suspended in 1932.

The property is underlain by Keewatin-type rocks, chiefly andesite but with some rhyolite, and, in the North shaft area, some acidic porphyritic rock which is intrusive into the andesite but is probably of Keewatin age. Apart from this, no intrusive rocks have been encountered on the property. In both the North and South shaft areas, a number of quartz veins have been found in shear zones in the greenstones.

South Shaft Area.—The rocks are schistose, with shear planes striking N.68°W. The shearing, however, is of two types, dipping about 60° north-east in one type and 50° southwest in the other. Quartz veins occur in both types, but the only veins of importance found to date are in the southward dipping shears, in which they commonly cut across the planes of shearing. These veins are younger than those in the northward dipping shears. Adjacent to the veins, the greenstone is carbonatized, silicified, and contains pyrite.

The veins, or vein systems, consist of a series of narrow, more or less parallel, veins, stringers, and lenses of white quartz, through which needle-like crystals of tourmaline are usually distributed. Metallic minerals present are pyrite, minor chalcopyrite, and occasionally visible gold. One vein (No. 25) has been traced on surface over a length of 150 feet, with a width of eight inches near its eastern end but much narrower toward the west. Assays over a width of two feet and a length of 100 feet are reported to have returned $8.00 in gold per ton, but sampling of the same vein on the 200-foot level indicated that the gold content is negligible. Another vein (No. 19) was followed in drifts on the 200-foot level for a total length of

200 feet, with thickness ranging from four inches to nearly a foot, but systematic sampling gave disappointing results. No. 24 vein was traced on surface for 55 feet with maximum width of two and a half feet. It would appear that, while high, erratic assays were obtained from some of the veins, their average gold content across mineable widths is low.

North Shaft Area.—The structure here is similar to that in the South shaft area, but in addition to the two types of northwesterly shearing noted there, a third set of shears or joint planes strike N.70°E. and dip 70° northward. The two principal veins, or vein systems, are in shear zones that strike northwest and dip northeast. They are 250 feet apart, one (No. 10) south, and the other (No. 8) north, of the railway.

No. 10 vein has been exposed on surface for a length of 325 feet, and in drifting on the 200-foot level for about half that length. It consists of a series of short lenses of white quartz, one inch to three feet thick, which almost invariably cut across the foliation of the schist. Where cut in the cross-cut on the 200-foot level, the lenses and stringers are distributed over a width of forty feet, in which the proportion of quartz to schist is about one to four. Mineralization, consisting of pyrite, is concentrated for the most part in the schist adjacent to the lenses, the quartz itself, and the schist elsewhere, containing but little pyrite. The pyrite is in well-formed cubes which may be of considerable size, and some are coated with a film of bornite. Native gold also occurs as a film coating pyrite crystals, where it seems to have been precipitated as the last phase of the mineralization. It has been found, however, that only very restricted portions of the pyritized border zone carry appreciable amounts of gold. It is reported that assays of fourteen samples taken from a prospect pit averaged $12.50 in gold per ton, but that a number of channel samples from the underground workings averaged less than $3.00 per ton.

No. 8 vein has been traced on surface for a length of 140 feet and on the 200-foot level it has been drifted on for 450 feet. It was on this vein that the winze was sunk to the 300-foot horizon. The vein system is apparently much narrower than No. 10, but in all other features the two are similar. An average of $6.00 in gold per ton is reported from assays of ten channel samples taken across widths of three feet (Bell, pp. 39-51; Tasehereau, 1932, p. 105, 1933, pp. 91-92).

Lots 8, 9, and 10, Range II (Cummings-Trudel Mining and Development Company, Limited).—On these lots, which are not far west of the Venus south shaft, a number of narrow gold-bearing quartz-tourmaline veins, similar both structurally and mineralogically to those on the Venus property, have been investigated. Some high gold assays are reported, but commercially valuable concentrations of gold have not so far been found (Cooke *et al.*, p. 286; Tasehereau, 1933, p. 91).

Southern Part of Lots 47 and 48, Range II (Vallée Claims).—Some surface work and diamond drilling has been done on these lots along a fractured zone in porphyritic granodiorite. The zone has been traced for a length of 1,200 feet with average width of three feet. Over a length of 65 feet it is fairly well mineralized with pyrite, and some interesting gold assays have been reported from samples taken along this section (Taschereau, 1934, p. 112). The granodiorite in which the mineralization occurs is presumably near the south margin of a small boss of this rock which intrudes the Keewatin-type volcanics and is exposed in a few outcrops in range II from lot 42 to lot 49.

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DISTRICT BETWEEN DUPARQUET AND ROUYN BELTS

General Note

The district here considered comprises a chain of five townships extending eastward from the Quebec-Ontario boundary. From west to east, these are Montbray, Duprat, Dufresnoy, Cléricy, and La Pause. Duparquet township adjoins Duprat on the north, and Rouyn township is immediately south of Dufresnoy. In the main, these townships are underlain by Keewatin-type volcanics, but closely associated with these are two wide belts of sedimentary rocks, one extending northwestward through La Pause and Cléricy townships and the northeast corner of Dufresnoy, the other, with westerly trend, closely adjacent to the north border of La Pause and Cléricy. There are no Temiscamian-type sediments in any of these townships.

Intruding these volcanic and sedimentary rocks are a number of granitic bodies, the three largest being the Flavrian Lake mass occupying about twenty-five square miles in southern and central Duprat, the Dufault Lake mass, about the same size, in southwestern Dufresnoy, and a wide dyke which extends northwestward across the southwest quarter of Cléricy and for a short distance into Dufresnoy. Smaller bosses, sills, and dykes of generally less acidic rock of the type commonly known as 'older-gabbro' are widely distributed, particularly in the three western townships, as also are later gabbro and diabase ('younger diabase') dykes.

Montbray Township

Oriole Mines, Limited.—This Company has investigated two groups of claims near the centre of the west boundary of the township, on which there are several zones of sulphide mineralization. One of these, in rhyolite at its contact with intrusive diorite, has been traced for a length of 500 feet and has been explored in three test-pits. These expose chalcopyrite, both in massive patches and disseminated, with a minor amount of pyrrhotite, across widths up to ten feet. Work on the property, carried out in 1927 and 1928, included a geophysical survey and some 2,000 feet of diamond drilling (Dufresne and Taschereau, pp. 109-111; Taschereau, 1929, pp. 83-85).

Robb-Montbray Mines, Limited.—The claims of this Company are in range II, near the southeast corner of the township. They are underlain by rhyolite flows which are cut by irregular masses and dykes of quartz diorite. Two gossan-covered shear zones in the rhyolite, striking northwest and 400 to 600 feet apart, have been investigated, but only the southern one has been found to contain mineralization of interest. Along this zone, which is about 2,000 feet long and up to 600 feet wide, the rhyolite is brecciated, silicified, and chloritized, and is intruded by quartz diorite dykes which, however, are not brecciated. In three places along the zone, where the rhyolite has been converted into a rock consisting almost entirely of chlorite, chalcopyrite bodies have been formed by replacement of the chlorite. The deposits have been explored underground from a shaft.

Deposit No. 1—750 feet southeast of the shaft—consists of disseminated chalcopyrite, with some small lenses of massive chalcopyrite, principally in a zone 100 feet long and 20 feet wide. Its average tenor at the surface is $1.50 in gold per ton and 2 per cent copper, but diamond drilling indicated that the grade at depth is somewhat lower than this.

Deposit No. 2—400 feet slightly north of west of the shaft—appears to be pear-shaped, with a depth of 80 feet and a width, near the bottom, of 50 feet. Assays gave an average of $0.80 in gold per ton, and 2.5 per cent copper.

Deposit No. 3—about 400 feet west of the shaft—gave much the highest assays and was more extensively explored than the others by underground workings and diamond drilling. At the surface, it is a zone upwards of 500 feet long and 50 feet wide, carrying disseminated chalcopyrite below commercial grade, but with greater concentration in two places, where assays as high as $21 in gold per ton and 12 per cent copper were obtained. The Company reported that, underground, a number of even higher grade ore shoots were found but that they seldom exceed 15 feet in length and become fewer and smaller with depth.

These deposits are unusual as compared with other sulphide deposits in Western Quebec in that they contain practically no pyrite or pyrrhotite. The gold seems to be mainly 'native', but some is present in tellurides.

In addition to much trenching and the sinking of several test pits, work on the property has included an electrical survey, more than 21,000 feet of diamond drilling, and the sinking of a shaft to 560 feet, with nearly 6,000 feet of lateral work on six levels. This work indicated that the ore occurrences are too small and scattered for profitable mining, and all operations were suspended in 1929 (Cooke *et al.*, pp. 224-227; Taschereau, 1929, pp. 85-86).

Southern Part of Lot 62, Range I.—In 1926-27, *Coniagas Mines, Limited*, prospected a group of claims in the extreme southeast corner of Montbray and in the three adjoining townships. The claims are underlain by acidic and basic volcanics which are intruded by masses of diorite, and sulphide mineralization was found in several places. In Montbray township, the rhyolite along a northwesterly shear zone is highly chloritized and replaced by pyrite and chalcopyrite, some of which is massive. The mineralization is exposed over a length of 150 feet and a width of 10 feet (Cooke *et al.*, p. 227; Taschereau, 1928, p. 115). The gold content, if any, of this ore is not known, but assays of 3 per cent copper are reported.

The Eplett-Metcalfe Mining Company, Limited, did some work in 1927 on their property in range V, at the Montbray-Duprat township line. The claims are underlain by Keewatin-type volcanics, chiefly acidic, which are intruded by a sill of 'older gabbro', and both are cut by a north-south dyke of 'later gabbro', about 75 feet wide. Sulphide mineralization, chiefly chalcopyrite and pyrrhotite, occurs in the 'later gabbro' dyke. In addition to surface work, diamond-drill holes totalling about 2,000 feet were put down on the property, and an inclined shaft was sunk at the margin of the dyke to a depth of sixty feet (Dufresne and Taschereau, pp. 108-109).

Notre Dame Gold Mines, Limited.—This Company did some surface work in 1928 on a group of claims lying on either side of Kanasuta river, at about the centre of the township. On the west side of the river, some shear zones in rhyolite and rhyolite breccia are mineralized with a little pyrite and chalcopyrite, and, on the east side, quartz veins, said to be gold-bearing, occur in a mass of intrusive diorite (Taschereau, 1929, p. 85).

Lots 35 to 39, Range-Line I-II (Fred Thompson Claims).—These claims, on the south and southwest side of Nelson or Colnet lake, are underlain by fine-grained, basic lavas which, on the west shore of the lake, are intruded by a small boss of granite (Nelson Lake granite). Shear zones in the lavas adjacent to the granite contain lenses and stringers of quartz, some of which are mineralized with pyrite (chiefly) and chalcopyrite, and, in places, the adjacent lavas contain as much as 10 per cent pyrite. A quartz vein or lens, more than three feet wide and sparingly mineralized with pyrite, has also been found cutting the granite. No assays have been reported from these occurrences (Ross and Asbury, pp. 3-4).

Duprat Township

Copper Occurrences

Waite Amulet Mines, Limited.—The property of this Company is on either side of the Duprat-Dufresnoy township-line. As the deposits are essentially copper-zinc ores, with only a low content of gold and silver, they are described in the section dealing with the base-metal deposits (see pages 361-383).

Rhyolite Rouyn Mines, Limited.—This Company holds a number of claims in Duprat township to the southeast of Duprat lake, west of the Waite Amulet property. At various times between 1927 and 1939, surface exploration was carried out on the claims and diamond-drill holes aggregating more than 10,000 feet were put down. The chief deposit so far discovered is about 1,000 feet to the east of the northeast end of Fourcet lake, where a north-northwesterly trending fault-vein zone in andesite, from a few inches to twenty feet wide, has been exposed at intervals by stripping and test-pits over a length of 600 feet. The zone consists of a quartz-breccia matrix veined by quartz which, in places, contains disseminated chalcopyrite. The total width of quartz in the zone averages one to two feet, and its chalcopyrite content ranges from *nil* to about 10 per cent. An assay of an average sample of the quartz containing chalcopyrite gave 4.8 per cent copper, with small amounts of gold and silver (Wilson, pp. 136-139).

Bedford Mines, Limited.—This property is in Duprat township, west of Waite Amulet and south of Rhyolite Rouyn Mines. A large amount of trenching and test-pitting, and some diamond drilling, was done on these claims in 1926 by the Consolidated Mining and Smelting Company of Canada. The work was confined chiefly to a northwest trending ridge, consisting chiefly of rhyolite and rhyolite breccia, which in places contains pyrite in scattered aggregates up to six inches in diameter, in disseminated cubes, and in seams and veins up to an inch or more wide. Generally, the amount of pyrite is small, but in three pits it was estimated to form 5 to 10 per cent of the rock. In one of these relatively rich concentrations of pyrite, chalcopyrite and sphalerite in aggregates and zones up to half an inch wide were noted (Dufresne, pp. 122-123; Wilson, pp. 139-140).

Corona Mines, Limited.—These claims, which are near the southeast corner of Duprat township, are underlain by Keewatin-type volcanics (rhyolite and andesite) which, in the western part of the property, are in contact with the Flavrian Lake granite mass. During the years 1926-28, the Company explored the claims by trenching, test-pitting, a geophysical survey, and some 2,000 feet of diamond drilling. Some chalcopyrite and pyrite, chiefly disseminated, was found in narrow fracture zones in the volcanics, but the mineralization was not in sufficient quantity to be of economic interest (Wilson, pp. 140-141).

Coniagas Mines, Limited.—During 1926 and 1927, this Company investigated a group of claims at the southeast corner of Duprat township. The underlying rocks are acidic and basic lavas, cut by quartz diorite (older gabbro) and more acidic intrusives. Sulphide mineralization was found in a number of places and particularly near the corner-post of the township, where a north-south shear zone in rhyolite breccia contains pyrite and chalcopyrite, some of which is massive. The mineralization was exposed over a length of 150 feet with a width of about ten feet. The presence of gold is not recorded (Dufresne and Taschereau, p. 115).

Gold Occurrences

Flavrian Gold Mines, Limited.—This property comprises portions of lots 21 to 28, range I, Duprat township, immediately southwest of Flavrian lake. It is underlain by Keewatin-type volcanics, chiefly andesite and rhyolite flows, which, in the southeast part of the property, are in contact with the Flavrian Lake granite mass. In the southwest, an olivine gabbro (younger gabbro) dyke, 100 feet wide, striking northwest and dipping 60° southwest, cuts rhyolite. On the south side of this dyke, the rhyolite is sheared over a width of six feet and is cut by a quartz vein, one to four feet wide, accompanied by quartz stringers. This vein has been exposed in cross-trenches at intervals of 50 to 100 feet for a length of 500 feet. It is mineralized with pyrite, but assays indicate that the gold tenor is erratic.

What is known as the 'shaft' vein occurs in a shear zone, 10 to 15 feet wide, striking east-west and dipping steeply north. Along this shear is a zone, six inches wide, of clay gouge, evidently representing a strong fault. On the south side of this 'mud seam', a quartz vein one to four inches wide is exposed in trenches for a length of 325 feet, and, over a width up to ten feet, the quartz and adjacent schists are mineralized with pyrite and an occasional speck of chalcopyrite. The zone has been cut at depths of 55 to 110 feet by nine diamond-drill holes, and has also been explored underground from a shaft in lot 25, sunk in 1935 to a depth of 325 feet.'

About 1,500 feet northeast of the shaft, a shear zone in andesite, striking N.60°E. with high dip to the north, has been exposed for a length of 200 feet. Within the shear, the andesite is silicified and veined by quartz across widths up to ten feet. Both the schist and the quartz are well mineralized with pyrite, and visible gold has been reported in the quartz veinlets (Ross and Asbury, pp. 11-13).

St. Jude Gold Mines, Limited.—The property of this Company is in lots 21 to 23, ranges I and II, Duprat township, about half a mile northwest of the Flavrian shaft. It is underlain by andesitic lavas which are cut by irregular masses of gabbro and by dykes of quartz porphyry and lamprophyre. The Flavrian Lake granite mass lies just to the east. Five or more parallel quartz veins, or systems of veins, one to three hundred feet apart, occur in fractures in the andesite in lot 23, near range-line I-II. One fracture has been exposed for a length of 1,200 feet, with quartz, heavily mineralized with chalcopyrite and pyrite, almost continuous along the central 600 feet. The Company reported some very high gold assays from this vein over widths generally less than two feet but in places up to four feet.

To the west and south of these veins, pyrite mineralization was found in several places in closely spaced quartz stringers and in the adjacent silicified andesite. In one of these occurrences, galena and chalcopyrite also are prominent. Gold assays are generally low, but some as high as $9.10 per ton over a width of four feet were reported (Ross and Asbury, p. 13).

Capital Rouyn Gold Mines, Limited.—During 1928 and 1929, this Company investigated two quartz veins cutting granodiorite on their property in Duprat township at the north end of Flavrian lake. One of these veins, which was exposed in a deep trench for a length of fifty feet and a width ranging up to one foot, contains free gold. The other has been traced on surface for a distance of 300 feet. It contains some small lenses of nearly pure chalcopyrite and the wall-rocks are mineralized with disseminated sulphides. A prospect shaft was sunk on this vein and a small amount of lateral work was done at a depth of fifty feet. The ore was found to be of low tenor, however, and operations were suspended (Taschereau, 1929, p. 86; 1930, p. 117).

DUFRESNOY TOWNSHIP

General Note

Dufresnoy township is underlain for the most part by Keewatin-type lavas, chiefly rhyolite and andesite. In the southwest quarter, around and to the north and west of Dufault lake, these are intruded by sills and dykes of diorite and gabbro and by a large body of later granodiorite, and here and elsewhere in the township they are cut by still younger dykes of 'later diabase'. Faulting and related shearing, with diverse trends, is very prevalent, and in some localities the rock is carved into polygonal or wedge-like blocks. Iron and copper sulphides in solutions ascending along some of these faults have been deposited within them or carried to rocks favourable for replacement. For the most part, such sulphide mineralization has been found in brecciated rhyolite. Pyrite is the commonest sulphide, but it may be accompanied by some pyrrhotite, and locally there is an appreciable amount of chalcopyrite or sphalerite, or of both these sulphides. In the deposits that have been found up to the present, gold is present only in small or negligible amount (Wilson, Ambrose).

Copper and Copper-Zinc Occurrences

Waite-Amulet Mines, Limited.—The Amulet and Amulet-Dufault mines of this Company are near the western border of the township. These are essentially copper-zinc mines and are described in the section dealing with the base-metal deposits (see p. 361-383).

McDougall Mines, Limited.—This property is at the west, and close to the south, boundary of the township, south of the Amulet mine. In 1926 and 1927, the Company investigated a number of occurrences of sulphide mineralization by trenching and prospect pits, by diamond drilling, and from an inclined shaft, 120 feet deep, with 850 feet of drifting on the 100-foot level. The following description of the deposits is reproduced from the report by Wilson (pp. 141-142).

"The rocks outcropping in the area consist mainly of Amulet rhyolite and rhyolite flow breccia and the Amulet Hills andesite. A northeasterly trending dyke of quartz diorite crosses the property near the shaft, and dykes of rhyolite (quartz-albite) porphyry and andesite occur in places. The deposits in the property belong to three classes: (1) veins of quartz and chalcopyrite along the northwesterly trending McDougall fault, which cuts off the Amulet rhyolite and rhyolite breccia on the south; (2) mineral aggregates in the rhyolite adjacent to the overlying andesite contact, similar in relationship to ore deposits of the Amulet property; and (3) east-west trending, mineralized shear zones, probably formed along faults subsidiary to the McDougall fault.

"Prospect pits have been excavated at intervals southeasterly from the shaft along almost the entire exposed length of the McDougall fault, a distance of about 2,000 feet. These openings range up to 40 feet long along the fault, 25 feet transverse to the fault, and 10 feet deep. In this distance, wherever the fault is exposed, a zone of veins and brecciated rock dipping 50 degrees to the northeast is present. The vein material consists mostly of quartz, but chalcopyrite in varying degrees of concentration up to almost solid lenticular masses 2 feet wide and 8 feet long is also present. The individual veins of quartz range for the most part from one-half inch to six inches wide. The aggregate width of vein material probably does not average more than two feet, and the total average width of all the zone five feet. Slickensiding was noted in the wall of one of the pits.

"The mineral deposits along the rhyolite breccia-andesite contact, where exposed, consist chiefly of pyrite, disseminated and in aggregates, and chalcopyrite, filling fractures or in aggregates. The vein material in the east-west trending zones of shearing, as along the McDougall fault, consists mainly of quartz and chalcopyrite".

Beaver Mountain Copper Mines, Limited.—This property is at the west boundary of the township, immediately east of the Waite mine (Taschereau, 1931, p 80). There are two groups of claims, to the northwest and south, respectively, of Beaver hill. In the north group, trenching and prospect pits extending over a length of 250 feet have exposed rusty zones in pillowed andesite which contain pyrite, pyrrhotite, and some chalcopyrite, disseminated and in aggregates up to eight inches in diameter. In the south group, fractures in similar rusty andesite contain pyrite. In 1930, about 1,000 feet of diamond drilling was done on this property (Wilson, p. 136).

Newbec Mines, Limited (formerly Norbec Mines, Limited).—This property is in the west-central part of Dufresnoy township, a short distance northwest of Dufault lake. Some surface work and diamond drilling was done on the property in 1925. This work was resumed in 1927 and between that year and 1930 a shaft was sunk to a depth of 270 feet and some 1,300 feet of lateral work was completed on levels at 60, 125, and 250 feet. From the 250-foot level, a winze was put down to 275 feet. In 1930, 278.26 tons of ore averaging 6.74 per cent copper was shipped to the smelter of Noranda Mines, Limited. Operations were then suspended, but some additional diamond drill holes were put down in 1939.

The shaft is sunk in andesitic lavas at a point about 850 feet north of the northern margin of the Dufault Lake granodiorite stock, which here trends east-west, and the same distance west of a dioritic sill, striking N.20°W., which cuts the stock. It is thus in the acute angle between these intrusive bodies. At the point where the shaft was sunk, the volcanics are cut by a fault, trending N.70°E., and the fault fracture for a width of about one foot is filled with chalcopyrite and other sulphides. Between the surface and the 250-foot level, the orebody appears to be pipe-like in form, with very irregular dimensions but perhaps averaging 30 feet by 5 to 10 feet in cross-section. It was found, in the underground workings, that the ore does not continue within the fault. On the 250-foot level it occurs on both sides of, and is cut by, the fault, indicating that the ore fills an earlier fracture with which the later fault more or less coincides.

At several other places on the property, shear and fracture zones in the volcanics contain pyrite and chalcopyrite, and also quartz stringers which are similarly mineralized, and at one place a shaft was sunk to a depth of 100 feet or more on a vein of quartz and sphalerite about two feet wide. Up to the present, however, no large body of commercial ore has been discovered on the property (Taschereau, 1930, pp. 123-124; Cooke *et al.*, pp. 231-233; Wilson, pp. 123-125).

Insco Mines, Limited (subsidiary of the Inspiration Mining and Development Company, Limited).—The property of this Company comprises the southern part of Dufault lake and some adjacent ground in ranges I and II. Development work has included diamond drilling in 1938 and 1939 and a geophysical survey in the latter year. The survey outlined several areas that show magnetic 'anomalies' but all of them are within the portion of the property covered by the lake. Sulphide mineralization has been discovered on some of the islands and assays of material from one or two of these occurrences are reported to have shown the presence, in small amount, of gold (Ross, 1940, pp. 22-23; Ambrose, pp. 44-45, 62-70).

Continental Copper Mines, Limited.—This Company, which was incorporated in 1938, owns two large groups of claims in ranges III, IV, and V, Dufresnoy township, including part of the ground that was formerly held by *Gilbec Mines, Limited,* and the *East Bay Copper Company, Limited.*

The property extends eastward from the large bay at the north end of Dufault lake.

Some development work was done on the Gilbec property during the years 1927-29. This included a considerable amount of stripping and trenching, more than 3,000 feet of diamond drilling, a geophysical survey, and the sinking of a shaft to a depth of 115 feet, with lateral work on the 50- and 100-foot levels. In 1927, a zone, 5 to 15 feet wide, along which there has been replacement of brecciated andesite by chalcopyrite and pyrite, was exposed for a length of 200 feet, and similar mineralization was found on lot 35, range IV, in another zone which had been indicated during the geophysical survey. The rock here is an agglomerate consisting of blocks, up to two feet in diameter, of cherty and porphyritic rhyolite, coarse and fine tuffs, and hornblende diorite, much of it highly chloritized, cut by a network of quartz veinlets, and containing a considerable amount of chalcopyrite and pyrite. It was in this zone that the shaft was sunk, but the underground work failed to encounter similar mineralization to that found on surface (Taschereau, 1929, pp. 95-96, 1930, pp. 122-123; Ambrose, pp. 41-42).

On the former East Bay claims, south of Gilbec ground, surface work and diamond drilling prior to 1930 had revealed four heavily pyritized shear zones in volcanic breccias in lot 37, range III. These zones, with strike N.65°-80°W. and vertical dip, are spaced from 50 to 100 feet apart across a total width of 600 feet and have been exposed for lengths of 200 to 500 feet. Individually, from north to south, they have widths of about 40, 50, 100, and 90 feet. The southernmost zone is just north of the shore of Dufault lake. In 1939, Continental Copper Mines drilled two holes to check high assays for copper that had been reported from the earlier drilling. In one hole, 615 feet north of the lake, sections were found carrying up to 50 per cent pyrite, but the highest content of copper reported was 2.45 per cent over a core length of 13.4 feet. This hole, which was drilled to a depth of 1,012.4 feet, revealed little of interest below 480 feet. The other hole drilled to an inclined depth of over 1,000 feet, also gave disappointing results (Taschereau, 1930, p. 122; Ambrose, pp. 40-41).

MacDonald Mines, Limited.—This property extends eastward from East Bay ground and includes part or the whole of lots 37 to 45, range III, Dufresnoy township. The contact between the east nose of the Dufault Lake granodiorite stock and the Keewatin-type volcanics to the east of it trends north-south across the eastern half of the property, in lot 43, but just south of range-line II-III it turns abruptly west, and a band of the granodiorite, about a quarter of a mile wide, extends westward as far as Dufault lake. A triangular area between this band and the southern margin of the main part of the stock is occupied by volcanics, which thus underlie the east-central part of the property. These rocks are acidic pyroclastic breccias, similar to those on the adjoining East Bay ground. The volcanics east of the stock are massive rhyolite. They are intruded by numerous dykes and masses of diabase and gabbro.

As the result of systematic exploration, by trenching, test-pitting, and about 9,000 feet of diamond drilling, carried out during the years 1937-40, copper, and some gold, mineralization was discovered at a number of places, in both granodiorite and volcanics. On lot 39, near the west boundary of the property, two diamond-drill holes put down at the contact between granodiorite and sheared and brecciated rhyolite encountered pyrite, and some chalcopyrite, mineralization in both rocks to depths of 600 and 700 feet.

A pit sunk in granodiorite at the centre of lot 43 exposes highly fractured rock cut by several quartz veins, the widest about five feet. Over a length of fifteen feet, this vein is heavily mineralized with coarse pyrite, considerable chalcopyrite, some sphalerite, and galena, and the adjacent wall-rock also is well pyritized. The Company reported assays of $4 to $5 in gold per ton from this vein, but that, where cut by diamond-drill holes at a depth of thirty-five feet, results were disappointing.

Farther northward in lot 43, trenching and some diamond drilling in volcanics near their contact with granodiorite disclosed disseminated pyrite in a carbonatized shear zone three to five feet wide. Assays of 4 per cent copper and $2 to $3 in gold per ton across a width of three feet were reported (Ross, 1940, pp. 23-24; Ambrose, pp. 49-50).

Cléricy and La Pause Townships

General Note

(See Volume II, pp. 80, 84, and Figure 8)

A band about 2½ miles wide of sedimentary rocks, chiefly greywacke and slate (Kewagama group), extends northwest from Chassignolle lake, at the centre of the south boundary of La Pause township, to the northwest corner of Cléricy, and a narrower band of similar sediments, trending east-west, closely follows the north boundary of these townships. The area, wedging out at the west, between these bands, and thus including the northeast part of Cléricy and almost the whole of La Pause, is occupied by older volcanics (Malartic group). The rocks on the southern side of the northwesterly trending (Cléricy) band are younger volcanics (Blake River group). These underlie the south half of Cléricy and the southwest corner of La Pause. In Cléricy, they are intruded by a dyke-like body of granitic or dioritic rock (the Cléricy dyke) which crosses the southwest quarter of the township in a northwesterly direction. Cutting all these rocks in a number of places are smaller dykes and sills of various rock types, including 'later diabase'.

Several faults have been mapped in these townships. They are of two types: faults with associated shear zones which approximately parallel the bedding of the rocks, and cross faults. The most important strike fault (the Destor fault) closely parallels, and is a short distance to the north of, the Cléricy band of sediments.

La Pause township is heavily mantled with drift and lake clays, and outcrops are few. In Cléricy, on the other hand, and especially in its southwest and south section, rock outcrop is fairly abundant.

Numerous occurrences of sulphide mineralization, and also of gold-bearing quartz veins, are known in these townships, many of them in shear zones associated with the Destor fault and in, and adjacent to, the Cléricy dyke. Molybdenite occurs in an altered acidic dyke in lot 19, range III of La Pause (Ambrose).

Cléricy Township

Copper Occurrences

Aurel Mines, Limited.—The property of this Company is in the west part of ranges IV and V. It is underlain by Keewatin-type volcanics, chiefly of intermediate composition, which, on the west, are intruded by the granodiorite of the Cléricy dyke. Between 1925 and 1928, a considerable amount of work was done on the property by, successively, the *Archean Mines Development Company*, the *Harvie Mining Exploration Company*, and the *Harvie Mining Company*. In addition to surface exploration, this work included some diamond drilling, the sinking of three prospect shafts, and the driving of an adit. The property then lay idle until 1939, when *Beattie Gold Mines (Quebec), Limited*, made a geophysical survey of an area around one of the shafts and followed this with diamond drilling. The results of this work have not been made public.

The deposits investigated are of two types: zones along which the lavas contain abundant pyrite, some pyrrhotite, and a little chalcopyrite and sphalerite, both disseminated and in veinlets; and quartz veins containing chalcopyrite or sphalerite. The pyritic zones have ill-defined margins, but some are 100 or more feet wide and hundreds of feet long (Dufresne and Taschereau, 1928, pp. 125-127; Taschereau, 1929, p. 98; Cooke *et al.*, pp. 229-230; Ambrose, pp. 38-39).

Maybell Mines, Limited.—In 1929 and 1930, this Company investigated two zones of sulphide mineralization on lot 8, range I. On this lot, acidic volcanics that form two parallel northwesterly trending ridges are in places heavily mineralized with disseminated pyrite and some pyrrhotite and chalcopyrite. The more northerly zone can be followed along the west of the ridge for about 1,200 feet, with width ranging up to 200 feet. The other zone has similar dimensions but with a lesser concentration of sulphides. In addition to stripping, trenching, and test-pitting, these zones were explored by 12,734 feet of diamond drilling. These occurrences are about half a mile southwest of the Cléricy granodiorite dyke, and three-quarters of a mile north of east of the shaft of *Roybell Mines, Limited* (see p. 123), who own the Mabell property (Taschereau, 1930, p. 126, 1931, pp. 81-82; Ambrose, p. 59).

Gold Occurrences

Richmond Group.—These claims are in the extreme north of Cléricy township, adjacent to the north-south centre-line. Crossing the central part of range IX, not far south of the Destor fault, are two ridges of sheared and carbonatized 'greenstone', trending N.80°W., separated by a strip of low land about 200 feet wide. The northerly range is 1,200 feet long, the other 500 feet. The rock of both ridges is injected by a network of lenticular, tourmaline-bearing quartz veins, up to 40 feet wide and 200 feet long, and on the north side of the northern ridge a zone of the sheared greenstone containing disseminated pyrite over a width of 20 feet was traced for a length of 100 feet.

Investigation of these occurrences included a series of cross-trenches up to 350 feet long spaced about 250 feet apart, and diamond drilling aggregating more than 5,000 feet. Most of this work was done by *Star Gold Mines, Limited,* in 1928 and 1929 (Taschereau, 1930, p. 128; Ambrose, p. 55).

Northeast Quarter of Cléricy Township, Ranges VI and VII.—A considerable amount of surface exploration has been done on a group of claims in ranges VI and VII between Kinojévis river and the eastern boundary of the township. The northwesterly trending contact between the Malartic group volcanics to the north and the overlying Kewagama sediments crosses the group diagonally, as also does the Destor fault, which parallels, and is not far to the north of, this contact. Near and roughly parallel to the contact, the volcanics are intruded by some granite dykes, two of which have been traced for 8,000 feet and 5,000 feet, with width up to 400 feet. Close to the east boundary of the township both volcanics and sediments are cut by two northerly striking dykes of 'younger diabase'.

The volcanics, chiefly pillowed andesite, are usually more or less sheared and along some zones the rock has been converted to a carbonate-chlorite schist which is heavily mineralized with pyrite. A considerable amount of trenching and test-pitting has been done along such a zone in lots 51 and 52, range VII, but assays are reported to have yielded only a 'trace' of gold.

Many short, irregular lenses of quartz, up to two feet wide, cut greenstones near the south side of lots 59 and 60, range VII. They contain tourmaline and a considerable amount of pyrite, but have not been reported to carry gold.

West of Kinojévis river, in lot 44, range VII, a shear zone in andesite has been explored from an adit driven in the river bank for a length of 37 feet. The more intensely sheared material, for a width of seven feet, consists of chlorite (about 50 per cent) and quartz-calcite lenses, and contains much disseminated pyrite and some molybdenite. Intruding the schists along their strike is a dyke of feldspar porphyry. It is reported that gold can be panned from the material of this shear (Ross and Asbury, pp. 26-27; Ambrose, pp. 47-49, 51-52).

Primrose Exploration Company, Limited.—The property of this Company includes part of lots 18 to 22, ranges IV and V, Cléricy township, immediately east of the holdings of Aurel Mines, Limited. A number of gold-bearing quartz veins in pillowed andesite have been investigated by stripping and trenching. One of these, in lot 20 along range-line IV-V, has a length of 310 feet and averages about thirty inches wide. Scant pyrite is present in both walls of the vein and also in the adjacent andesite on the south (footwall) side over a width of eighteen inches. Visible gold is reported to have been observed in several places along the vein.

Thirty feet north of the west end of this vein are two similar veins which unite to form a single vein one foot wide. This vein has been exposed for a length of eighty feet. Some thirty feet to the northwest, a smaller vein, six to eight inches wide, has been stripped for ten feet (Ambrose, pp. 54-55).

Roybell Mines, Limited.—This property is near the southwest corner of the township. A gold-bearing quartz mass was discovered here in 1935, near the middle of lot-line 12-13, range I, and in the following years was investigated by various interests prior to the acquisition of the property by *Roybell Mines*, incorporated in 1939. Work on the property has included much stripping and trenching, channel and bulk sampling, several thousand feet of diamond drilling, and the sinking of a three-compartment shaft to a depth of 265 feet, with some lateral work at 125 and 250 feet.

The gold-bearing quartz occurs in bedded tuffs at the southwest margin of the Cléricy granodiorite dyke. The tuffs are either an inclusion in, or an embayment into, the dyke. Their surface outcrop is pipe-shaped, with the 'bowl', at the western end, about 120 feet across, and the 'stem' some 30 feet wide and finally tapering out to the east for a total length of 350 feet. They are in contact with the granodiorite on the north and with a 'younger diabase' dyke, at least 300 feet wide, on the south.

There are several masses of quartz in the tuffs, the two largest having an outcrop area of the order of 100 feet by 25 feet. In workings on the 250-foot level, the amount of quartz is negligible, but whether this is due to pinching out or to displacement by a fault is not known. However, two diamond-drill holes put down from a valley just north of the shaft encountered twenty feet or more of vein material at a depth of about 200 feet.

The quartz is milky to vitreous, and in places contains much tourmaline. Visible gold is reported to be of common occurrence, and, according to the Company's assay plans, gold occurs only in the quartz. In the most northerly mass, which dips about 45 degrees north, the gold tends to occur along or near the footwall. Surface sampling gave $24.15 in gold per ton across 9 feet, and $14.09 across 19.7 feet in one section of this mass, and $12 to $15 across 4 feet in another section 50 feet long. The gold appears to be more erratically distributed in the southern mass, but bulk sampling gave returns up to $17.06 in gold per ton over 9 feet. Channel sampling of the quartz in the shaft gave encouraging returns on the west face and somewhat lower on the east face. Intersections obtained in diamond drilling were disappointing. All but two of them gave '*nil*' or only 'trace' in gold (Ambrose, pp. 56-59).

Bouchard-Cléricy Gold Mines, Limited.—This Company holds a group of claims near the southeast corner of the township, about a mile east of Cléricy lake. They are underlain by andesitic lavas (Blake River group) which in places are sheared and carbonatized and traversed by quartz veins, some of which are gold-bearing. Some of these, in the northern part of lots 44 and 45, range I, have been investigated by stripping and trenching, two prospect shafts, and some diamond drilling. This work was carried out at various times between the years 1924 and 1937.

The vein on which the greatest attention has been concentrated crosses lot-line 44-45 about 1,150 feet south of range-line I-II. On surface, it has been exposed for 160 feet along its east-west strike, ranging from about a foot to four feet wide. The quartz is milky to vitreous. Veinlets and stringers of similar quartz cut the adjacent andesite, which is heavily impregnated with coarse pyrite and contains also some tourmaline. Some high assays in gold are reported from surface sampling of this vein. A shaft 90 feet deep was sunk on this vein and a small amount of lateral work was done. Diamond drill holes, spaced 50 feet apart over a strike length of 200 feet, have intersected the vein at a vertical depth of approximately 100 feet. About fifty feet to the south, another east-west quartz vein, two feet wide, is exposed for a length of fifty feet in a strong shear zone, four feet wide. Surface sampling is reported to have returned low to medium assays in gold. This vein has been cut in several drill holes.

In earlier years, quartz veins, some of them containing visible gold, had been discovered in a low ridge of andesite about 400 feet east-northeast of the occurrences referred to above. These were investigated by diamond drilling in 1929, and in the following year a prospect shaft was sunk to a depth of fifty feet, at about the centre of the ridge. Adjacent to the quartz veins and stringers, the andesite is rusty-weathering and highly carbonatized, and contains much pyrite. The veins, which are tourmaline-bearing, contain some pyrite and, rarely, chalcopyrite. Numerous channel samples were assayed, but with two exceptions they returned an average of less than one dollar in gold per ton. About 1,200 feet west of the prospect shaft, a series of short quartz lenses and associated stringers in carbonatized andesite has been exposed by stripping for a length of 120 feet. There is much pyrite in the quartz, but assays of two representative samples indicated that the gold content is negligible (Bell, pp. 30-35; Ambrose, p. 39).

La Pause Township

La Pause Gold Mining Corporation, Limited.—The property of this Company is at the southwest end of La Pause lake, near the centre of the township. It is underlain by volcanics and interbedded sediments (Malartic group) which are intruded by two relatively large bodies, and numerous dykes and sills, of albite porphyry. Cutting these rocks are large numbers of quartz veins, many of which have been explored by stripping, trenching, and some test-pitting.

Near lot-line 20-21 and just south of range-line IV-V, a zone, 35 feet wide, of highly chloritized volcanic rock intruded by dykes of albite porphyry, both brecciated, has been exposed along its strike for 200 feet. Cementing the breccia are veinlets of quartz which contain some carbonate and pyrite. A grab sample is reported to have given a high assay in gold.

Most of the work on the property has been done about a mile farther southwest, along and adjacent to the southwest flank of a ridge of volcanic rocks that crosses range-line III-IV from lot 18 to lot 20. The rock in the lower ground adjacent to the ridge is highly sheared and has been converted to chlorite-carbonate schist, which is intruded by many dykes and sills of albite porphyry. Along this zone, a quartz vein, about twenty-six feet wide, has been exposed by stripping and trenching for a length of 190 feet, and along its strike, 110 feet to the west, a vein twenty feet wide is exposed for forty feet. Channel sampling of the latter is reported to have indicated only a low content of gold. Many other quartz veins, containing much pyrite, calcite, chlorite, and tourmaline, have been found in this part of the property, and in two places molybdenite has been found along fractures and joint planes in albite porphyry dykes (Ambrose, pp. 45-47).

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PREISSAC, LA MOTTE, AND LA CORNE TOWNSHIPS

General Note

Extending completely across these three townships is a batholith of granitic rock (the La Motte-La Corne batholith or batholiths) which has a length, east-west, of about thirty-seven miles and a width of ten to twelve miles. It occupies about three-quarters of the area of Preissac and La Motte townships and almost the whole of La Corne, from which it continues eastward into Fiedmont and southward into Vassan. The rocks marginal to, or appearing as inliers within, the batholith are for the most part Keewatin-type volcanics with, in some places, bands of sediments. There are occurrences of peridotite in the central part of Preissac and in western and southern La Motte, and a dyke of this rock has been found in northwestern La Corne. The granitic rocks are cut by a number of northeasterly striking later gabbro dykes.

Gussow (pp. 149-156; see also *Geology of Quebec*, Vol II, pp. 99-101) distinguishes three principal rock types in the batholith: hornblende granodiorite, which occupies an area of 87 square miles, or about two-thirds of the La Corne mass; muscovite granodiorite, which outcrops over an area of 45 square miles on both sides of La Motte (Okikeska) lake; and biotite granodiorite, underlying an area of about 95 square miles and occupying the greater part of the La Motte area. Accompanying these are aplitic and pegmatitic facies, which are particularly abundant within the muscovite and biotite granodiorites, where, in some outcrops, they constitute up to 50 per cent of the rock. Gussow gives a number of analyses of each type, from which it appears that they are all relatively high in potash, the percentage of which is seldom lower than that of soda and is generally very much higher.

Cooke (pp. 136-138) describes the rock in the eastern part of La Corne township as augite-hornblende syenite, with minor amounts of a still more basic facies which he refers to as amphibolite.

The granitic rocks are all massive and they are notably free from alteration and also from shearing. In places, they are cut by northeasterly striking 'later gabbro' dykes.

Mineral Occurrences

The only recorded copper sulphide mineralization in any of these townships is on lots 10 and 13, range IV of La Motte. On lot 10, stripping and trenching over a length of 420 feet has exposed a zone of highly metamorphosed sedimentary rocks in which quartz veinlets are distributed across a width averaging ten feet. Both the quartz and the wall-rock contain pyrite and, in places, minor amounts of pyrrhotite, chalcopyrite, and sphalerite. Assays of four chip samples gave *nil* or only a 'trace' in gold. The occurrence in lot 13 is similar and appears to be in the same band of sedimentary rock (Ross and Asbury, p. 29).

No gold mineralization has been recorded in close association with the batholith, but molybdenite deposits of interest occur in some of the quartz and pegmatite veins or dykes, particularly in La Corne and Preissac townships. These and other Quebec occurrences of molybdenite are described on pages 407-420. Associated with the molybdenite are very minor amounts of native bismuth, bismuthinite, and stibnite. Beryl, in crystals up to four inches in diameter, has been found in pegmatite dykes in the south part of Preissac township.

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DASSERAT TOWNSHIP

General Note

Dasserat township is at the Quebec-Ontario boundary, two townships west of Rouyn. The northern two-thirds is underlain by Keewatin-type volcanics, intruded by a number of 'older gabbro', and also more acidic, dykes and sills, and the southern part by Temiscamian-type sediments. The contact between the volcanics and sediments is concealed beneath Huronian (Cobalt series) sediments, a band of which extends across the township in range III, with two arms branching from its northern side toward Dasserat lake.

Gold mineralization of interest has been found at a number of places in the township, chiefly in the volcanic rocks, but investigation has so far failed to reveal any large orebodies of commercial grade.

Mineral Occurrences

Eric Canadian Mines, Limited (Russian Kid Claims).—A quartz vein containing much free gold discovered in 1924 on lots 6 and 7, range VIII, was investigated in subsequent years by cross-trenching, two prospect shafts, and a limited amount of diamond drilling. It outcrops on the shore of Labyrinthe lake, whose eastern bay projects for a short distance into the township from across the interprovincial boundary, and has been exposed for 350 feet along its strike of N.70°E. The width varies between two and seven feet. The vein follows closely a sheared and ill-defined contact between quartz diorite, on the north side, and granite, the latter possibly a differentiate of the diorite. The vein is very heavily mineralized with coarse pyrite, which is abundant also in the wall-rock over a width of one to three feet on either side of the vein. The average tenor of the vein matter, excluding free gold, was reported as $6 to $7 per ton, and of the heavily mineralized wall-rock, $3 to $4 per ton (Cooke *et al.*, pp. 234-235; Ross and Asbury, p. 4).

Monarch Mines, Limited.—This property, comprising part or the whole of lots 27 to 31, ranges VI and VII, is at the centre of Dasserat township, adjacent to the west shore of Dasserat lake. The main gold occurrence is in the north part of lot 30, range VI, where a series of quartz veinlets are localized in the vicinity of a faulted contact between a 45-foot dyke of feldspar porphyry and sheared Keewatin-type volcanics. A prospect shaft sunk here to a depth of 56 feet revealed spectacular free gold in a number of the veinlets in the volcanics, but little or none in those in the porphyry. Small shipments of high-grade ore were made from veins cut in this shaft. Sixty feet to the west of this, a shaft was sunk to 150 feet and about 1,300 feet of lateral work was completed on the 125-foot level, exploring the contact zone on both sides of the dyke. This work failed to encounter concentrations of gold such as had been found in the prospect shaft, and operations were suspended in 1937. A number of pyritized quartz veins have been uncovered in other parts of the property, but apparently they did not prove of commercial interest (Bell, p. 3; Ross and Asbury, pp. 4-5).

Renault Mining Company, Limited.—This property is adjacent to the south shore of Dasserat lake, on either side of range-line IV-V. At the lake shore, the volcanics are intruded by two adjoining bosses, each about a mile and a half in its larger dimension. One of these is diorite porphyry; the other, which is later than, and appears as dykes in, the first, is syenite porphyry. Both rocks are sheared in places, and along such zones they are sparsely mineralized with pyrite (chiefly) and chalcopyrite and contain veins of quartz. Some of these occurrences have been investigated by trenching and test-pitting, and from an adit driven for fifty feet into the hillside near the lake shore, but apparently the veins contain little or no gold. The main vein is in a shear zone in syenite porphyry and has been exposed in cross-trenches and pits for a length of 600 feet. It varies in width from one to four feet and is accompanied by several veinlets, a few inches wide. Where exposed near one of the prospect pits it contains up to 10 per cent pyrite, and a channel sample assayed $0.17 in gold per ton. The adit was driven at the western end of this vein (Cooke *et al.*, pp. 106, 114; Ross and Asbury, pp. 5-6).

The Renault Mining Company also holds a small block of claims at the south shore of Arnoux lake, in the south part of range VII, close to the eastern boundary of the township. Several quartz veins, up to eight feet in width, are exposed along the lake shore, cutting quartz diorite (Ross and Asbury, p. 6).

Eclipse Mining Company, Limited.—This Company did some surface exploration and diamond drilling on its claims in lots 53 and 54, range VI, during 1937. This is about one mile southwest of Arnoux lake, and the wide sill of quartz diorite with southwesterly trend that skirts the lake crosses the claims. In places, fractures and narrow shears in the diorite contain pyrite and an occasional quartz vein. One of these veins has been traced for a length of 200 feet. In a pit near its eastern end, some pyrite occurs in the diorite, but not in the quartz (MacKenzie, p. 21).

Arncœur Gold Mines, Limited.—The Arncœur property is immediately south of the Eclipse Mining Company's ground. It extends south from the east-west centre-line of Dasserat township to just south of the west end of Fortune lake, and eastward from Desvaux lake to King of the North lake. It is adjoined on the east by the Francœur property, in Beauchastel township.

The property is underlain by Keewatin-type volcanics which are intruded by a wide, sill-like mass of quartz diorite that trends slightly south of west from the south shore of King of the North lake to Desvaux lake, and similar quartz diorite is found farther north intruding the volcanics on both sides of Demin lake. The volcanics strike about 10° south of west, and, broadly, there is a central band, about 2,500 feet wide, of acidic lavas, with basic lavas to north and south. A shear zone follows closely the contact between the acidic lavas and the basic flows to south of them and is apparently the westward continuation of the shear in which the Francœur and Arntfield orebodies occur, in Beauchastel township. In Dasserat, it is not far north of the diorite sill.

Most of the work carried out on the property during 1936 and 1937 was designed chiefly to explore this shear zone. It included a geological survey of the claims, a considerable amount of stripping and trenching, and more than 18,000 feet of diamond drilling. In several places, the sheared volcanics were found to be impregnated with carbonate and pyrite, and in one or two instances visible gold was observed in quartz stringers. Quartz veins containing pyrite and occasional grains of chalcopyrite were found also in fractured and sheared diorite just north of Fortune lake and near the west shore of Demin lake. Northwest of Fortune lake and a few hundred feet north of the main shear, a mineralized zone in trachyte, mostly less than three feet wide, is traceable for 200 feet. Assays of samples taken along thirty feet of this zone over a width of three feet are reported to have returned up to 0.5 oz. gold per ton, but in general the gold content of the material at surface and encountered in drilling was low (MacKenzie, pp. 19-21).

Immediately south of the Arncœur property, between Fortune lake and the small Samia lake a few hundred feet to the west of it, several veins or lenses of quartz occur in massive quartz diorite. Individually, they are not more than fifty feet in length and they have a width up to five feet. In places, the veins and adjacent wall-rock contain scattered grains of pyrite and are reported to be gold-bearing.

Gignac Gold Mines, Limited.—This property is at the north end of Opasatica lake, in the southeast corner of Dasserat township. It is underlain for the most part by Temiscamian-type sediments, chiefly greywacke and conglomerate, now largely converted to mica schist. Intruding these are a small boss and a dyke of granite, and two 'later gabbro' dykes. Near the north boundary of the property, the schists are overlain by Huronian (Cobalt series) conglomerate.

Numerous quartz veins occur in the Temiscamian rocks, both parallel to and cutting across the schistosity. Most of those observed are barren, but two of them, close to range-line I-II, on opposite sides of the north bay of Opasatica lake, contain some pyrite and chalcopyrite. These have been investigated by test-pitting and some diamond drilling, but assays of surface samples indicate only a low content of gold (Ross and Asbury, p. 7-8).

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BEAUCHASTEL TOWNSHIP

General Note

The Keewatin-Temiskamian contact is believed to strike east-west across Beauchastel township about a mile and three-quarters north of its south boundary (Figure 17). The western eight miles of this contact is concealed beneath a belt, two miles wide, of flat-lying Cobalt sediments, out of which have been eroded the prominent Kekeko hills. This is the most easterly point at which these late-Precambrian sediments have been found in the Province of Quebec. North of this band, the township is underlain by the much older Keewatin lavas, intruded in places by igneous rocks of various types and ages. The lavas, to a distance of two to three miles north, have generally a west to northwest strike, the latter being typical in the western section of the township. Dips range from steep to 45 degrees, commonly to the north.

The oldest recognized intrusive rock, and the one which is present in largest amount, is a dark, coarse to fine grained diorite ('older gabbro') which, in the central part of some of the larger masses, grades into granodiorite. Less common, but widely distributed, are bosses and dykes of syenite porphyry and quartz porphyry, which, it is evident, are not all strictly contemporaneous. Thus, the Aldermac sulphide deposits are along the southern margin of a complex boss of porphyry in which successive invasions of material may be recognized. The oldest is a dark-coloured, porphyritic syenite, while one of the youngest is a very light coloured, fine grained rock composed of albite and quartz, with an almost entire lack of ferromagnesian minerals.

The Flavrian Lake granite mass extends south from Duprat township into Beauchastel, crossing its north border with a width of five miles. Its south margin is close to range-line VIII-IX. The mass consists of a variety of coarse-textured, pink or white, albite granites. Both the granite and the adjacent volcanics are intruded by quartz porphyry and aplite bodies which are apparently genetically related to the granite, and the volcanics nearby have been severely altered, both by the addition of granitic material and by recrystallization.

Lamprophyre dykes are not uncommon in the township. Generally, they are altered, but some very fresh biotite-pyroxene lamprophyres cut the orebodies of the Aldermac and Arntfield mines.

The youngest intrusive rocks are 'later' gabbro or diabase dykes. Like the porphyries, they are not all of the same age. These later dykes, and also the rocks of the Cobalt series, have been faulted and sheared to some extent, but much more pronounced is an older faulting and shearing in which only the early-Precambrian rocks have been involved and which, in some instances, persists for many miles. These major zones of dislocation are important because valuable mineral deposits are associated with some of them. Such a zone of shearing enters Beauchastel from the west and, with flat arcuate course convex to the north, extends eastward from just north of King of the North lake, through the Francœur and Arntfield orebodies, to south of Wasa lake. The width of the shearing varies from place to place, with a range from a few feet to 300 feet.

The probable continuation of the Horne Creek fault crosses the east boundary of the township just south of the Rouyn highway, at range-line VI-VII, and is believed to continue for seven miles farther in a west-southwest direction to MacKay lake, south of the Aldermac mine.

There is another pronounced fault along Pelletier creek, at the east boundary of the township, in ranges IV and V. It apparently strikes about N.30°E.

It is possible that some of these long, and often wide, shear zones originated as thrust faults related to the strong north-south compressional forces that folded the rocks of the district into easterly striking folds.

Gold, and also copper, mineralization has been found at many points in the township, in which there are, or have been, several producing mines. A variety of deposits are represented. Some are replacement deposits, others quartz-vein deposits. In some of the former, replacement has consisted chiefly in silicification and carbonatization of the country rock, with minor introduction of sulphides, as in the Arntfield and Francœur gold-bearing orebodies; in others, the deposits consist largely of massive sulphides, including an appreciable amount of chalcopyrite, and contain more or less gold, as at the Aldermac mine. The gold-bearing quartz veins frequently contain tourmaline, carbonate, and sulphides, which may include some chalcopyrite, as at the Lake Fortune mine, or arsenopyrite, present in Wasa Lake ore. The Lake Fortune ore contains also gold tellurides.

One feature common to all the gold deposits of the township is that the gold content of the ore bears no relation to the amount of pyrite and other sulphides present. This seems to indicate that most, if not all, of the gold was introduced independently of the sulphides.

Veins containing molybdenite have been found at several localities in the northwest quarter of the township, in lots 12 to 15, range X, and in lot 16, range IX (Robinson, 1940, pp. 6-7). The mineral also occurs very sparingly in the ore of the Halliwell mine, lot 34, range VIII (MacKenzie, 1941, p. 19).

Mines and Mineral Occurrences

Lake Fortune Gold Mines, Limited

The property of Lake Fortune Gold Mines surrounds the east end of Fortune lake, at the west boundary of the township. It is underlain by basic volcanics which, in the north part of the property, are intruded by a sill-like mass of quartz diorite. It was here that the first discovery of gold in Western Quebec was made, by Alphonse Olier and Auguste Renaud, in 1906, the year that gold was discovered in the Kirkland Lake district, Ontario.

Between 1907 and 1935, the possibilities of the property were investigated by various interests. During the years 1910 to 1914, the Union Abitibi Mining Company did a considerable amount of surface work and sank a 140-foot inclined shaft, from which several hundred feet of lateral work was carried out. The property then lay idle until 1922, when Lake Fortune Gold Mines unwatered and sampled the mine. Since 1923, controlling interest in the property has been held by the Towagamac Exploration Company who, at various times up to 1935, did much trenching and diamond drilling and also sank a shaft to a depth of 490 feet at the east end of Fortune lake. Lateral work was carried out on two levels, at 355 and 465 feet. The shaft is sunk in the hanging-wall of a strong, northerly dipping shear zone in the lavas close to their contact with the south margin of the quartz diorite sill. Gold mineralization was found along sections of the shear zone in which there are narrow bands of carbonate and lenses and veins of quartz up to several inches wide. Drilling from the surface had indicated an ore shoot 500 feet long and 3.6 feet wide, assaying 0.513 oz. gold per ton, between the 300- and 500-foot horizons. In the underground workings, spectacular free gold and tellurides were reported in a few places, but the zone was found to consist of discontinuous lenses or veins, and no appreciable length of ore of commercial grade was encountered (Cooke *et al.*, pp. 262-263; Bruce, pp. 59-64; Tanguay, 1936, pp. 45-46; MacKenzie, 1940, Map. No. 462*A*).

Francœur Gold Mines, Limited

The property of Francœur Gold Mines lies to the north and east of Lake Fortune ground and is adjoined on the east by the holdings of Arntfield Gold Mines. Exploration was started here in 1923 to investigate occurrences of gold mineralization that had been found along and near the shear zone already referred to that has been traced from Desvaux lake, in Dasserat township, to Wasa lake, in central Beauchastel. Early work included the sinking of an inclined shaft and some lateral work on two levels. In 1935, the shaft was deepened to 745 feet and two additional levels were opened. Meanwhile, diamond drilling had indicated ore farther west along the shear zone, and in 1936 sinking was commenced of No. 2 shaft, 2,000 feet west of No. 1. From this shaft, which has a 45-degree incline, levels were opened at four horizons. A mill was erected and started operating in July, 1938. Its initial capacity was 200 tons of ore per day.

At that time, work in the No. 1 shaft area had indicated, east of the shaft, a lens-like body of ore extending from the surface to the third level, 430 feet on the incline, and estimated to contain 35,000 tons of ore grading 0.25 oz. gold per ton. Its maximum length, which is attained on the second level, is 222 feet, and its width there is just over six feet. A smaller but richer body was indicated by preliminary work on the 720-foot level, west of the shaft.

Early in 1938, it was estimated that there was nearly 150,000 tons of ore in the No. 2 shaft area, averaging 0.26 oz. gold per ton. Five ore shoots had been developed on the first level and had been cut in workings on the second level. The largest is 210 feet long, averages 35.2 feet in width, and grades 0.27 oz. gold per ton. The others are seven feet or less wide and are shorter.

In 1937, drilling from the surface west of No. 2 shaft intersected mineralization of interest along the continuation of the shear zone in that direction.

For 2,000 feet west of the shaft, the surface is completely drift covered, but the drilling and subsequent underground work showed that the shear zone here traverses lavas ranging in composition from rhyolite to andesite, and that orebodies occur in both the hanging-wall and the footwall. Mineralogically, they resemble the bodies farther east.

In 1939, re-sampling of some old trenches 800 feet north of the main shear zone disclosed material of ore grade. This work, supplemented by diamond drilling and by underground work at the second level from No. 2 shaft, has proved substantial bodies of ore. These occur in trachyte and agglomerate, where these rocks are cut by a strike fault dipping steeply southward. Where the fault passes through andesite, the rock is barren. Other similar south-dipping faults nearby remain to be investigated (Cooke *et al.*, pp. 270-275; Bruce, pp. 72-73; MacKenzie, 1940, pp. 24-26).

Arntfield Gold Mines, Limited

Gold was first discovered on this property in 1923, by F. S. Arntfield. Arntfield Gold Mines investigated this and other discoveries by stripping, diamond drilling, and from three shafts, one sunk to a depth of 1,000 feet, and a substantial body of ore was developed. Early in 1935, a cyanide mill was erected, and production of gold commenced in July of that year. From an initial capacity of 165 tons per day, the mill was stepped-up gradually to 340 tons per day in 1939. Recovery during the first year of operation approached 0.2 oz. gold per ton, but in subsequent years it was found difficult to maintain that grade. All operations were suspended in April, 1942. In 1944, the property was acquired by the Arntfield Mining Corporation, Limited.

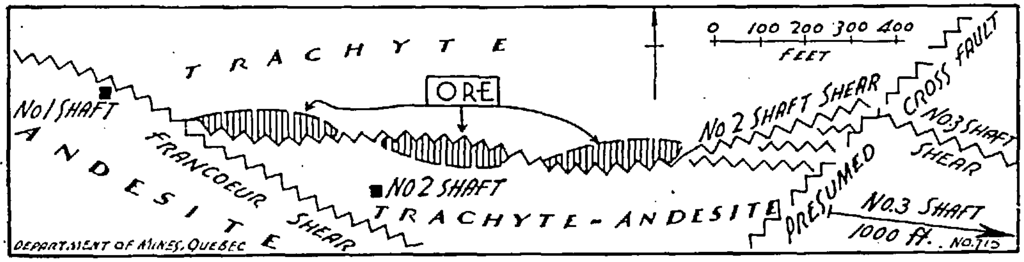
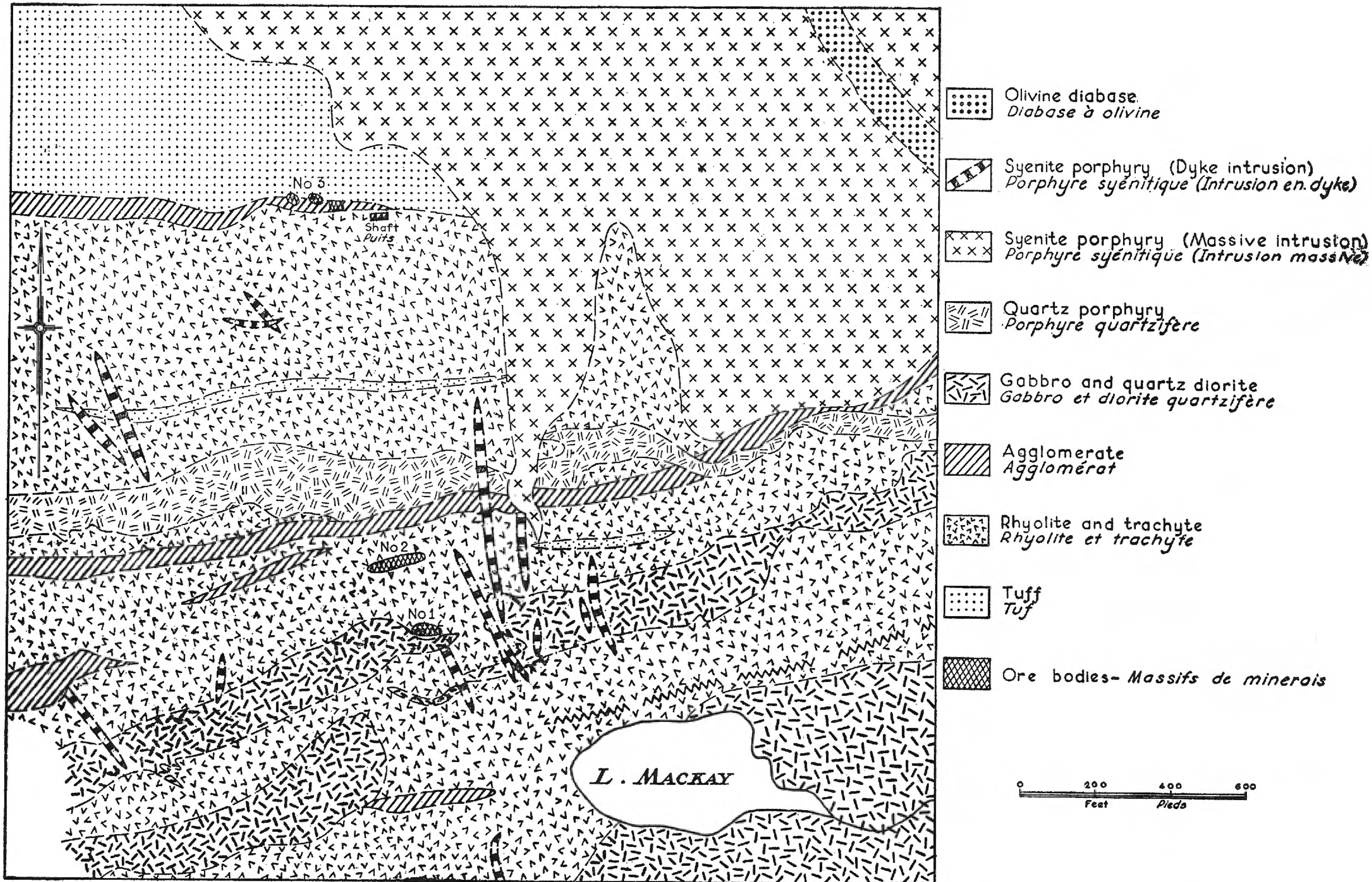


FIGURE 18.—*Arntfield mine, generalized structure near No. 2 shaft.*

Geology

The predominant rocks in the vicinity of the workings are acidic and basic lavas with lenses of interbedded volcanic fragmentals which, in part, grade into fine grained tuffs. They strike N.75°-90°W. and dip north at varying angles, commonly at about 45 degrees.

It is clear from the evidence now available that the bed-rock in this area is cut into blocks by faults. These blocks have been shifted relatively to one another, but the amount and manner of movement has not in most cases been determined. Because of this, each block constitutes a unit, the structure of which must be attacked as a separate problem. When each has



DEPARTMENT OF MINES, QUEBEC, No. 716 — MINISTÈRE DES MINES, QUÉBEC, No. 716

Fig. 19 - ALDERMAC MINE, Surface plan —— MINE ALDERMAC, Plan de surface

been worked out as far as is possible, it may be found that, by comparing rock series or by correlation of peculiar types, the original fold structure can be reconstructed. Enough is known now to make it clear that the known ore-bearing zones are on the south limb of a much-faulted syncline.

Faults are of several ages, but, so far as is known now, those with large displacements were all in existence prior to the formation of the gold ores. Those which appear to represent the largest adjustments strike within 30° of east-west and dip between 45°N. and vertical. These fault zones are marked throughout most of their length by layers of schist up to 100 feet thick, and hence have been designated *schist zones.* They are valuable guides to ore, since, near them, fracturing provided openings that were easily penetrated by mineralizing solutions.

All of the ore found to date is in one of these east-west shear zones, and its distribution shows a definite correlation with certain types of wall-rock. Briefly stated, the ore is always associated with acidic flows or fragmental rocks or with the quartz porphyries that have intruded them. These may occur on one or both sides of the 'break' and the ore is usually, though not invariably, formed by replacement of the rocks. While there are some exceptions, it is generally true that the barren stretches are less fractured and altered than the ore.

It appears probable that the east-west shear zones were in the main initiated as bedding faults due to slippage between beds during folding.

Orebodies

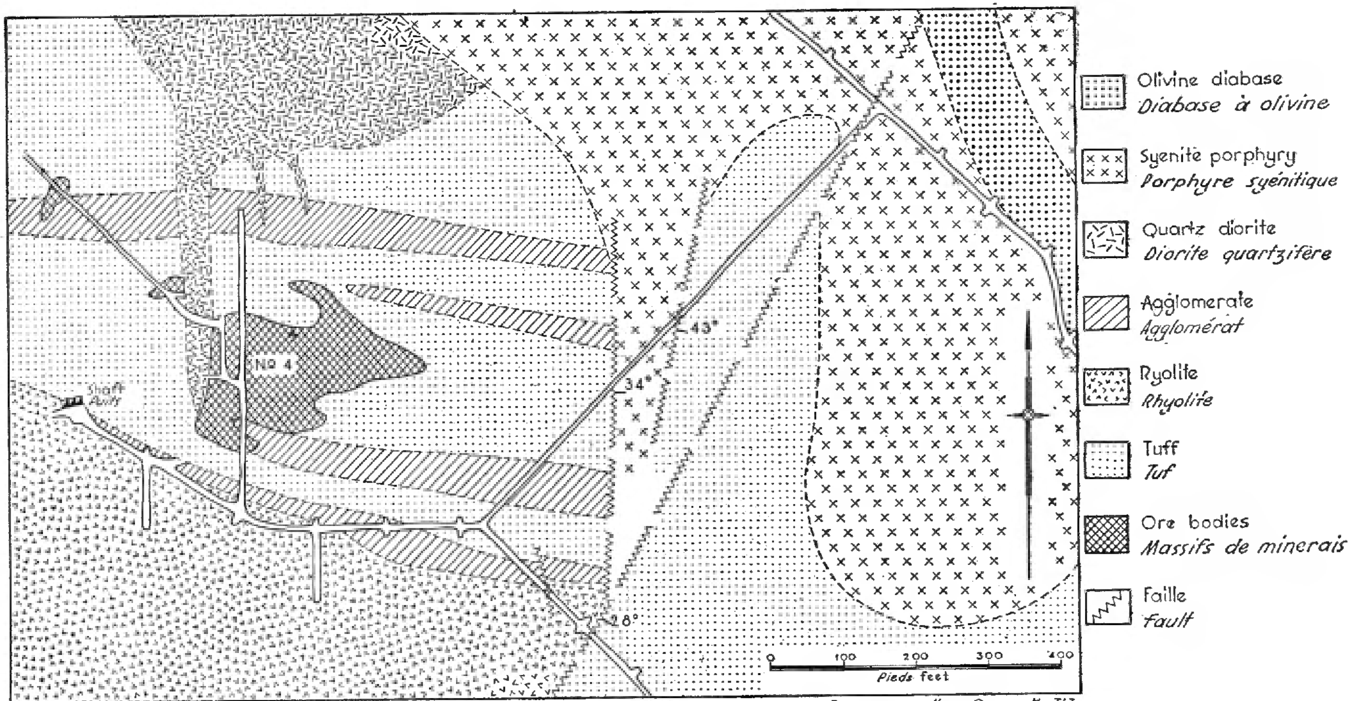
From each of the three shafts, exploration of the main ore-bearing shear has been carried out.

Seven or more orebodies have been developed from the No. 2 and No. 3 shafts, with an average length of 175 feet and an average thickness of from 6 to 30 feet.

Systems of fractures localized by gentle flexures in the controlling faults have, in the main, afforded the channels for the mineralizing solutions. The ore is typically massive, fine-grained, pinkish or grey. The common gangue mineral is fine quartz and with it are associated carbonates, sericite, plagioclase, and pyrite. Both coarse and very fine-grained pyrite are present and the gold is generally closely associated with the latter. However, no quantitative relationship between pyrite and gold exists, which would suggest that gold was introduced, at least in part, separately (Cooke *et al.*, pp. 270-275; Malouf, pp. 427-434; Bruce, pp. 64-72; MacKenzie, 1940, pp. 22-24).

Aldermac Copper Corporation, Limited

The first staking on the Aldermac property was in 1922, by A. A. MacKay. In 1925, rock trenching and diamond drilling revealed the presence of some massive sulphide bodies with appreciable content of copper and gold, and in 1927 a shaft was sunk in range VI, 1,760 feet north of the centre range-line of the township and 150 feet east of lot-line 20-21, to explore and develop these bodies at depth. In later years, the shaft reached a depth of 1,625 feet.



MINISTÈRE DES MINES, QUÉBEC, No.717 DEPARTMENT OF MINES, QUEBEC, No. 717

FIGURE 20.—*Aldermac mine, plan of eighth level.*

To treat the ore, a concentrating mill was erected and was placed in operation in January, 1932. It had a capacity to treat 500 tons of ore per day and later was enlarged to double that capacity. The concentrator made two products: a high-grade copper concentrate, carrying some gold and silver, and a pyrite concentrate, high in sulphur. Much experimental work was carried out with a view to utilization of the sulphur content of the pyrite (Freeman, Hübler).

All operations at the Beauchastel property of the Aldermac Copper Corporation ceased in October, 1943. The machinery, equipment, and buildings were salvaged. From the commencement of operations, the mine produced 30,845 tons of copper, 10,675 ounces of gold, and 389,100 ounces of silver, and shipped 557,400 long tons of pyrite. The average copper content of the ore treated, over the life of the mine, was 1.65 per cent (Lafontaine, p. 74).

General Geology

The rocks in the vicinity of the shaft are Keewatin-type acidic lavas, mostly rhyolite, with occasional interbedded bands of tuff and volcanic agglomerate. These rocks strike generally east-west. The dip at surface is nearly vertical but gradually changes to 70° south at the 1,000 foot horizon and to 60° south at levels below that. The shaft is believed to be in the north limb of a syncline whose axis is about a mile to the south. The tuffs and agglomerates are banded, mostly acidic, and usually massive; it is in these rocks that the orebodies occur.

About two thousand feet south of the shaft is the western end of a large mass of gabbro, intruding the volcanics. Between this mass and the shaft are sill-like bodies of gabbro and one of quartz porphyry, following the strike of the flows but having off-shoots that cut across them. Three hundred and fifty feet northeast of the shaft, at surface, is the southwestern margin of a considerable mass of syenite porphyry that extends north and northeast and has a diameter of possibly a mile and a half. Gunning (1927) considers that this body is a composite intrusion of successively emplaced masses and dykes. The oldest facies is dark, fine grained to porphyritic, and contains chiefly augite, or ægirine-augite, and albite and orthoclase feldspar. Succeeding facies are lighter in colour, due to a higher feldspar content, and in these the ferromagnesian constituent is soda-amphibole, with, in some types, biotite and muscovite. In some of these later facies, the potash feldspar phenocrysts are two to three inches long. Last to be injected were narrow dykes composed almost altogether of albite and quartz.

A few biotite-rich lamprophyre dykes occur in the ore area and elsewhere, and a long quartz diabase dyke, 80 to 100 feet wide, strikes northwesterly across all other rock types, through a point 1,200 feet northeast of the shaft.

An important fault, besides others of lesser magnitude, occurs in the ore area, on which both possibly pre-ore, and definitely post-ore, movements have taken place. The apparent displacement indicates a thrust fault which has displaced the banding of the volcanics at least 360 feet, and the No. 4 orebody 150 feet.

Other faults are present that strike north-south and dip 35° to 45° east. A shear zone, up to 40 feet or more in width, striking N.75°W. and dipping 60° south, contained the No. 3 orebody.

The dykes of syenite porphyry and quartz diorite which intersect the tuffs and agglomerates that contain the orebodies have aided in the localization of the ore-bearing fracture zones within the tuff and agglomerate beds.

Orebodies

The lens-shaped orebodies of the Aldermac mine are replacements of acidic tuffs and agglomerates. Their vertical extent is considerably greater than their length along the strike. Some, or parts, of these bodies are solid sulphides; in others, the replacement of the original rocks is not complete. The sulphides are dominantly pyrrhotite, or pyrite, with minor amounts of chalcopyrite and sphalerite. Gold and silver are very sparingly present.

J. Ellis Thompson (quoted by Cooke, p. 180) made a detailed study of the ore and considered that the metallic mineralization was the result of successive periods of deposition. Pyrite was the first mineral to be formed, then, in succession, magnetite, pyrrhotite, sphalerite, and chalcopyrite. Each of these minerals replaces, to some extent, those deposited earlier.

The wall-rock alteration consists chiefly of chloritization and silicification. Surrounding the pyrrhotite-rich No. 3 and No. 5 bodies, the alteration is dominantly chloritic; highly siliceous tuffs and agglomerates are so intensely altered that they are almost beyond recognition where they pass into the ore zone.

The orebodies that were mined are three in number: No. 3 has a maximum length and width of 300 feet and 40 feet, respectively, and extends from 70 feet below surface to just below the 500-foot horizon. It strikes N.75°W. and dips 60° south. It consists largely of pyrrhotite, with a small amount of pyrite.

No. 5 orebody occurs in the same shearing as No. 3, about 100 feet to the east-northeast. It has a width of up to 40 feet, a length of 100 to 150 feet, and a vertical extent about from the 125-foot to the 450-foot horizon.

No. 4 orebody is 50 feet north of, and below, No. 3. Its apex is just below the 250-foot level and it has been explored to below the 1,150 foot horizon. It is elliptical, with irregular bulges, in plan, 40 to 180 feet wide, and up to 320 feet long. It consists largely of massive pyrite with a minor amount of pyrrhotite. Some chalcopyrite is also present. Vertically, the ore cuts across the bedding of the tuffs and agglomerates at an angle of 20 to 25 degrees.

Two other orebodies are known, but the work done on them did not indicate the presence of a large tonnage (Cooke *et al.*, pp. 175-183; Bruce, pp. 74-86; MacKenzie, 1940, Map No. 462*A*).

Wasa Lake Gold Mines, Limited

This property adjoins Aldermac ground on the south and southeast. Following the discovery, in 1936, of a high-grade gold-bearing quartz stringer in an andesite outcrop, stripping revealed a larger vein to the south of the outcrop and diamond drilling gave numerous intersections of good

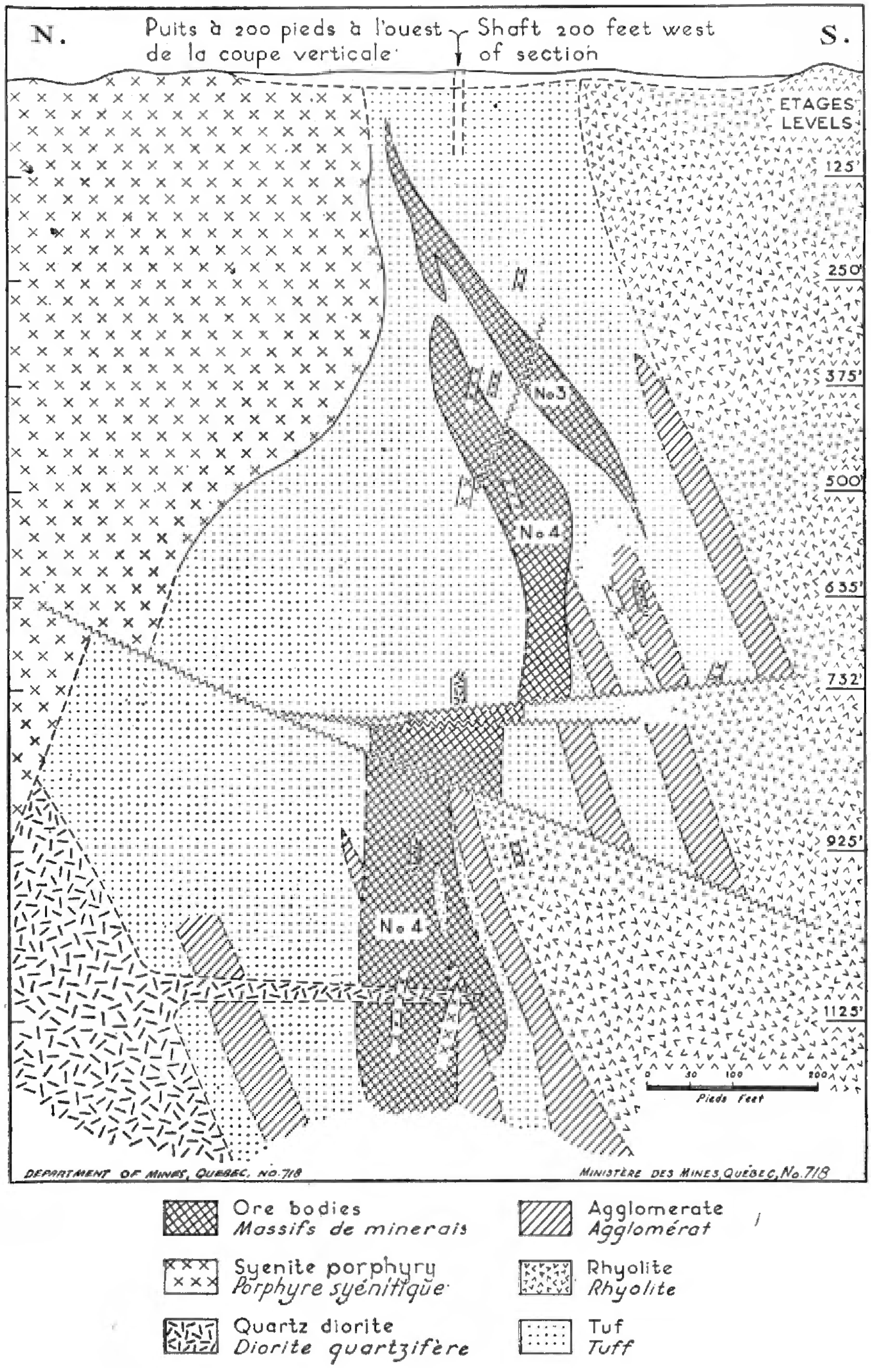


FIGURE 21.—*Aldermac mine, vertical section.*

grade. A vertical shaft was then sunk and 1,300 feet of lateral work was done at the 200-foot level. By this time, a Company, known as *La Mine D'Or Champlain, Limitée*, had acquired the property and work was continued until the spring of 1938. In 1944, this Company was re-organized as Wasa Lake Gold Mines, Limited.

The underground work gave only a limited amount of information as to the nature of the gold-bearing bodies. It showed that they occur in or near shear surfaces and zones. These form a system which may be rather complicated, but which, with sufficient work, can certainly be worked out. Actually, only three of the gold-bearing sections cut by diamond-drill holes were reached or approached closely by the underground workings. These proved to be in a somewhat irregular quartzose mass or masses formed by replacement of the volcanics.

On the 200-foot level, a length of 100 feet of ore has been proved, with extensions beyond this possible. The average thickness is ten feet and the grade is between 0.14 oz. and 0.20 oz. gold per ton. Muck samples average 0.19 oz.

On a sub-level, at 80 to 120 feet east of the section just described and 32 feet above the 200-foot level, a vein dipping flatly westward was opened for 115 feet and was found to average 0.34 oz. gold per ton over a true width of 49 inches, with the full width not exposed. This very probably connects, on the 200-foot level, with the section previously described.

A narrow vertical shear zone was drifted on at the 200-foot level for a length of 200 feet, showing mineralization throughout. A 25-foot length gave an average of 0.534 oz. gold per ton over 45 inches, but the remainder was below ore grade.

The rest of the underground work gave little useful information. The drifts were opened partly as a base for diamond drilling which had been planned to explore north, south, and west for controlling structures, to define the system of shears, and to gain further information concerning the bodies cut by the surface drill holes. Unfortunately, the operation was suspended before this could be done. Only three short holes, totalling 543 feet, were drilled from underground. One of these cut 26 feet of ore averaging 0.22 oz. gold per ton, but the workings were not advanced to open this body.

Additional surface diamond drilling was started in April, 1944, at a point about 1,000 feet north of the discoveries. The first hole cut material of ore grade in a strong shear (the Wasa shear zone). It is a persistent zone, marked by a weak to strongly developed schistosity, occurring between a series of acidic volcanics to the north, and intermediate to basic volcanics to the south. In marginal parts, and in less sheared and altered sections within the zone, it can be seen that the original rock was a basic tuff. The zone strikes between N.78°E. and E.-W., dips northward at 50°, and ranges from 45 to 160 feet in thickness.

The orebodies were formed within the shear zone by replacement and consist chiefly of quartz, carbonates, pyrite, and chlorite. Fuchsite and hematite are present in small amount. Visible gold is extremely rare. The highest grade parts are usually rich in silica and contain considerable amounts of fine-grained pyrite. Outside the orebodies, the schist is more or less replaced by fine-grained quartz, carbonates, and pyrite, the quartz and pyrite decreasing outward or appearing in patchy distribution, and carbonates increasing in amount. This replacement and cementation has strengthened the rock considerably.

By the end of 1944, about 18,000 feet of diamond drilling had been completed and the presence of upwards of 2,000,000 tons of ore had been indicated, with an average grade of 0.19 oz. gold per ton uncut and 0.17 oz. cutting all high assays to 0.40 oz. per ton.

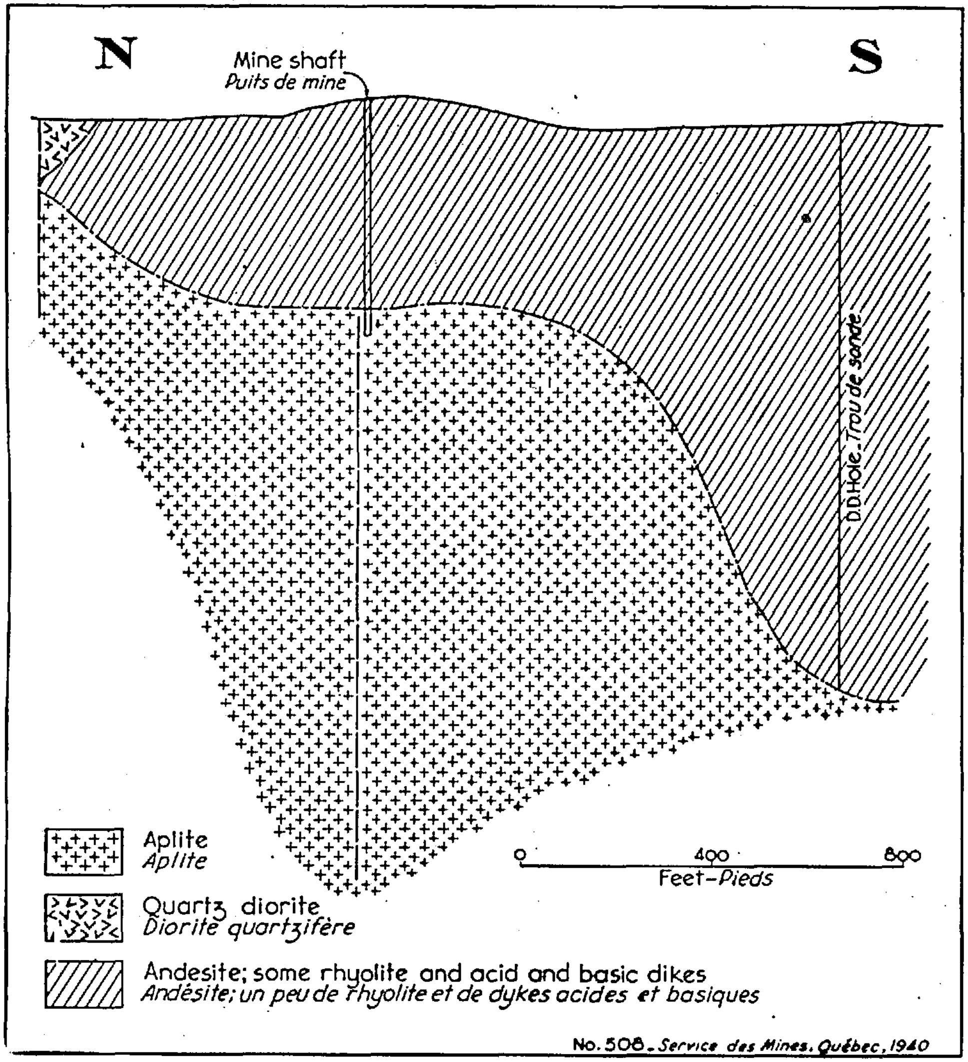


FIGURE 22.—*Halliwell mine, north-south vertical section* (Que. Bur. Mines, G.R. 7, 1941, Fig. 2).

Halliwell Gold Mines, Limited

The Halliwell property lies east and west of the centre-line of Beauchastel township in ranges VII and VIII. The mine shaft is in lot 34, range VIII. The surface rocks in the vicinity of the shaft are Keewatin-type volcanics, chiefly andesite, which, about 750 feet west of the shaft, are intruded by a body of quartz diorite. The orebody, now worked out, occurred in the andesite about 250 feet west of the shaft, where the rock is irregularly fractured, much chloritized, and speckled with sulphides, both chalcopyrite and pyrite and, rarely, pyrrhotite, sphalerite, and molybdenite. Quartz is not prominent in the ore, but it occurs as occasional lenses, and some fractures in the andesite are filled with quartz and calcite and contain a little chalcopyrite.

In the underground workings, it was found that the ore bottomed at about the 450-foot level, at the roof of a mass of aplite (alaskite granophyre) which has intruded the andesite near its contact with the quartz diorite. This aplite body approaches the surface toward the north and appears in a small outcrop 1,800 feet northeast of the shaft, but toward the south its roof slopes downward and, in a drill hole put down 1,000 feet south of the shaft it was encountered at a depth of 1,200 feet. The orebody was cone-shaped, with the base sixty feet in diameter and the height also sixty feet.

The gold content of the ore varied from place to place within the orebody. Locally, it amounted to several ounces per ton, but, for the 2,719 tons that were mined, recovery was rather less than half an ounce per ton. The copper content was similarly variable, from one to several per cent. The ore taken from the mine was shipped to the Arntfield mill for treatment.

Work on the property from the time of the first discoveries in 1926 included a very large amount of trenching, geophysical surveys, some 40,000 feet of diamond drilling, and the sinking of the shaft to a depth of 496 feet, with lateral work on three levels, most of it on the lowest, 450-foot, horizon, from which raises were driven to explore, and later were used in mining, the orebody. A number of occurrences of gold-bearing mineralization were found outside of the immediate shaft area, but the drilling indicated that none of these was of commercial size or grade. All operations on the property were suspended in 1938 (MacKenzie, 1941).

Other Occurrences of Gold and Copper Mineralization in Beauchastel Township

Lots 10 to 16, Range X.—A quartz vein, which in places is as much as sixty feet wide, extends in a northeasterly direction across these lots. Two outcrops of similar quartz in lots 7 and 8, range IX, indicate that it continues far to the southwest. There are no reports of gold having been found in this vein (Robinson, 1940, p. 6).

Lot 24, Range IX (Buffam Claims).—A highly silicified zone in rhyolite, mineralized with pyrite, has been exposed in trenches over a length of 360 feet, trending east of north. In one trench, the zone has a width of about forty feet. Interesting gold assays were reported from material taken from the trenches, but results obtained from diamond drilling were disappointing. The occurrence is near the west margin of the Flavrian Lake granite mass (Tanschereau, 1933, p. 72; Robinson, 1940, p. 6).

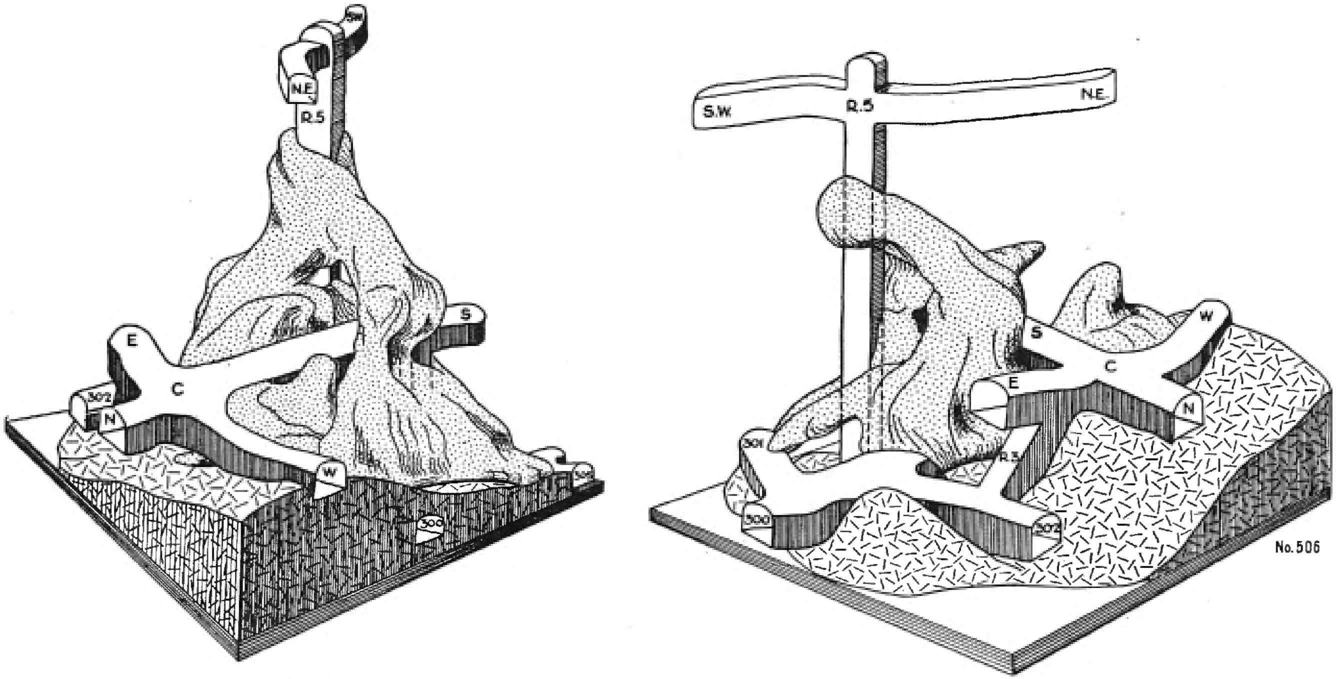


Figure 23.—*Halliwell mine, drawing from model of orebody* (Que. Bur. Mines, G.R. 7, 1941, Fig. 3).

Lots 31 and 32, Range IX (Duke Claims).— Trenches in lot 32 have exposed large, irregular masses of white quartz over widths up to fifty feet in the aplitic border facies of the Flavrian Lake granite. Coarse cubes of pyrite occur in clusters in the quartz, but their distribution is erratic. Low assays in gold have been reported. Similar, but smaller, quartz veins with pyrite mineralization occur in lot 31 (MacKenzie, 1941, p. 23).

Northeast Corner of Townhsip (New Ribago Mines, Limited).—This property, which extends eastward from Beauchastel into Rouyn township, is underlain by Keewatin-type volcanics, andesite in the northwest and rhyolite in the southeast. During the years 1926 to 1929, a considerable amount of surface exploration was carried out and, in the northern part of the property, a shaft was sunk to a depth of 147 feet, at which horizon a small amount of lateral work was done. In 1937, when New Ribago Mines was incorporated, further stripping and trenching was carried out and fourteen diamond-drill holes were put down by Noranda Mines, Limited, who held an option on the property.

Numerous quartz veins, ranging in length from 50 to 600 feet and most of them less than three inches wide, have been found in northeasterly trending shears in the volcanics. The majority of them are mineralized with pyrite, and some also with chalcopyrite; both minerals are also present disseminated through the adjacent wall-rock. Low gold assays were reported from some of the veins. The results of the underground work from the shaft did not prove encouraging, and the diamond drilling indicated that the sulphide mineralization does not extend to depth (Taschereau, 1938, p. 53; Ross and Asbury, pp. 13-14).

Buffalo Canadian Gold Mines, Limited.—On this property, which is at the east boundary of Beauchastel township, in range IX, quartz stringers mineralized with pyrite and some chalcopyrite occur in sheared and silicified rhyolite, which, in the vicinity of the veins, also contains finely crystalline pyrite. Free gold was reported in one of the veins.

In 1929, a 112-foot shaft was sunk on the mineralized zone and a small amount of lateral work was done on the 100-foot level. In 1931, the property was acquired by Buffalo Canadian Gold Mines, who exposed the zone by stripping and trenching over a length of 135 feet and a width of five feet. In 1943, *Montmagny Gold Mines, Limited*, subsidiary of the Buffalo company, commenced a diamond-drilling programme to explore the mineralization at depth (Taschereau, 1932, pp. 84-85; Lafontaine, p. 74).

Les Mines D'Or Provencher.—This property is at the west boundary of Beauchastel township, in ranges VI and VII. Crossing lots 2 to 4, range VII, with easterly strike, is a dyke of quartz diorite, up to 200 feet wide and exposed for a length of 1,500 feet. Traversing the dyke, with trend N.40°E., is a zone up to thirty feet wide along which the diorite is silicified and carbonatized and contains disseminated pyrite. This zone has been explored in trenches over a length of 200 feet, and also by some diamond drilling. The south margin of the dyke, which is similarly silicified and mineralized with pyrite, has also been investigated. Assays of samples from both zones indicate only a very low content of gold (Robinson, 1941, p. 6).

Lots 3 and 4, Range VI, Beauchastel Township (Morgan-Piché Claims). —Sulphide mineralization occurs on these claims in two bands of rhyolite, between which is a band about sixty feet wide of basic volcanics. The occurrence has been investigated by trenching and some diamond drilling. The northern band of rhyolite is intruded by a syenite porphyry dyke which, where exposed in two trenches, is forty feet and twenty-five feet wide, narrower to the east. Both the dyke and the rhyolite contain disseminated pyrite. Assays of samples taken in two trenches, each more than 100 feet long, across the band are reported to have shown an interesting but not commercial content of gold. The rhyolite in the southern band is similarly mineralized with pyrite over a considerable width. A grab sample relatively rich in pyrite assayed 0.238 oz. gold per ton (Robinson, 1941, pp. 5-6).

Lots 15 and 16, Range VII, Beauchastel Township (MacDonell Claims). —These claims are underlain by Keewatin-type volcanic rocks which, immediately to the east, are intruded by the large, composite body of syenite porphyry already referred to in describing the Aldermac mine. The volcanic rocks are much altered and fractures in them contain narrow veinlets of pyrite, with some chalcopyrite. These have been explored by trenching and test-pitting, but the results of this work have not been published (Robinson, 1941, p. 7).

Blocks 15 and 16, Range-line V-VI, Beauchastel Township (Beauchance Mines, Limited).—This property is about one mile southwest of the Aldermac shaft and the same distance northeast of the Arntfield property. The claims are underlain by northeasterly striking rhyolite flows with interbanded beds of breccia, some of which are ash beds and others probably flow breccia. Along a zone striking N.75°W., and presumably following an early fracture plane, the rhyolite and breccia are replaced by sulphides, almost wholly pyrite, with magnetite toward the edges. In the rhyolite, the zone of complete replacement is comparatively narrow, three to six feet, but where it crosses the breccia it suddenly widens to thirty feet or more of solid sulphides, with partial replacement extending outward for 100 to 200 feet farther. Actually, three beds of breccia are cut by the zone. They are, from northwest to southeast, 15, 32, and 18 feet thick and separated by 60 and 80 feet of massive rhyolite. The occurrence presents an excellent example of the influence of the physical character of the rock upon the process of replacement. The pyrite is reported to give low assays in gold (Cooke *et al.*, pp. 222-224).

Eastward from Lot 21, Range V, Beauchastel Township (East Aldermac Mine).—A strong fault, believed to be the westward continuation of the Horne Creek fault, passes along the north shore of MacKay lake, which is immediately south of the Aldermac mine, with a trend of S.70°W. Paralleling and north of this fault is a pronounced zone of mineralization which is practically continuous for a distance of at least four miles in an east-northeast direction from the Aldermac mine. At various times, and by various interests, much exploratory work has been done along this zone, but up to the present no orebody of commercial value has been discovered.

Lots 3 to 10, Range III, Beauchastel Township (Guinard Gold Mines, Limited).—Between two small lakes, Renaud and Olier, on this property, Temiscamian-type sediments, chiefly conglomerate, are intruded by a small composite body of porphyritic syenite, fractures in which contain quartz stringers mineralized with pyrite and chalcopyrite. These occurrences were investigated a number of years ago by stripping and trenching, some diamond drilling, and from a prospect shaft sunk to a depth of sixty-five feet. A grab sample taken by S. H. Ross from the shaft dump and consisting of syenite porphyry, quartz, pyrite, and chalcopyrite, assayed $1.12 in gold per ton (Ross, 1940, pp. 4-5).

Ranges III and IV, at East Boundary of Beauchastel Township (Durbar Gold Mines, Limited).—The northern half of this property is underlain by Keewatin-type volcanics, the southern half by Temiscamian-type sediments. At the north boundary, the volcanics are intruded by small bodies of quartz diorite. Most of the exploratory work on the property has been on the northernmost claim, where, along certain zones, the interbedded tuffs and lava flows are sheared and carbonatized and contain quartz veins. Tourmaline is present in many of the veins, and all of them carry some pyrite. The adjacent rock is carbonatized and also contains disseminated pyrite.

The main vein, at about the centre of range IV, has a maximum width of eight feet and has been traced for a length of 350 feet, but in general the veins are lenticular, narrowing rapidly along their strike from a width which seldom exceeds six feet. An inclined shaft has been sunk on the main vein, and some lateral work carried out on the 100-foot level. Fairly consistent assays are reported from sampling of this vein, with one channel sample across a width of five feet returning $15 in gold per ton.

In the south part of the property, chalcopyrite has been found in quartz veins, up to one foot wide, in a fault zone in the Temiscamian-type conglomerate (Cooke *et al.*, pp. 275-276; Hawley, pp. 52-55; Bell, p. 15).

Riverside Gold Mines, Incorporated (McDonough Claims).—On this property, immediately west of the northern claims of Durbar Gold Mines, a vein, similar to the main vein on the latter property, has been explored by trenching and some diamond drilling. It has been traced for 150 feet over which it varies in width from eight inches to four feet. Assays for gold are reported to have given erratic results (Hawley, p. 55; Bell, p. 15).

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ROUYN TOWNSHIP

The township of Rouyn lies in the great east-west belt of mineralization which extends westward from Bell river to the Quebec-Ontario boundary, a distance of more than eighty miles, and continues for an additional forty miles in Ontario, to the Kirkland Lake gold mining district. The orebodies of the Horne mine of Noranda Mines, Limited, are the outstanding deposits in the section of the belt in Rouyn township and, due to them, much attention has been focused on the township since 1922. Besides being the second largest producer of gold in the Dominion, the Horne mine is noteworthy for its large output of copper. There are a number of other producing mines in the township, but their chief or sole product is gold, with some associated silver. In 1942, these mines were: Powell, Senator-Rouyn, Stadacona, McWatters, and Granada. These, and other gold deposits of interest, are described in the pages that follow. The Horne mine is dealt with in a subsequent chapter (p. 338), together with other Quebec copper mines and deposits.

Detailed geological mapping on a published scale of 800 feet to the inch has been completed recently in the northwest quarter of the township by M. E. Wilson, of the Geological Survey of Canada. The remainder of the township has been mapped, but, except locally, the geological features are not shown in great detail. The description of the Horne mine orebodies, by Peter Price, in the section of this volume dealing with the copper deposits, elucidates many problems concerned with the structural geology and mineral deposits of the general area.

General Geology

Except in the eastern part of the township, rock outcrops are locally numerous and extensive. The oldest rocks in the northern part are Keewatin, or Keewatin-like, volcanics and, in the south, Temiscamian, or Temiscamian-like, sediments. Most, if not all, of these sediments are believed to be younger than the volcanics. The latter include all types of flows and a small but important proportion of coarse and fine volcanic fragmentals. The sediments are chiefly greywackes and more or less sheared conglomerates, with some slates (see Figure 17).

The boundary separating the Keewatin- and Temiscamian-like groups may in large part be a fault or series of faults.

Although pebbles of granite, syenite, and vein quartz are present in the conglomerate bands of the sedimentary series, no intrusive body known to be older than these sediments has thus far been recognized in this township. The oldest known intrusive rocks are dykes and sills, now much altered, which resemble, and are probably closely contemporaneous in age with, the lavas they intrude. They are of somewhat rare occurrence and most commonly are of 'greenstone' or rhyolitic type. The next oldest intrusives, also highly altered, approximate quartz diorite in composition and were known formerly as 'older gabbro'. Related to these are dykes of albite granite. Intruding the volcanics in the northern part of the township are many small and large, irregular bodies of this 'older gabbro' which, locally, forms a high proportion of the rock as a whole; but intrusions of this type are rare in the sediments. A body of albite granite (the Powell granite), somewhat similar to that referred to above as an acidic facies of the 'older gabbro', occurs north of the Horne Creek fault, about a mile northwest of the Horne mine. It has a length, east-west, of five miles and a width of upwards of one mile, but only the eastern part is in Rouyn township. It is intruded by small dykes, some acid and others basic in composition. The only other body of granite in the township is a small mass which intrudes the schists at the southeast corner. Younger, minor intrusives include occasional lamprophyre dykes. Apparently much later than all the foregoing are a group of diabase and gabbro dykes ('later gabbro'). They are not all of the same age and have different trends, but all dip steeply. An age determination made by the helium-ratio method indicates that the Noranda diabase dyke is of late-Precambrian age (Wilson, p. 47).

Structure

In both the lavas and the sediments, dips are steep to moderate, and the main fold structures have a general eastward trend, though divergences from this are common, especially in subsidiary folds. A faulted anticline is believed to explain the pattern of the rocks in the general locality of the Horne mine.

Faults are numerous, and along some of them considerable displacement has taken place. Many of the strong faults strike easterly or slightly north of east. Perhaps the most important of these is the Horne Creek fault, which passes just north of the Horne mine, but there are others of like strike to north and south of this. A second group of strong faults strike northeasterly, and many of these terminate against, or pass into, easterly striking faults. There are many faults of this type in the township, two prominent examples being the Pelletier Lake fault and the Davidson Creek fault. A third group of faults have northwesterly strike. There are comparatively few of these and they are of small displacement. Study of faults on the Powell property indicates that they are older than the easterly and northeasterly faults. More northerly directions of failure have also been noted. The result of all this faulting has been to make a complex mosaic of terrain which, lithologically and stratigraphically, presents many problems even where faulting is absent. The importance of these faults in the localization of ore in favourable structures, often subsidiary features of the faults, is clearly evident in many of the deposits.

Mineralization

The orebodies in the township present a variety of types, and most of them have been formed by deposition of material from a succession of mineral-bearing solutions. Copper mineralization of importance is confined to the northern part of the township and reaches its optimum in the sulphide orebodies of the Horne mine. Only minor amounts of chalcopyrite or other copper minerals have been found in deposits south of the Bagamac fault, which is near the south shore of Tremoy (Osisko) lake. Arsenopyrite is even more restricted in its distribution. Absent from deposits in the northern two-thirds of the township, it makes its first appearance near the northern margin of the sedimentary belt, and less than a mile farther south it is an important constituent of the gold-bearing quartz veins of the Granada mine. From there eastward arsenopyrite is of frequent occurrence and it is prominent in the gold ore of the McWatters mine. Other metallic minerals, and also gangue minerals, occurring in the ore deposits of the township are more widespread than chalcopyrite and arsenopyrite. Gold is widely distributed, but it is not by any means present in all veins or mineralized zones, and when it is present, as in the sulphide orebodies of the Horne mine or the quartz veins of the McWatters mine, it is erratic in its occurrence, with no close relationship to any other mineral, often forming ore shoots. The gold is often seen veining both the gangue minerals and the other ore minerals and is obviously one of the last minerals to have been emplaced.

Noranda Mines' geologists are of opinion that the copper and gold mineralization in the orebodies of the Horne mine took place after the intrusion of the 'later diabase' dykes. On the other hand, dykes of a like nature cut, and are therefore younger than, the gold-bearing quartz veins and ore zones of the Stadacona, Granada, McWatters, and certain other mines in the township. Unless, as it might be argued, the gold in these deposits was introduced at a very much earlier date than that in the nearby Horne orebodies, there must have been a great interval of time between the formation of the quartz veins and the emplacement of gold in their ore shoots. If it is accepted that the gold mineralization occurred long after the formation of the quartz vein-systems and that there were intervening structural events, such as faulting and fracturing, most of the complexities and anomalies of the distribution of gold within the township are easily explainable.

Northwest Section of Rouyn Township

Powell Rouyn Mines, Limited

The inclined (No. 1) shaft of the Powell Rouyn mine is a mile and a half west, and half a mile north, of the Noranda smelter, and 4,000 feet a little east of south of the Pontiac Rouyn shaft. The orebodies on the property are of two types: gold-bearing veins or vein-systems, including the Powell or Main vein and the Southeast vein; and sulphide deposits carrying both copper and gold.

After intermittent work which began in 1922, Powell Rouyn Mines started an extensive exploration and development programme which included much surface work, some 7,000 feet of diamond drilling, deepening of the inclined shaft from 225 feet to 500 feet, the sinking of two additional shafts, and the completion of a road from the property to the Noranda smelter. Shipment of ore to the smelter, as gold-bearing siliceous flux, began in September, 1937. In September, 1940, the Company's own mill, of about 450 tons daily capacity, started operation for the treatment of ore of low-silica content, but high-silica ore continued to be shipped to Noranda. In April, 1942, this mill was closed down, and since then all the ore has been treated at the Noranda smelter. Production of gold to the end of 1943 has been as follows:

Year	Ore Treated	Gold Produced
1937	29,565 short tons	4,345 fine ounces
1938	159,430 " "	25,567 " "
1939	255,020 " "	36,203 " "
1940	225,250 " "	25,134 " "
1941	333,303 " "	37,399 " "
1942	301,194 " "	34,810 " "
1943	266,069 " "	34,549 " "

The ore reserves as at March 31st of the following years, were estimated to be:

1944	576,678 tons	containing 0.134 oz. gold per ton
1945	460,024 "	" 0.135 oz. " " "

Geology

The northern part of the property is underlain by volcanic rocks, the southern part by granite (Powell albite granite). The volcanics are chiefly andesite but include some rhyolite and rhyolite tuff, either interbedded with the andesite or lying structurally above or below it. The complexity may be due to faulting. This volcanic assemblage is considered to be in the north limb of the Noranda anticline (Cooke *et al.*, pp. 236-240; Wilson, pp. 125-132).

The Powell granite does not differ greatly from the rhyolite except in texture, and, where the rhyolite has been recrystallized by the metamorphic action of the granite, the contact is hard to place. Locally, notably near Héré (*Rosebury*) lake, some 2,000 feet northwest of No. 1 shaft, the granite is so heavily chloritized that it has a more or less dioritic appearance on a weathered surface.

The rocks are intersected by numerous faults. The strongest of these is the Horne Creek fault, which passes 4,000 feet south of No. 1 shaft, with strike N.80°E. Undoubtedly there have been recurrent movements on this pronounced structure, and one of the latest of these displaced the south part of the Powell 'later diabase' dyke 700 feet west of its north section.

Another strong fault, designated No. 3, strikes northeast through a point 1,500 feet north of No. 1 shaft. The zone of shearing along this fault is exposed in three localities, with a maximum width of ten feet. Locally, the sheared andesite and rhyolite contain chalcopyrite mineralization.

No. 1 fault, striking east-west and traced for 4,000 feet, passes 80 feet south of No. 3 shaft. To the west, it approaches and may join No. 3 fault. The Powell 'later diabase' dyke is apparently not displaced by it. Chalcopyrite mineralization is known at two points in the neighbourhood of this fault.

The No. 2 fault zone is about 900 feet south of No. 1 and 1,000 feet north of the north margin of the Powell granite mass. It outcrops adjacent to the west side of the later diabase dyke and from this point can be traced westward for about 1,200 feet.

The Powell, or Main, vein and the Southeast vein are in close alignment and may be localized along a 'break' that is not all mineralized and that is at least 3,500 feet long. Their strike in general is N.35°W., with the dip 60° northeast. Schistosity is not prominent along this 'break', but locally the rocks are brecciated. East-west transverse faults which themselves contain vein material cut the main veins, segments on the south side of the faults being displaced usually westward. These faults correspond closely in strike with the Horne Creek fault, along which, as already mentioned, there has been a westward displacement of the southern part of the Powell 'later diabase' dyke.

Reference is made to other directions of shearing or faulting in the descriptions of the chief mineral occurrences that follow.

Gold-Bearing Quartz Veins

The Powell or Main vein zone is mined from the No. 1 inclined shaft and from the No. 2 vertical main operating shaft, which, in 1945, had a depth of 2,625 feet, with the first level at 200 feet and succeeding levels at 150-foot intervals to 2,540 feet. The zone strikes approximately N.30°W. and the dip averages 58° northeast. At surface, it is intermittently exposed for a length of 1,000 feet and underground it has been followed for more than 1,800 feet. The wall-rock is mostly Powell granite, but at the north end it is rhyolite. In places, it is dark grey, due to chloritization. The width of the mineralization ranges from less than a foot to over twenty feet, the average being about ten feet, of which one-half is quartz, occurring as veins that range in width from less than an inch to upwards of twenty feet. Locally, the zone contains a considerable amount of breccia and is intersected by numerous mineralized, transverse faults.

The vein material is mostly milk-white quartz in which pyrite occurs as scattered crystals or granular aggregates. The only other metallic minerals recorded are specularite and native gold. The transverse faults contain quartz, calcite, ankerite, pyrite, specularite, chalcopyrite, marcasite, and gold. The chalcopyrite is present in aggregates up to several inches in diameter, and is seen filling fractures in pyrite. The specularite also is later than the pyrite, which it coats, and some late quartz has been noted veining pyrite. The gold is largely, if not wholly, associated with pyrite, and is in greater concentration in the transverse veins than in the main vein zone. According to Wilson (p. 130), calcite was originally present in the transverse veins in considerable quantity. Down to the 1,050-foot level of the mine, the lowest at the time of his visit, he found 'caverns', up to five feet in diameter, along the veins, from which the calcite had been dissolved away.

The Southeast vein zone is intermittently exposed in outcrops and prospect pits for a length of about 800 feet between 1,200 and 2,000 feet southeast of No. 1 shaft. It lies wholly in Powell granite. The width of quartz in the zone ranges from one to fifteen feet. The Company estimated that, at surface, for a length of 594 feet, the average width of gold-bearing material and mineralized rock is nine feet. Mineralogically, this vein zone is apparently similar to the Main zone.

The Northwest vein has been explored for a length of 1,200 feet by a series of trenches and shallow diamond-drill holes. Over this length, the combined results of assays of surface samples and ten bore-hole intersections indicate an average grade of 0.198 oz. gold per ton over an average width of three feet.

Wilson (p. 134) suggests that these three Powell vein zones, and also the Pontiac Rouyn vein, described later, are probably parts of a single general vein system, but that the Pontiac Rouyn vein has been displaced 1,000 feet eastward by faulting.

No. 4 vein, also known as *E* vein, is about 4,200 feet a little north of east of No. 1 shaft. It is in rhyolite, east of the later diabase dyke, and consists of veins of quartz, containing some pyrite, in a zone up to four feet wide. The vein strikes northwest and is intermittently exposed in outcrops and trenches for a length of 400 feet. A length of 303 feet is reported to average 0.057 oz. gold per ton across a width of 6.7 feet of quartz and wall-rock.

Sulphide-Bearing Zones

Four zones or areas of copper-bearing sulphide mineralization have been investigated. They all lie in or adjacent to faults.

Two of the deposits are associated with fault No. 1. The east, or No. 3, shaft, 1,700 feet southeast of No. 2 shaft, was put down to explore one of these. Broken rock on the shaft dump contains aggregates of chalcopyrite, pyrrhotite, and pyrite up to an inch and more in diameter.

Along the same fault, 900 feet west of the shaft, are a number of prospect pits, the largest 40 feet long and up to 18 feet wide. The andesite exposed in all these openings is rusty weathering, fractured, and traversed by small faults, and locally is mineralized with small aggregates of sulphides, including some chalcopyrite.

Along the No. 2 fault, a mineralized zone in rhyolite tuffs has been exposed for about 300 feet in an east-west direction, ranging in width from six inches to four feet. The eastern end of the zone is about 700 feet west of the 'later diabase' dyke. The zone is obliquely displaced in places by minor faults. It consists chiefly of chalcopyrite and quartz. An average sample taken by Wilson (p. 128) assayed 10.09 per cent copper, and 0.02 oz. gold and 2.92 oz. silver per ton. The zone has been explored by diamond drilling, and assays of the mineralized rock intersected are reported by the Company to have ranged from 3.70 to 13.93 per cent copper, and 3.00 to 5.88 oz. silver per ton, across true widths of four to five feet.

Chalcopyrite mineralization outcrops in three localities spaced over a length of about 1,000 feet along the No. 3 fault. In the most northeasterly exposure, 1,700 feet north of No. 1 shaft, the rock is andesite; in the others, it is rhyolite. At each locality, veins from three to eight inches wide, consisting of abundant chalcopyrite, some quartz, and varying amounts of pyrite, occur in the sheared volcanics over a width of four to eighteen inches.

Despina Gold Mines, Limited

This property is in the northwest corner of Rouyn township and extends beyond into the three adjacent townships. The underlying rocks are chiefly andesite flows, striking northeast and dipping southeast. Two ravines traversing the property with this strike are thought to mark the positions of faults, and along them the andesite is much sheared and is cut by transverse fractures, striking nearly east-west. A number of mineralized veins have been found in these fractures. One of them, 150 feet east of the northwest corner of the township, has a width of about six feet and contains chalcopyrite and pyrite, but no gold, and some 1,400 feet south of this is a similarly mineralized vein, ten feet wide. Between these are three other narrow veins or stringers which have been traced for lengths of 200 to 700 feet. Like the wider veins, these contain copper and iron sulphides, but they are consistently high in gold, with some assays as high as one ounce per ton reported over widths of a few inches.

These occurrences have been investigated intermittently by various interests, including Vickers Mines, Limited, in 1927, Ceres Explorations, Limited, in 1935, and Despina Gold Mines, Limited, in later years. In addition to a considerable amount of trenching and test-pitting, some diamond drilling has been carried out (Dufresne and Taschereau, pp. 107-108; Ross and Asbury, pp. 20-21).

Pontiac Rouyn Mines, Limited
(Since 1943, *Anglo-Rouyn Mines, Limited*)

The Pontiac Rouyn shaft is about two and a quarter miles northwest of the Noranda smelter and a mile north-northwest of the main operating shaft of the Powell Rouyn mine. It is in the northwest corner of Rouyn township, half a mile northeast of Rosebury lake. Exploration on the property, carried out between 1933 and 1935, included more than 9,000 feet of diamond drilling and the deepening of a previously sunk, inclined prospect shaft from 50 feet to about 250 feet, with a small amount of drifting on the 120-foot and 200-foot levels. It was reported that this work indicated 160,000 tons of ore, of which 72,000 was estimated to carry 0.233 oz. gold per ton.

The property is underlain by Keewatin-type volcanics which include an older andesitic assemblage and younger rhyolitic flows, with both of which there are some interbedded tuffs. These rocks are presumably on the northeast flank of the Noranda anticline.

About 150 feet northwest of the shaft, the volcanics are cut by a fault (No. 2 fault) striking N.50°E. It underlies the drift-filled valley of Héré creek. Wilson considers that the horizontal displacement on this fault is of the order of 2,000 feet, the block of rhyolite on the southeast side having moved northeast with respect to the older andesite of the northwest side. About 900 feet southeast of this is another fault (No. 1) with similar strike and also of considerable displacement. It cuts across an outcrop just to the north of the road leading to the shaft from the Macamic-Noranda highway, at a point 2,200 feet east of the shaft. Here the rock is sheared and fractured over a width up to fifteen feet and is rather heavily mineralized with chalcopyrite and pyrite.

The most important orebody so far discovered on the property is the one on which the shaft was sunk. Underground work and diamond drilling have explored it for a length of 660 feet along its northwesterly strike. It dips at 60° to the northeast. The wall-rock is andesite, with granite (not exposed at surface) forming the hanging-wall in some places. Within the sheared rock are narrow gold-bearing quartz veinlets extending over a width up to eight feet and probably averaging about three feet. Wilson (p. 134) has suggested that this vein zone was originally a direct northward continuation of the vein zones of similar strike and dip on the adjoining Powell Rouyn property and that its present offset position of about 1,000 feet eastward of the latter is the result of displacement along a northeast trending fault. As on the Powell Rouyn property, the zone here is cut by east-west faults of small displacement and, where these are numerous, the gold tenor of the ore is higher than average.

The sulphide mineralization associated with the No. 1 fault has been exposed in ten prospect pits and by strippings over a length of 150 feet in a northeast direction. In the fractured zone, sheared silicified andesite is abundantly mineralized with aggregates and lenticular veins, from one inch to five feet wide, composed of about equal amounts of chalcopyrite and quartz. Pyrite is abundant in places, and, in polished sections, is seen to occur as grains included in the chalcopyrite. Rarely, sphalerite also is present, at the margins of, or adjacent to, grains of pyrite (Wilson, pp. 132-135; E. K. Foeckler, personal communication, 1940).

Joliet-Quebec Mines, Limited
(Brownlee Property)

Less than a mile north-northwest of the Noranda smelter, west of the Macamic road, work has been done on ground now controlled by Joliet-Quebec Mines. Besides surface exploration, this has included a considerable amount of diamond drilling and, more recently (1945), the sinking of a shaft to a depth of 600 feet. This work has indicated a large tonnage of mineralized rock containing one per cent copper, but up to the present no high-grade orebodies have been reported. Although adjoining Noranda ground, the two properties are separated geologically by the Horne Creek fault.

The most important zone of mineralization is in altered rhyolite breccia about 3,500 feet north of the Horne Creek fault, striking slightly north of east. Over a length of 2,000 feet and an average width of 300 feet, the breccia contains pyrite, disseminated, in aggregates, and filling small fractures, and, in places, chalcopyrite occurs either in aggregates up to half an inch in diameter or filling irregular fractures in the rock. Quartz veins are not common. Average samples of the pyritic breccia taken by Wilson from surface workings in the east-central and northwest part of the Brownlee claim assayed a 'trace' to 0.20 oz. silver per ton, but contained no gold (Ross *et al.*, p. 41; Wilson, p 144).

Don Rouyn Property
(Sold in 1934 to *Noranda Mines, Limited*)

This property, consisting of mining concession 235, is in the northwest quarter of Rouyn township, immediately west of the Chadbourne group of Noranda Mines, Limited, and southwest of Powell Rouyn ground. Between 1925 and 1929, Don Rouyn Gold Mines, Limited, explored mineral occurrences on the property by several thousand feet of surface rock-cuts and trenches, numerous prospect pits, and 8,500 feet of diamond drilling. A shaft was sunk to 100 feet and a small amount of lateral work was carried out at that level.

The shaft is in the Powell Lake granite mass, 1,300 feet north of the easterly striking Horne Creek fault. The granite contains inclusions of quartz diorite and volcanics, chiefly rhyolite, and is cut by dykes of rhyolite and andesite, and in places, adjacent to these and in the granite itself, there are zones of shearing and faulting, parallel to, and presumably related to, the Horne Creek fault. These zones range in width up to five feet and contain veinlets of quartz and ankerite carrying chalcopyrite and pyrite. The veinlets are from half an inch to six inches wide. Locally, short stretches of the zone contain as much as one per cent copper across a width of three to four feet (Wilson, pp. 144-145).

Quemont Mining Corporation, Limited

The property of this Company, subsidiary of the Mining Corporation of Canada, Limited, is immediately northwest of that of Noranda Mines, Limited. Its south boundary is close to the shore of Horne Creek bay, at the northwest end of Tremoy (Osisko) lake. The mine shaft is on a point jutting from the south shore of this bay.

Between 1926 and 1930, a shaft was sunk to a depth of 925 feet and some thousands of feet of lateral work, and also of diamond drilling, was carried out from several levels. Work was resumed in 1944, when a new programme of diamond drilling was commenced. This work has indicated an orebody of considerable dimensions. The rocks intersected in the workings consist chiefly of rhyolite, intruded by dykes and masses of quartz diorite and the Noranda dyke of 'later diabase'. The rhyolite contains pyrite, which carries gold in varying amounts.

The shaft is a short distance south of the Horne Creek fault, which has been intersected in the underground workings and in diamond-drill holes over a length of at least 1,800 feet. The fault strikes N.80°E. and dips steeply north . The mine workings show a width of 250 feet of fractured and crushed rocks in the fault zone. Some of this material consists of rock fragments, mostly smaller than a pea, in a matrix of clayey gouge. Gouge seams from a quarter of an inch to three and a half inches wide are present, and the less comminuted rock splits readily along slickensided surfaces. That movements have recurred at widely separated intervals and in different directions on this important fault is certain.

Northeast Section of Rouyn Township

The section of the township here considered extends from a little west of the north-south centre-line to the eastern boundary, and from the north boundary as far south as Tremoy lake and, farther east, Rouyn and Routhier lakes. Parts of this northeastern section of the township are low in rock outcrop.

The area is underlain by volcanics, and it is known to be traversed by a number of faults and shear zones. The Horne Creek fault enters from the west, passing eastward across the township at about two miles south of its north boundary. At a point three and three-quarter miles from the east boundary, it is believed to merge with a fault striking northeast. About half a mile southeast of the latter, another northeast fault, on the strike of the Pelletier Lake fault, is indicated, and still other faults or shear zones with this trend are thought to branch off the Horne Creek fault in the vicinity of Tremoy lake.

In this northeast section of the township, exploratory work has been rather localized.

Wiltsey-Coghlan Mines, Limited

Two prospect shafts were put down by this Company in 1934 near the east shore of Tremoy lake. One was sunk to a depth of 84 feet, and a 38-foot cross-cut was opened to the east from the 77-foot level. Sulphide mineralization containing some copper and gold was reported in the face of the cross-cut. The other shaft, 675 feet to the northeast, is 101 feet deep. Some sulphide mineralization was encountered in a cross-cut driven 42 feet to the south on the 97-foot horizon (Taschereau, 1935, p. 85).

During 1933 and 1934, diamond-drill holes aggregating 6,000 feet were put down. Some 1,600 feet of this was carried out by Cléricy Consolidated Mines, Limited, near the east boundary of the property. They reported a low tenor of gold in a zone of sulphide mineralization in altered rhyolite. Little work was done between 1934 and 1944; in the latter year a new programme of diamond drilling was started.

Donalda Mines, Limited

This Company, formerly Donalda Copper Mines, Limited, holds upwards of 4,000 acres a little northeast of the Noranda Mines property. Gold, and a low content of copper, are reported in various zones within altered rhyolites and related volcanics. Exploratory work has revealed a mineralized body of tabular form with low dip toward the northwest. Plans for sinking a shaft were announced in 1945.

Guardian Gold Mines, Limited

This property is about three miles west and two miles south of the northeast corner of Rouyn township. Some 1,500 feet of trenching have been done along a rusty-weathering shear zone, ten to fifteen feet wide, in carbonatized volcanics. It has a northwesterly trend and passes diagonally across an east-west ridge. Within this zone is an apparently continuous vein, two and a half to three feet wide, of white quartz, which contains a little tourmaline and sericite. Fractures in the quartz and also in the adjacent wall-rock contain pyrite and a little chalcopyrite. A grab sample of vein quartz traversed by pyrite stringers assayed 0.98 oz. gold per ton; a similar sample with no pyrite gave only 0.03 oz.

Ville Marie-Rouyn Property

This property, which was acquired by Eldona Gold Mines, Limited, in 1944, is about two and a half miles slightly north of east of the Noranda smelter and just north of the east-west trending Horne Creek fault. It is drift covered. In 1939, the Mining Corporation of Canada carried out a systematic programme of diamond drilling over an area 1,500 feet north-south by 250 feet east-west to probe for mineralization north of the fault corresponding to that on the Noranda property south of the fault. The drilling intersected a contact, striking 10° east of south, between andesite (to the east) and rhyolite, which crosses range-line VIII-IX about 6,700 feet east of the north-south centre-line of the township. It was thought that this contact might correspond to the similar contact about 1,300 feet east of Noranda shaft, south of the fault, but if so it is displaced 14,000 feet to the west on the south side of the fault. On the other hand, it is known that the Noranda north-south 'later diabase' dyke is displaced 700 feet to the west on the north side of this fault.

The drilling revealed the presence on the property of zones of sulphide mineralization, up to fifty feet wide, in sheared quartz diorite and rhyolite, containing about 5 per cent pyrite with some veins of solid sulphides, including chalcopyrite, up to two inches wide. Quartz stringers, up to eight inches wide, some containing chalcopyrite, were also intersected. None of the copper mineralization cut by the drilling approached commercial grade, and assays for gold gave negative results.

Seguin-Rouyn Gold Mines, Limited

During 1933 and 1934, this Company did some surface work and 7,500 feet of diamond drilling on its property north of Routhier lake (claims 85336-40), where gold-bearing mineralization had been discovered in 1932.

About 500 feet northwest of a large 'later diabase' dyke that strikes northeast along the northwest shore of the lake, volcanic fragmental rocks are traversed by easterly striking fractures with steep to flat dips to the north. These rocks are carbonatized and sericitized and contain pyrite, and along the fractures are quartz stringers, mostly less than an inch wide. Associated with the quartz are tourmaline, chlorite, and pyrite, and, in some nearly flat seams exposed in one of the trenches, Hawley observed free gold.

The zone, which has been traced for 400 feet by drilling, is forty feet wide and is bordered on the north by a less altered and mineralized zone thirty-five feet wide, beyond which the rock is again highly schistose. Several other mineralized zones of lesser interest have been found on the property (Taschereau, 1934, pp. 103-104, 1935, p. 83; Hawley, 1934, pp. 64-65).

Central Section of Rouyn Township

The section of the township dealt with under this heading comprises an east-west belt, two and a half to three miles wide, whose northern limit is approximately three miles south of the north boundary of the township. The Noranda mine and the towns of Noranda and Rouyn are just outside of (north of) the belt.

The western part of this belt is underlain chiefly by Keewatin-type volcanics, but in the eastern part these are flanked on the south by Temiscamian-type sedimentary rocks, the contact between the two formations trending somewhat north of east. These volcanic and sedimentary rocks are cut by a variety of intrusive rocks. Faulting and shearing, dominantly with east or northeast trend, is a pronounced feature of the belt, whose structure is still but imperfectly known.

There are three producing gold mines in the belt: Senator Rouyn, Stadacona, and McWatters. In addition, gold-bearing mineralization of interest has been found on a number of other properties.

Senator-Rouyn, Limited

The shaft of the Senator-Rouyn mine is about three and three-quarter miles south, and one and an eighth miles east, of the northwest corner of the township. Pelletier lake is one mile to the south, and the Noranda shaft two and a half miles to the northeast. The description that follows is based largely on information furnished by A. C. Lee, consultant for Senator-Rouyn, Limited.

Trenching on surface in 1936 uncovered a vein having a central section seven feet wide of good grade ore, with short high-grade shoots. In 1937 and 1938, a shaft was sunk to 500 feet. Early in 1945, it had been completed to a depth of 2,000 feet and levels had been opened at 125-foot intervals to a depth of 1,375 feet. The mine started production in October, 1940, and a year later a mill of 300 tons daily capacity was in operation. To the end of 1944, the total tonnage milled was 414,116, from which 74,894 ounces of gold were produced, an average recovery of 0.181 ounce per ton of ore milled.

Geology and Structure

The orebodies are in a mass of quartz diorite (older gabbro). This, and the similar rock occurring to the north, westward from Tremoy lake, and to the south, in the vicinity of Pelletier lake, probably are parts of a single intrusive body. Andesite dykes, up to five feet wide, cut the diorite or appear to grade into it. Later than these are a few quartz porphyry and feldspar porphyry dykes, up to ten feet wide. Some strike northwesterly, parallel to the ore zone, others at right angles to it.

The No. 1 orebody occurs in a zone of shearing and alteration striking N.50°W. and dipping 45° to 52° northeast. It has a drift length of 500 to 600 feet, which is maintained with remarkable uniformity at least to the 1,375-foot level. This panel of ore has no lateral plunge but extends directly down the dip. Its average width is probably somewhat greater than drift width, but in places it is considerably wider than this and on the 1,250-foot level its central part is sixty feet wide. To southeast, the ore terminates against a zone of faulting, known at the mine as the *Y* fault, or faults. The strike of this fault on the 875-foot level is N.73°E., and its dip here is 80° to 85°, north. Elsewhere, there are flat branches, with dip as low as 40°. Generally, the fault is marked by a narrow zone of crushing in the diorite, but, where it encounters the ore zone, the rock over a width of ten to fifteen feet is strongly sheared and rust coloured, and contains numerous seams of clayey gouge. What is known as the No. 2 East fault, on the 1,375-foot level, may be the downward expression of the *Y* fault. It has displaced the ore and the 'later diabase' dyke for short distances.

The No. 2 ore zone branches from the footwall of No. 1 and partially parallels it in strike. It is, however, steeper, having a dip of 60° northeast. It leaves the No. 1 body at the 875-foot level and is as much as 130 feet southwest of it on the 1,375-foot level. Although mineralization extends for

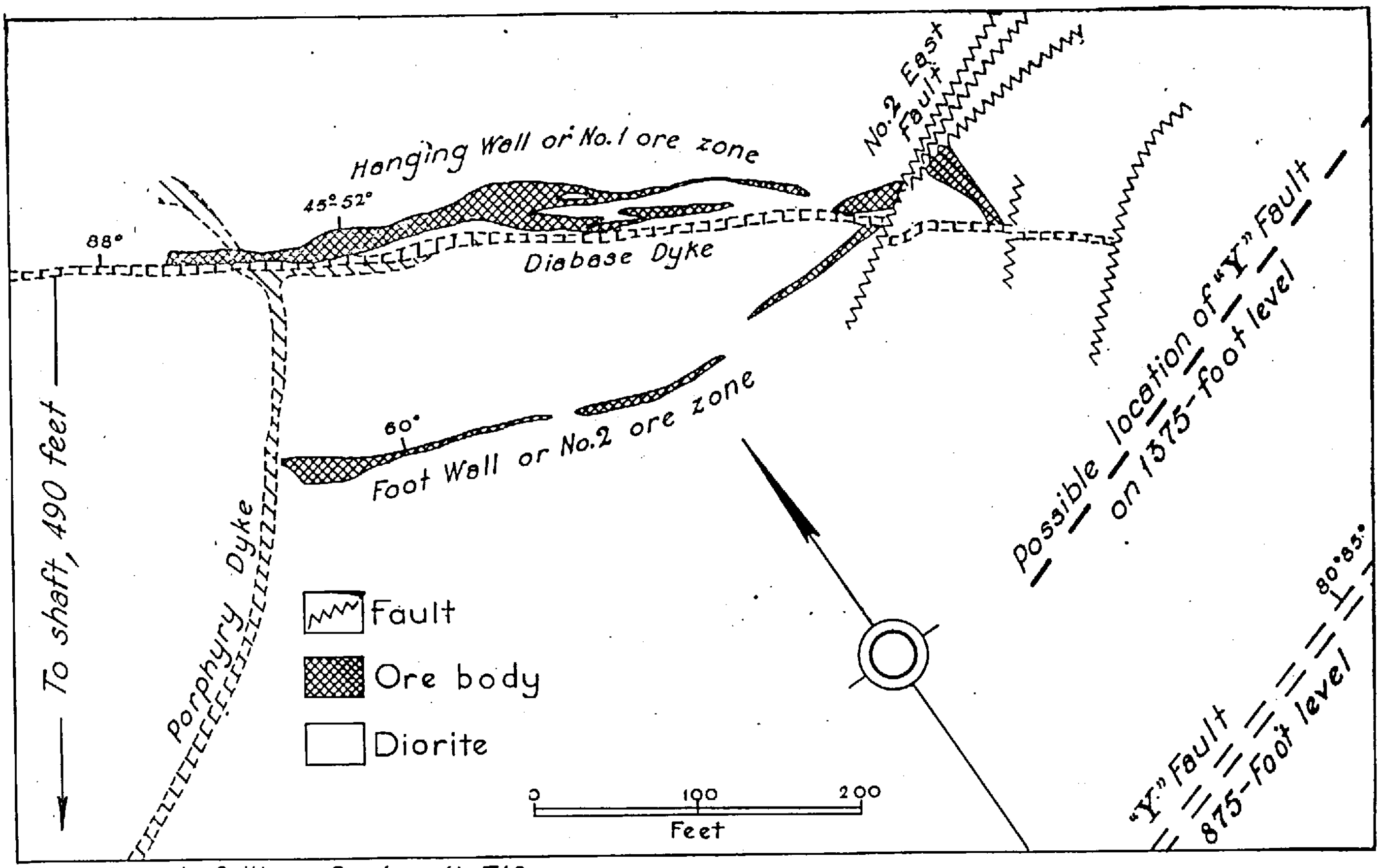

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FIGURE 24.—*Senator-Rouyn mine, plan of 1,375-foot level.*

a greater length than in the No. 1 orebody, the known ore length is shorter, being only 175 feet on the 1,250-foot level. Also, the zone is generally less than drift width. Towards its southeast end, it approaches and possibly joins the No. 1 body in the vicinity of the *Y* fault zone, and its strike here is probably related to the easterly trend of that fault.

Particularly on the 1,250-foot level, a number of veins and bodies of quartz, with accompanying mineralization, extend out southwesterly from the No. 1 orebody into the massive diorite between it and the No. 2 orebody, increasing the width of the former body to sixty feet. They parallel the *Y* direction of faulting.

A narrow 'later diabase' dyke, with steep dip, strikes northwesterly with the No. 1 ore zone and cuts the orebody at the 1,375-foot level. At the east end of this level, the dyke is displaced to the right by small faults, probably related to the *Y* fault zone.

Mineralization

In the No. 1 ore zone, the diorite is heavily sheared, altered, and bleached over a width three to five times that of the main mineralized section. Within the latter, carbonatization and silicification of the rock are very pronounced, and white mica as well as some green chrome-bearing mica (fuchsite) are present. In places, porphyry dykes that have intruded the diorite are altered and mineralized and constitute ore. Quartz stringers and masses from a few inches to many feet wide parallel and also cut across the shearing. Pyrite, some of it coarse, is present in moderate amount. Free gold is seen occasionally.

The diorite in which the No. 2 orebody lies is heavily sheared, much chloritized, and well mineralized with fine to medium grained pyrite. Unlike that of the No. 1 zone, it is not much bleached, carbonatized, or silicified. There is very little quartz in this zone.

Stadacona Rouyn Mines, Limited

Gold was discovered on this property in 1923, on the east shore of Pelletier lake, about two miles south of the town of Rouyn. Surface exploration and diamond drilling having given encouraging results, a shaft was sunk to a depth of 600 feet, a cyanide mill with a capacity of 240 tons per day was erected, and production was commenced late in 1936. By 1943, the shaft had been deepened to 1,875 feet, with levels at intervals of 125 feet, and the capacity of the mill had been increased to about 500 tons per day. In that year, 137,662 tons of ore was treated, with gold recovery averaging $6.29 per ton. Ore reserves were estimated at 398,286 tons. In 1939, the property was placed under the supervision of a liquidator and inspector, until 1945, when it was taken over by Stadacona Mines (1944), Limited.

The property is underlain by Keewatin-type lavas, which strike N.65°E. and dip steeply northward. A short distance northwest of the shaft, these are cut by the northeasterly trending Pelletier Lake fault. Two mineralized zones, about 215 feet apart, occur in the volcanics southeast of the fault, both having the same strike as the fault. Up to the present, commercial orebodies have been found only in the more northerly (No. 2) zone. They consist of quartz lenses, some of which have lengths of 100 feet to upwards of 900 feet, with widths up to sixteen feet. The lenses contain some calcite, iron carbonate, pyrite, a little chalcopyrite, and gold. The gold is in part at least in the free state in the quartz. The ore zone is cut by a north-south diabase dyke, and most of the ore has apparently been found west of this dyke (Hawley, 1932, pp. 47-50; Bell, pp. 19-20).

McWatters Gold Mines, Limited

The McWatters shaft is a mile and three-quarters from the east boundary of Rouyn township and 500 feet south of the centre-line. Sinking was commenced in 1933 near a gold-bearing vein that had been discovered the previous year. From the bottom of the shaft, at the 400-foot level, a winze, or internal shaft, was sunk in later years to the 1,500-foot horizon. The erratic occurrence of the orebodies entailed considerable underground exploration, amounting by the end of 1939 to more than six miles of lateral workings and much diamond drilling.

A mill was erected and placed in operation in 1934, and was later enlarged to treat about 100 tons per day. Up to the end of 1939, a total of 181,644 tons of ore was milled, yielding 72,580 ounces of gold, or an average of 0.40 ounce per ton. The mine was closed in June, 1944, owing to exhaustion of the known orebodies. The mill equipment was sold.

General Geology

The geology in the vicinity of the mine is extremely complex. All the rocks except the youngest intrusive ('later diabase') have been involved in intense folding, and strong faults have sliced these structures into wedges. Along individual faults there have been successive movements and these have been in different directions, resulting in the formation of related fractures and drag folds of diverse attitudes. The relative competence, under stress, of the various rock types involved has played its part in complicating the resultant structural pattern. As the mineralized bodies were formed, in great measure, by successive emplacements of material in openings originating not simultaneously but from time to time, the search for ore has been a most difficult problem.

The strong Thompson Creek fault, striking N.87°E. and dipping 55° north, crosses the property about 1,100 feet north of the shaft. All the evidence indicates that this is an old zone of dislocation, yet a 'late diabase' dyke two and a quarter miles east of the shaft is offset by the fault, with the north part displaced 1,500 feet to the east. On the north side of the fault, to the immediate north of the McWatters property, is a down-faulted block of Temiscamian-type conglomerate, about 1,000 feet wide and more than two miles long, lying within the Keewatin-type volcanics, showing that there has been vertical movement also along this fault. On the McWatters property, a short distance south of the fault, drag folds in highly sheared and carbonatized quartz-diorite or lava pitch east at 35° to 40°. If only one movement occurred on the Thompson Creek fault, with displacement on the north side east and down, related drag folds should pitch to the west—not to the east.

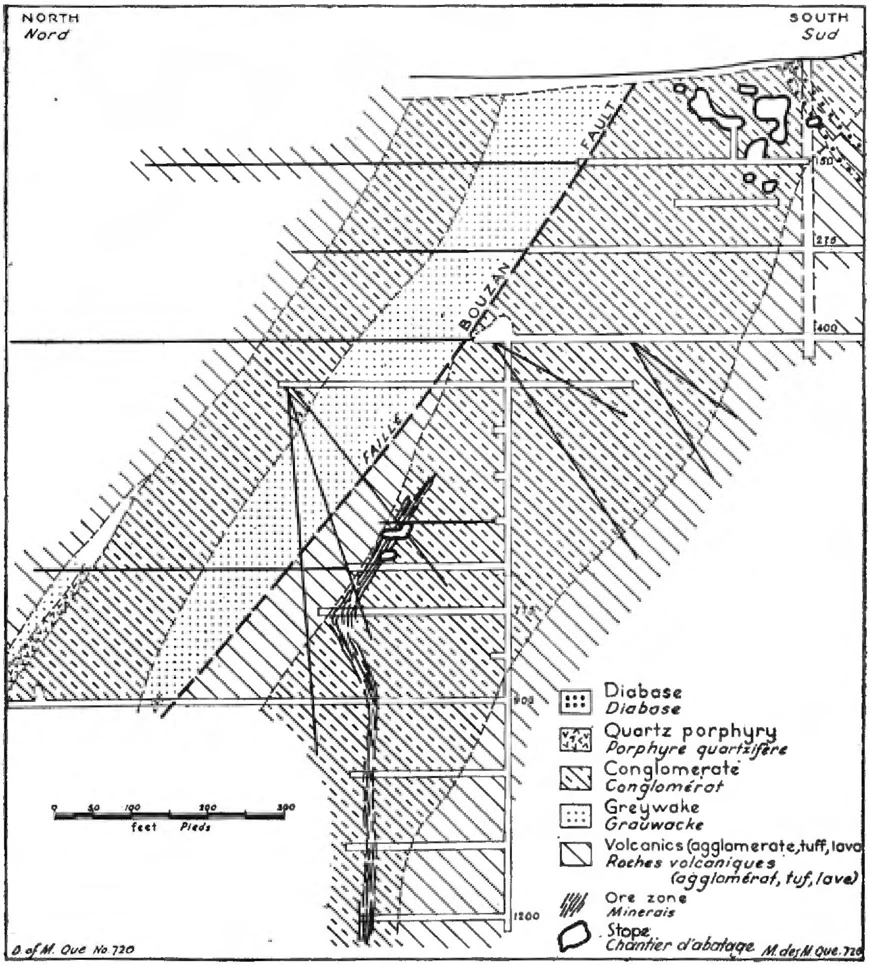

FIGURE 25.—*McWatters mine, vertical section through shaft.*

Another fault—Bouzan Lake fault—trends N.67°E. from Bouzan lake toward the Thompson Creek fault. It dips at 55° to the northwest. At surface, it passes about 230 feet north of the McWatters shaft. On the 400-foot level, a north-south 'later diabase' dyke is offset 270 feet by this fault, with displacement on the north side to the west. Elsewhere, the fact that the rocks on the two sides of the fault do not match suggests that the amount of displacement has been considerable. Where seen in the mine, this fault follows a relatively straight course, along which there has been little or no development of schist. Its strongly slickensided walls are separated, at most, by a few inches of gouge. There is a brecciated zone in the hanging-wall, as much as 45 feet wide in places. The orebodies lie close to and south of this fault.

With the exception of minor intrusives, the rocks in the vicinity of the mine workings are of Keewatin type and include pillowed and amygdaloidal lavas, fine bedded tuff, greywacke, volcanic agglomerate, and a rock that Hawley (1934, p. 13) describes as 'volcanic conglomerate'. The last two are closely related. All these types are more or less schistose and often highly altered. The chief extreme type of alteration is a heavy impregnation of iron-bearing carbonate.

Small intrusive masses of quartz diorite lie north of the mine workings, close to the south side of the Thompson Creek fault, and, in part, the rock is schistose and altered. What was formerly mapped as quartz diorite in the mine workings is now presumed to be Keewatin-type volcanic 'greenstone'. A few narrow dykes of feldspar porphyry or quartz porphyry have been encountered in the lower mine workings north of the Bouzan Lake fault. The youngest intrusives are 'later diabase' dykes, some of which strike northeast, others northwest. Two small dykes of this rock pass a few feet northeast of the shaft, dipping about 70° southwest. They cut tourmalinized schist and gold-bearing veins, and one of them is itself cut by irregular stringers of quartz and carbonates and is mineralized with pyrite.

The conglomerate bed, in which the orebodies occur, has a width on surface of nearly 300 feet, from the Bouzan Lake fault (230 feet north of the shaft) to 150 feet south of the shaft, and since it has a steep dip, the thickness of the bed is between 250 and 300 feet. Although both the fault and the conglomerate strike north of east, the former has the more northerly trend. As a consequence, the ore-bearing conglomerate bed becomes progressively farther away from the fault as the two are followed eastward, but toward the west it approaches the fault and is eventually cut off by it.

Orebodies

In the earlier mining operations, the main productive bodies were on and above the 150-foot level, with minor occurrences only between this and the 400-foot level. This ore was found, in the main, in five mineralized shear zones, which more or less closely parallel the Bouzan Lake fault and lie to the south of it in the conglomerate, the most southerly zone being at the contact of the conglomerate with the underlying tuffs. Presumably, these shears are related in origin to the strong fault they parallel. The drag-folded nature of parts of them suggests that subsequent adjustment on this or the Thompson Creek fault affected the previously formed schist. As compared with the tuffs, greywacke, and agglomerate, which also suffered considerable dislocation, the conglomerate was more favourable for the development of suitable openings for the mineralizing solutions to follow, presumably due to its greater brittleness.

The discovery vein, or No. 8 mineralized shear zone, outcrops fifty feet north of the shaft. Its richest section was 110 feet long and six to twelve feet wide, with other, smaller sections of interest a short distance beyond that length. This zone contained ore down to the 75-foot sub-level and is traceable to the 150-foot level. The other veins worked in the upper part of the mine were similar in character.

The disappointing results in the upper workings led to the sinking of the winze, and to the discovery within the conglomerate of a relatively strong and continuous zone of mineralization from about the 650-foot to the 1,200-foot horizon. The width of this zone, which was not all ore, was from fifteen to thirty feet. The average width of the ore was fifteen feet and stopes 200 feet and more in length were opened in it on the several levels.

The mineralization on the upper levels is intimately related to shear zones, which often are intensely drag-folded, the folds generally, but not in all cases, pitching eastward. Quartz veins and veinlets follow the shearing and drag folds and also occur as flat gash veins across these structures; consequently, the quartz-rich bodies are very irregular in shape and variable in continuity. The grey-blue quartz is generally well fractured and is the dominant gangue mineral. The mineralized zone on the lower levels is of more consistent habit; drag folds and irregular structures are not common, the bulk of the quartz following the direction of foliation of the zone.

Some of the quartz veins in the intensely drag-folded zones follow these structures faithfully, and it is a question whether some of this quartz is not actually earlier than the drag-folding. Later, introduced quartz would aid in the healing of the earlier fractures and account for much of the quartz that transgresses the drag-folded schists.

Tourmaline, as felted masses of fine needles, occurs in the quartz and also in the schist, paralleling the foliation. Quartz with some sulphides is later and cuts the tourmalinized schist, and both this quartz and the schist are cut by still later seams of fine pyrite accompanied by carbonate and quartz.

Albite is not prominent in the larger quartz veins but is found in the smaller veins and in the tourmalinized schist.

Pyrite and arsenopyrite, in well formed crystals, are associated with the quartz and tourmaline. A later, finer grained pyrite associated with carbonate (ankerite) follows seams which, in some cases, are flat-lying and more or less normal to the schistosity. Pyrrhotite and chalcopyrite are less common, but, like the later pyrite, are associated with carbonate veinlets and replace the earlier minerals.

Native gold and the telluride of gold, hessite, have been noted in fractures in quartz, ankerite, and arsenopyrite. The hessite, which is present in much smaller amount than the native gold, is, where found, intimately intergrown with the gold. High-grade occurrences of gold are not uncommon; where they occur, the veining of the older minerals by the gold is clearly visible (Hawley, 1934).

Bagamac Mines, Limited

The Bagamac shaft is on the south flank of a small rocky hill on the southern outskirts of the town of Rouyn, 800 feet east of the railway. The property includes much of the present town of Rouyn and some ground west of it. Development work has included much trenching and test pitting, upwards of 11,000 feet of diamond drilling, and a small amount of lateral work from the shaft bottom, at the 200-foot level. Very little work has been done on the property since 1934.

The rocks exposed on the property are rhyolite, rhyolite flow breccia, and andesite of Keewatin-type, and intrusive dykes and masses of quartz diorite, albite granite, and later diabase. The albite granite occurs locally within the diorite and is believed to be a facies of this intrusive. Crossing the property is a strong fault (the Bagamac fault) which is traceable along its strike for more than a mile both east and west from the shaft. Its outcrops are marked by a schistose zone with parallel or branching zones of fracturing up to twenty-five feet wide. The rocks adjacent to the fault have been chloritized and impregnated with carbonate.

Most of the trenches and prospect pits were excavated either along the Bagamac fault, or north of it in what is now the central part of the town of Rouyn. Openings along the fault exposed zones of disseminated pyrite up to eighteen inches wide, and aggregates or veins of quartz and rusty-weathering carbonate. It was reported that gold was found in some of the workings, but not in a deposit of workable grade and extent (Wilson, p. 146).

Dasserat Rouyn Goldfields, Limited

Since 1947 property of *Rouyn Improvement Ltd.*

This property, blocks 8 and 9, Rouyn, adjoins Bagamac ground on the east and borders the south shore of Tremoy lake; its western section occupies the eastern part of Rouyn townsite. Surface development work was carried out in 1924 by Dasserat Rouyn Mines, and diamond drilling by the Norlake Mining Corporation, Limited, in 1934 and 1935.

The rock underlying the property is chiefly rhyolite intruded by quartz diorite, the main mass of which grades into albite granite. This granite outcrops on the lake shore and extends south of it for 500 feet. It is cut by the Noranda north-south dyke of 'later diabase'. The east-west trending Bagamac fault crosses the property 700 to 800 feet south of the lake shore. The diabase dyke is not displaced by this fault.

A rock tunnel sixty feet long, three to six feet wide, and up to five feet deep, in the albite granite east of the diabase dyke has exposed a zone, five feet wide, along which the granite is impregnated with carbonate and pyrite, the latter fairly abundant in aggregates and filling seams. Free gold was reported along this zone. Numerous diamond-drill holes have intersected similar mineralization along zones of sheared rhyolite, but assays indicated only a low content of gold. (Wilson, pp. 146-147).

Glenwood Mining Syndicate

The claims of this Company are east of the Dasserat property. Exploration has been confined chiefly to a ridge of rhyolite and rhyolite breccia and has included trenching and test-pitting, 3,000 feet of diamond drilling, and the sinking of a 50-foot prospect shaft at a point about 1,800 feet south of Tremoy lake (Wilson, p. 147).

Farrell Rouyn Mines, Limited

These claims, bordering the south shore of Tremoy lake, are east and northeast of the Dasserat and Glenwood holdings, respectively. They are underlain chiefly by andesite, in which there are two parallel shear or fracture zones, trending west-southwest and about 100 feet apart. The more northerly zone is twelve feet wide, and within it, occupying a width from a foot and a half to four feet, are veins of quartz and ankerite. Individual quartz veins are from half an inch to eighteen inches wide. Pyrite is disseminated in the schistose wall-rock. In the other zone, exposed in only one outcrop, the rock is rusty for a width of fifteen feet and the largest quartz vein is one foot wide (Wilson, p. 148).

Abbeville Gold Mines, Limited

This property lies astride the Rouyn-Beauchastel township-line, west of Pelletier lake. During 1937, claims in range VI, Rouyn township, were explored by trenching and test-pitting and by 17,000 feet of diamond drilling. In the following year, a shaft was sunk to a depth of 261 feet at a point about 600 feet north of Pelletier lake, and in 1939 it was deepened to 375 feet. Lateral work on the 125- and 250-foot levels, and diamond drilling from the latter level, gave indefinite results and operations were suspended late in 1939.

Crossing the township-line and north of the shaft is a prominent east-west trending ridge of porphyritic rhyolite, half a mile long and a third of a mile wide. Along its south side, the rhyolite is in contact with a band of volcanic agglomerate. This east-west striking contact is sheared across a width of about twenty feet. The structure dips steeply northward and drilling has traced it for a length of 3,200 feet. The shaft is sunk in an agglomerate footwall. The best gold-bearing material was found in the rhyolite hanging-wall at places where it is cut by quartz stringers and mineralized with pyrite. Channel samples across drift widths are reported by the Company to have assayed 0.08 to 0.20 oz. gold per ton. A chip sample taken across a width of four feet by S. H. Ross assayed 0.14 oz. per ton (Ross and Asbury, pp. 23-23; Ross *et al.*, p. 39).

Pelletier Lake Gold Mines, Limited

The claims of this Company cover the central part of Pelletier lake and part of its east shore. To the immediate north is the property of Abbeville Gold Mines, Limited, and to the east that of Stadacona Rouyn Mines, Limited. A gold-bearing shear zone (No. 2) continues westward from the latter property across the southeastern corner of the Pelletier Lake claims and has been explored for a length of 700 feet in a drift from the 600-foot level of the Stadacona mine. This and other shear zones on the property have also been investigated by diamond drilling carried out by various interests since 1923.

Rock outcrops being confined to islands and the lake shore, the bedrock geology is in large measure known only from the results of diamond drilling. This has indicated that the claims are underlain chiefly by Keewatin-type volcanics which include andesite, agglomerate, and, in lesser amount, tuff. Intruding these are dykes of quartz diorite and 'later diabase'. Several faults and shear zones are known to be present, the most important probably being the Pelletier Lake fault, which is inferred to have an easterly strike along the west part of the south shore of the lake, but to trend northeast where it meets the east shore. One of these shear zones, forty feet wide, has been exposed in trenches on the east shore of the lake for a length of 450 feet, striking N.80°E. Across a width of three feet it contains quartz veins mineralized with pyrite (Ross and Asbury, p. 25; Ross *et al.*, pp. 41-42).

Rubec Mines, Limited

In and prior to 1928, some surface work and diamond drilling was done on the claims of this Company, which are adjacent to the south and southwest shore of Pelletier lake. Except in the southwest section, the claims are largely drift covered, but all the rocks exposed are Keewatin-type lavas or intrusive quartz diorite. In several places, shear zones in the volcanic rocks, containing quartz veins and mineralized with pyrite or pyrrhotite and a little chalcopyrite, have been explored by trenching and test-pitting. Along one of these zones, just south of the outlet of the lake, six diamond-drill holes totalling some 2,000 feet were put down. Assays of material from these workings are not available (Hawley 1932, pp. 50-52).

Red Gold Mining Company, Limited

This property lies astride the east-west centre-line of Rouyn township, adjoining Stadacona on the east. During the years 1937-38, a mineralized shear-zone in Keewatin-type lavas near the western boundary of the property was investigated by trenching and upwards of 19,000 feet of diamond drilling. The zone parallels, and is a short distance south of, the southeasterly trending Pelletier Lake fault (Bell, p. 20).

Keyroc (Quebec) Gold Mining Company, Limited

The Keyroc property is adjacent to the south shore of Rouyn lake, a mile and a half east of the Red Gold claims. In 1936, a prospect shaft was sunk to a depth of 143 feet, and some lateral work was done at the 125-foot level, to explore a mineralized quartz vein in Keewatin-type volcanics a short distance north of the Pelletier Lake fault. The results of this work were disappointing. In the following year the zone was further investigated by some diamond drilling (Bell, p. 20).

Bowes Gold Mines, Limited

This property adjoins McWatters on the west. It is clay and drift covered, but is underlain by Keewatin-type volcanics, including andesite, rhyolite and rhyolite breccia, and tuffs, which are intruded by a small mass of quartz diorite. Since the claims were first staked by J. Bowes, in 1923, they have been explored from time to time by various interests: Kinogevis Mining Co., Windfall Mining Co. and others. This work has included extensive trenching, a considerable footage of diamond drilling, and the sinking of a shaft to a depth of 130 feet, with some lateral work at the 100-foot level.

The shaft was sunk to explore a quartz vein, eight to twelve inches wide, which cuts carbonatized rhyolite and rhyolite breccia and has been exposed in trenches for a length of 170 feet. It strikes N.50°E. and dips about 40° southwest. Gold occurs in the quartz and the wall-rock is mineralized with pyrite and chalcopyrite. A number of other quartz veins, with similar associated mineralization and some of them gold-bearing, have been exposed in trenches or intersected in diamond-drill holes, both to the north and the south of the shaft, most of them in andesite.

Several northeasterly trending faults cross the claims, as also does the major east-west Thompson Creek fault. Lying at the north side of the latter is a small outcrop of down-faulted Temiscamian-like conglomerate. A test-pit in this has exposed a shear zone, about four feet wide, along which the conglomerate is impregnated with quartz carrying a little tourmaline, carbonates, and chalcopyrite (Hawley, 1934, pp. 44-47; Ross *et al.*, pp. 39-40).

East Rouyn (Quebec), Limited

(Since 1947 *New Rouyn Merger Mines, Limited*)

This property adjoins McWatters on the east lying between it and the Rouyn-Joannès township line. It is drift and clay covered, but trenching prior to 1933 revealed mineralization of interest. Since then, about 20,000 feet of diamond drilling has been completed, most of it in 1938 and 1939. Results of this work were encouraging and plans were made to explore the more favourable zones of mineralization from a shaft.

Investigation has been confined chiefly to the eastward continuation of the volcanic conglomerate bed in which the McWatters orebodies occur. On the latter property, the contact between the conglomerate and the agglomerate to the south of it trends slightly north of east and it continues almost due eastward on East Rouyn ground as far as a point about 1,300 feet from the east boundary of the township, where it turns sharply northward to strike N.25°E. After maintaining this course for about 900 feet it resumes its easterly trend and crosses the township boundary with strike slightly south of east.

At the sharp northerly bend, the conglomerate, normally about 300 feet wide, has a width of as much as 800 feet. It is heavily sheared across great widths and in places, particularly near its contact with the agglomerate, it is heavily mineralized. Some material of ore grade also occurs in the agglomerate immediately below. The mineralization resembles closely that in the ore zones of the McWatters mine, but here the rock is more highly carbonatized and silicified.

The diamond drilling, over a length of 400 feet, is reported to indicate two blocks of ore. One of these, above the 250-foot horizon, is estimated to contain 37,000 tons of ore averaging 0.164 oz. gold per ton over a stoping width of 27.8 feet; the other, cut at depths between 670 feet and 1,020 feet, contains an estimated 156,000 tons averaging 0.252 oz. gold per ton over a stoping width of 21.9 feet (W. J. Hosking, report to the Company).

SOUTHWEST SECTION OF ROUYN TOWNSHIP

The contact between the Keewatin-type volcanics and the Temiscamian-type sediments to the south of them crosses the southwest quarter of Rouyn township with a trend somewhat north of east. The sediments underlie a strip which has a width of three miles at the west boundary and three and a half miles at the north-south centre-line. Mineralization of interest has been found at many localities. The Granada mine, two and a half miles from the west boundary, is in the sediments and is the most southerly mine in the township.

Granada Gold Mines, Limited

(Formerly *Granada-Rouyn Mining Company, Limited*)

The Granada mine is about four miles due south of the town of Rouyn. A gold-bearing vein (No. 1) was discovered on the property in 1923, and, as the result of extensive surface exploration and diamond drilling, several other veins of interest were found during the next three or four years. In 1927, sinking of a vertical shaft on No. 1 vein was commenced. This shaft (No. 1) was taken to a depth of about 650 feet and from the 625-foot level an inclined winze was put down, following another vein (No. 2) on its northerly dip of about 50 degrees. In later years, the winze was continued to surface and was carried to a length, on the incline, of 2,100 feet, giving a total of thirteen mine levels. It is known as No. 2 shaft. The mine was brought into production in 1930 and was active until late in 1935, when the plant was destroyed by fire. Total production of gold during this period was 51,476 ounces from treatment of 181,679 tons of ore, an average recovery of 0.283 oz. gold per ton. Most of the production came from No. 2 vein. In 1935, a new shaft (No. 3), about 5,000 feet north of No. 1, was sunk to a depth of 450 feet on a gold-bearing vein discovered in that year.

Most of the veins on the property have been found in the Temiscamian-type sediments within an area about one mile east-west by half a mile wide. The rock here is chiefly conglomerate, with general strike N.80°E. and dip 50° to 65° north. Intruding it are dykes and lenticular masses of syenite porphyry, which have about the same strike and dip. The largest attains a width of 300 feet on surface, 800 feet east of the shaft, and it has about the same width at the 625-foot level. The gold-bearing quartz veins fill fractures in the conglomerate and interbedded greywacke, and also in the syenite. Associated with the quartz are varying amounts of carbonate, chlorite, sericite, and tourmaline. Of the metallic minerals present, arsenopyrite and pyrite, which are the most abundant, and pyrrhotite and molybdenite, in small amount, were the first to be deposited and are chiefly confined to the wall-rock over widths up to three feet on either side of the veins. They were followed by minor amounts of galena, sphalerite, and chalcopyrite. The gold follows the walls of the veins or fills minute fractures in the quartz. Some has been seen penetrating pyrite crystals, but otherwise the gold does not appear to be associated with the sulphides.

Both in vertical and horizontal sections, the veins have a lenticular habit. No. 2 vein was traced on the upper levels for a length of 1,600 feet, with maximum width of seven and a half feet. Cutting the veins are numerous post-quartz and post-ore faults with diverse trends, along some of which there has been considerable displacement. One of the richest sections of No. 2 vein was a fractured section between two north-striking faults.

No. 3 shaft was put down to explore a mineralized shear zone in Keewatin-type tuffs about 1,800 feet north of the Temiscamian-Keewatin contact. The zone trends east-west and is traceable on surface for 400 feet with a width up to fifteen feet. It contains quartz stringers mineralized with pyrite and had been little investigated at the time operations on the property were suspended in 1936 (Hawley, 1932, pp. 26-43; Taschereau, 1936, p. 47).

Astoria Quebec Mines, Limited

The shaft of Astoria Quebec Mines is a mile and a half south of the township's centre-line, about midway between the Stadacona and Granada shafts. It was sunk in 1937 to a depth of 269 feet and some 3,000 feet of lateral work was completed on the 125- and 250-foot levels. Other work on the property had included much trenching, the driving of a 175-foot adit, and some diamond drilling.

There are two chief areas of mineralization, about a quarter of a mile apart. In the more northerly, a shear zone in tuffs with some interbedded lavas is sparsely mineralized with pyrrhotite and chalcopyrite. Intruding the volcanics is a quartz diabase dyke, which is itself cut by a dyke of olivine diabase. The zone has been exposed in several small pits and in the adit. These show mineralization extending over a width of two to three feet, but it lacks continuity.

The shaft was put down to explore the occurrence to the south of this, where a zone in rusty-weathering carbonatized schists, 75 feet wide and exposed for 300 feet in an easterly direction, contains a stockwork of quartz stringers, some as much as a foot and a half wide. Ankerite, green chromiferous mica, and pyrite are abundant in the schists. Immediately to the south, the schists or tuffs are heavily mineralized with arsenopyrite across widths up to five feet, and quartz veins within them also contain arsenopyrite. Assays of material taken from some of these veins gave negligible returns in gold (Hawley, 1932, pp. 45-46; Taschereau, 1938, p. 54).

Northern Quebec Gold Mines, Limited

This property is one mile northwest of La Bruère lake and about a mile and a quarter east of the Granada mine. During the years 1931 to 1934, some gold-bearing quartz veins were explored by a considerable amount of trenching and stripping and from a 180-foot adit and a prospect shaft forty feet deep.

These workings are chiefly in schistose Temiscamian-type conglomerate and interbedded greywacke which are intruded by twenty or more syenite porphyry dykes from one to thirty feet wide. The quartz veins occur in the sedimentary rocks adjacent to the dykes, or in the dykes themselves. Sediments, dykes, and veins all strike slightly north of east.

Several dykes were exposed by the trenching and also by the adit, which was driven to cross-cut them. They pinch and swell along their strike, from mere stringers to a width that seldom exceeds two feet. They, and the adjacent wall-rock, are mineralized with more or less pyrite, and, locally, some of the veins are gold-bearing. The main vein was followed for a length of 360 feet, over 200 feet of which it was reported to contain fine gold (Hawley, 1934, pp. 55-56; Taschereau, 1934, p. 103, 1935, p. 82).

Southeast Section of Rouyn Township

Dransfield Quebec Mining Company, Limited

The claims of this Company are 3,200 feet south of Bouzan lake, which is a mile and three-quarters due south of Rouyn lake. The faulted contact between Keewatin-type volcanics (to the north) and Temiscamian-type sediments trends east-west through Bouzan lake. The sediments underlying the claims are greywacke with some lenticular interbeds of conglomerate. Their general strike is east-west, with dip 60° to 70° north. About 2,000 feet southeast of Bouzan lake, the sediments are cut by a northerly trending dyke of later diabase, sixty feet wide.

Numerous quartz veins occur in the sediments, paralleling the bedding. They range from a few inches up to eight feet in width, and in some zones are closely spaced over widths of as much as thirty feet. One vein has been followed for a length of 250 feet. The majority consist of quartz with a little sericite and are apparently barren, but a few contain tourmaline, pyrite, arsenopyrite, pyrrhotite, and gold (Hawley, 1934, pp. 49-51).

West McWatters Syndicate, Limited

These claims, which are on range-line IV-V, 7,000 feet southwest of the McWatters shaft, are underlain by Temiscamian-type sediments and, to north of these, Keewatin-type volcanics. The contact between the two formations is not exposed. Trenching across the sediments has exposed sheared greywacke and conglomerate containing quartz veins with widths from a few inches up to five feet. One of the veins has been traced for a length of 275 feet. In places, small amounts of pyrite, arsenopyrite, and chalcopyrite are present in both schists and quartz (Hawley, 1943, p. 57).

Adanac-Quebec Mines, Limited

This property is about one mile west of Valley lake and three miles from the south boundary of Rouyn township. A considerable amount of work was done here between the years 1932 and 1937, including the sinking of a shaft to a depth of 500 feet and lateral work on the 125-, 250-, and 500-foot horizons.

The claims are underlain by Temiscamian-like slates and greywacke, which lie south of the conglomerate band in which the Granada veins occur. The sediments are closely folded. Near the southwest corner of the property they are cut by two narrow dykes of quartz diabase.

Most of the development work has been concentrated on exploring the possibilities of a quartz vein which, on surface, follows a persistent vertical shear in the greywacke for a length of some 750 feet, trending slightly north of west. It pinches and swells to a maximum width of three feet, and locally it is abundantly mineralized with pyrrhotite, pyrite, chalcopyrite, and arsenopyrite. The sulphides occur also in the schistose walls, which are locally graphitic. Gold assays are reported from sections of this vein on the 125-foot level, but results from the extensive workings on the levels below this were disappointing (Hawley, 1934, pp. 60-63; Bell, p. 21).

Gold Valley Mines, Limited

Some surface work and diamond drilling has been done at various times on a group of claims bordering the northwest bay of Vallet lake, about half a mile northeast of the Adanac Quebec claims and a mile and a half south of the main workings of the McWatters mine. Formerly known as the Lemire claims, the property was held in turn by Gold Valley Mines, Limited, and Sturgeon Goldfields, Limited. In 1933, Sylvanite Gold Mines, Limited, carried out some work on the property.

The claims are underlain by Temiscamian-type greywacke and conglomerate and, along shear zones in these, a number of quartz veins have been found, which, in places, contain tourmaline. They are mineralized with pyrite and arsenopyrite, and some of them are gold-bearing. The schistose rock adjacent to the veins has been carbonatized and contains tourmaline and pyrite. Veins have been traced for lengths of 100 feet to more than 300 feet, and one of them has a length of at least 1,200 feet if an exposure of quartz beyond a drift-covered area represents its continuation. They vary in width from place to place and some of them fork or are represented by lenses and stringers spaced over a width of fifteen or more feet of the schistose sediments they traverse (Hawley, 1934, pp. 57-60).

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JOANNÈS TOWNSHIP

Joannès township is underlain by a conformable series of Keewatin and Temiscamian type volcanic and sedimentary rocks which are the westward continuation of the Malartic-Cadillac synclinal belt. The east-west trending Cadillac 'break' crosses the township about one mile north of its centre-line, and the Davidson Creek fault extends southwestward across the northwest quarter, meeting the Cadillac break at the 'big bend' of Kinojévis river and continuing along the southwest-trending stretch of that river. The Thompson Creek fault commences at, and extends westward from, the big bend (see insert Figure 26, p. 175).

The whole of the township south of the Cadillac break is occupied by sedimentary rocks of the Kewagama group, chiefly greywacke but with interbedded conglomerate for a width of half a mile to one mile adjacent to the break. North of the break, a belt, about two miles wide, of sediments of the Cadillac group, also chiefly greywacke, extends westward across the township as far as the Davidson Creek fault. These sediments occupy the trough of the syncline. On the west side of the fault they continue as two narrow synclinal bands. This belt is followed on the north by volcanics of the Blake River group, which extend far northward into Cléricy township and also underlie Joannès west of the Davidson Creek fault. The volcanics and sediments are intruded by a number of masses of quartz diorite, particularly in the vicinity of the Cadillac break and in the northeast quarter of the township; and granitic rocks, representing the southeast end of the Cléricy mass, cut the volcanics east of Marillac lake, in the northwest corner of the township. Younger than all of these are several northerly trending dykes of quartz gabbro up to one hundred and more feet wide, some of which are known to persist many miles (Gunning, Maps 614*A* and 615*A*).

Lying, as it does, immediately east of Rouyn township, and along the western continuation of the Malartic-Cadillac belt of mineralization, the township has received considerable attention from prospectors. Gold mineralization has been found at numerous places, chiefly in the vicinity of the Davidson Creek fault and in the northwest and northeast sections of the township, but up to the present no large deposits of commercial grade have been discovered. There has been a small production of gold from one property, the O'Neill-Thompson, between the big bend of Kinojévis river and the Joannès-Rouyn boundary. This and some other occurrences of gold mineralization are described briefly in the following pages.

Range X, East of Marillac Lake

A number of gold-bearing veins have been found in granitic rock (Cléricy granodiorite) which intrudes the Blake River volcanics one to two miles east of Marillac lake, in range X. The intrusive here is of very variable composition, ranging from quartz-rich granite to diorite, and in places it is highly altered and sheared and contains inclusions of 'greenstone'.

Work has been done on claims in this vicinity at various times since 1924, when gold-bearing veins and lenses, one of them five feet wide, were found cutting pale pink granite on the *Lowry claims* (Dufresne, pp. 134-136;

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James and Mawdsley, pp. 124-125). Others who have held claims include the *Marillac Mining Syndicate*, a part of whose holdings are known as the McDonnell group.

Five or more veins or mineralized zones have been investigated by trenching, and one by a limited amount of diamond drilling. The most southerly vein, five feet wide, outcrops in a small knoll on lot 18. About 1,300 feet north-northeast of this, a vein averaging three feet wide has been exposed in cross-trenches over a length of 400 feet. This vein, and others, some of them gold bearing, were also intersected at depth by three inclined diamond-drill holes.

Vicinity of Davidson Creek Fault

(From west to east)

O'Neill-Thompson Gold Mines Property

(Now *Rouyn Merger Gold Mines, Limited*)

The O'Neill-Thompson property is situated at and north of the east-west centre-line of Joannès township, between the 'big bend' of Kinojévis river and the Joannès-Rouyn boundary. At the big bend, Thompson creek enters Kinojévis river from the west and the depression it occupies marks a strong thrust fault, the Thompson Creek fault. At the river, this fault meets the southwesterly trending Davidson Creek fault. The orebodies on the O'Neill-Thompson property occur in the wedge-shaped block between these faults.

South of the Thompson Creek fault, the rocks for a width of 250 to 500 feet are sediments, chiefly conglomerate and greywacke. These are followed on the south by volcanics of the Blake River group, the zone of contact between the two being much sheared and carbonatized. It is along this contact, about two miles to the west, that the McWatters deposits occur (see page 162). The belt of volcanics is succeeded on the south by conglomerate and greywacke of the Kewagama group, which occupy the south part of the wedge-shaped block and continue eastward across Kinojévis river. About 500 feet south of Thompson creek, and immediately south of the Canadian National railway which closely follows the creek, the volcanics are intruded by two sill-like bodies of quartz diorite. The larger body, adjacent to Kinojévis river, has an exposed length of 2,000 feet and has been shown by diamond drilling to be a sill about 340 feet thick. The other body, 700 feet to the west, has a known east-west length of 900 feet and a width of 100 feet. A northerly trending quartz-gabbro dyke crosses the property and is apparently offset 1,100 feet to the east on the north side of the Thompson Creek fault (Gunning, p. 89).

Early exploration was largely in the south part of the property, where a shaft was put down just north of the east-west centre-line of the township, near the contact between the volcanic and sedimentary rocks. In 1933, attention was turned to discoveries immediately south of the Thompson Creek fault. Following extensive surface work and some diamond drilling, carried out by Noranda Mines, Limited, under an option arrangement, a shaft was sunk in 1935-36 to a depth of 160 feet, and a considerable amount of lateral work was done on levels at 80 feet and 160 feet. A 25-ton test mill was erected and operated for about three months, producing a small amount of gold. Early in 1944, these and other adjoining claims in Joannès and Rouyn townships were consolidated and a new company, Rouyn Merger Mines, Limited, was formed to develop them, changed later to New Rouyn Merger Mines, Limited.

The new shaft was sunk on a gold-bearing quartz vein cutting grey to green schist, either a tuff (Hawley, p. 67) or sheared greywacke and conglomerate (Gunning, p. 90). Between the two mine levels, the shaft passes

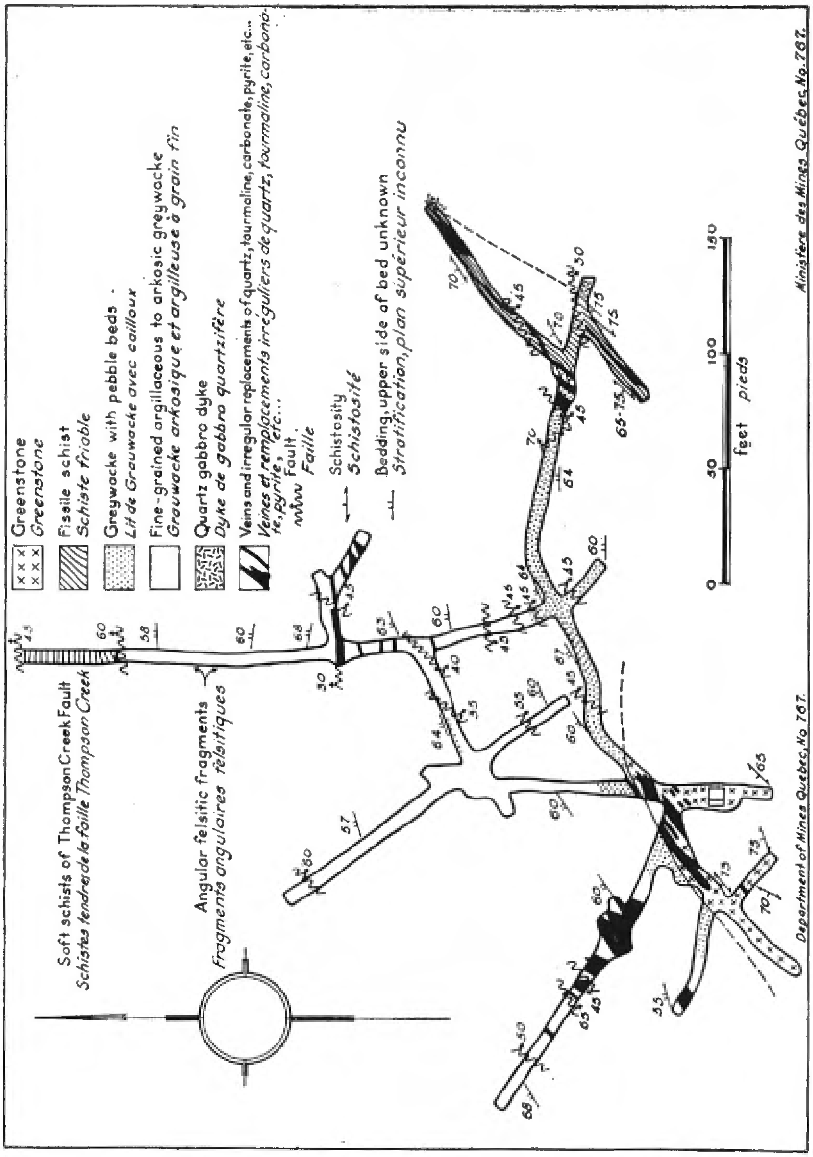

FIGURE 27.—*O'Neill Thompson, plan of second (160-foot) level.* (Geol. Surv. Can., Mem. 231, 1941, Fig. 4, p. 93).

through the sediment-volcanic contact, which dips at 65° to the north. Where exposed near the shaft, the vein has a maximum width of four feet, but it averages less than one foot. The vein matter is quartz, tourmaline, and ankerite, with pyrite as the chief metallic mineral, and, at depth, minor amounts of pyrrhotite and arsenopyrite. The vein was reported to contain free gold in considerable abundance. Most of the ore that was put through the mill came from an irregular quartz-tourmaline mass which, where cut on the 80-foot level, had a length of about thirty feet and a maximum width of ten feet. This was stoped out to a height of fifty feet above the level, when the grade was found to be uncommercial. A raise showed that the quartz and tourmaline continue to the surface. However, the downward extension of this body was not encountered on the 160-foot level. Both on the surface and in the underground workings, other similar veins and lenses, and also replacement bodies, some of them containing free gold, were found along or near the sediment-volcanic contact.

Replacement deposits in the quartz diorite sill near the shore of Kinojévis river, some 1,600 feet eastward from the shaft, were explored by Noranda Mines in 1933 by trenching, test-pitting, and some diamond drilling. This sill, striking northeast and dipping at 65° to the northwest, is intruded at the contact between volcanics (to the northwest) and sediments. Along joint planes striking in various directions, but particularly along those parallelling the strike of the sill, the rock is sheared, carbonatized, and replaced by fine grained pyrite and arsenopyrite, and in places these zones of replacement have a high tenor in gold. The main body explored lies about 140 feet stratigraphically below the top of the sill. It has a rudely lenticular shape with a maximum width of 35 feet and a length of at least 170 feet. The sulphide zone is covered with a shallow, dark red gossan from which gold may be panned, and channel samples taken across the full width of the zone are reported to have assayed \$5 to \$6 in gold per ton.

One hundred and sixty feet stratigraphically below this zone (forty feet above the base of the sill), a strong shear zone, three to eighteen feet wide, in the diorite has been traced for a length of 350 feet. Within it are quartz-tourmaline veins and lenses, up to four feet wide and twenty-five feet long. The schistose diorite enclosed in the quartz and lying between the lenses is mineralized with fine grained pyrite, and free gold was reported in one section of the zone.

Similar quartz-tourmaline lenses occur elsewhere in the diorite and also in the conglomerate to the southeast and in the tuffs that overlie the sill on the northwest.

Some narrow, lenticular quartz veins in tuffaceous schists a short distance north of the smaller diorite sill have also been investigated. They contain pyrite and minor chalcopyrite, arsenopyrite, and pyrrhotite. A diamond-drill hole intersected forty feet of quartz, but it was only sparsely mineralized.

Although the search for commercial deposits of ore in this section of the township has so far proved disappointing, the known favourable structure and the occurrence of some gold will no doubt encourage further close and careful study of its ore possibilities (Hawley, pp. 65-70; Gunning, pp. 88-94).

Big Bend Mining Corporation Claims

(Now *New Rouyn Merger Mines, Limited*)

This property is in range VI, south parts of lots 7, 8, and 9, Joannès township, immediately east of O'Neill-Thompson ground, but on the southeast side of Kinojévis river. It is underlain by Kewagama group sediments, chiefly greywacke but with some interbedded conglomerate. Intruding these rocks on lot 8 is a sill-like mass of quartz diorite that outcrops along and south of the Canadian National railway. Zones of shearing within the diorite and adjacent greywacke contain lenticular quartz-tourmaline veins mineralized with pyrite and a minor amount of pyrrhotite. These occurrences, which are less than 1,000 feet south of the Davidson Creek fault, have been investigated by trenching and other surface work carried out for the most part prior to 1934. Gold was reported in some of the veins (Hawley, pp. 71-72; Gunning, pp. 58-59).

The Big Bend property is adjoined on the east by what was formerly the Harper group of claims (see page 180). The eastern part of the quartz diorite sill lies in these claims, and in and near it are quartz-tourmaline veins similar to, and some the eastward continuation of, those on Big Bend ground.

Teck-Hughes Gold Mines, Limited

In 1934, spectacular visible gold was discovered in a narrow quartz vein cutting arkosic greywacke (Cadillac group) on lot 13, range VII, about 500 feet north of the Davidson Creek fault. The occurrence was investigated by Teck-Hughes Gold Mines, Limited. The vein, consists of grey quartz with intergrown coarsely crystalline ankerite. Pyrite is more abundant in the ankerite and adjacent wall-rock than in the quartz, and there is minor arsenopyrite, chiefly in the wall-rock. The vein has been exposed in trenches and test pits (one deepened to a prospect shaft) for a length of about 130 feet with an average width of two feet or less. Several assays ranging from $8.20 to $84 in gold per ton are reported across widths of 13 to 26 inches over a length of 120 feet of the vein. In 1938, three short drill holes were put down to intersect the vein at shallow depth. Two narrow veins were cut, but their gold content was negligible (Gunning, p. 98).

Joannès-Davidson Mines, Limited

Some surface work and diamond drilling was done during 1937-38 on ground held by this Company just east of lot-line 15-16, range VII, about 2,000 feet east of the Teck-Hughes prospect shaft. At this locality, which is a few hundred feet south of the Davidson Creek fault, a highly carbonatized shear zone in conglomerate (Cadillac group) contains a few lenticular and discontinuous quartz-tourmaline veins. Pyrite, arsenopyrite, chalcopyrite, and a little pyrrhotite occur around the margins of the veins and disseminated in the wall-rock. Gold assays ranging from 0.04 oz. to 0.20 oz. gold per ton are reported across widths of three to six feet (Gunning, pp. 78-80).

Lot 20, Range VIII, Joannès Township

Gunning's map 615*A* shows a heavily mineralized zone, striking east-west, in volcanics of the Blake River group on lot 20, range VIII, 2,000 feet south of range-line VIII-IX. This locality is 3,000 feet northwest of the Davidson Creek fault.

Washington Gold Mines, Limited

Work on this property has been concentrated chiefly in the central part of lots 25 and 26, range VIII, Joannès township, some 2,000 feet southeast of the Davidson Creek fault, where mineralized quartz veins occur in greywacke of the Cadillac group. In 1927-28, Notre Dame Gold Mines, Limited, original owners of the property, did a considerably amount of trenching, made an electrical survey, and put down eight diamond drill holes aggregating 3,000 feet. Additional trenching and test-pitting was done by Washington Gold Mines in 1936-37. Later, the property was acquired by Trueborn Gold Mines, Limited.

There are two types of quartz veins on the property. The first, and probably the older, consist of lenticular veins of dark grey to bluish, vitreous quartz that generally contain small amounts of white feldspar and mica and no metallic minerals.

The second type are veins and vein zones of milky-white, coarsely crystalline, and often drusy, quartz mineralized erratically with chalcopyrite, a small amount of pyrite, and, in some places, minute amounts of sphalerite and galena. A small percentage of ankerite, white mica, and chlorite accompanies the quartz in some places. Not uncommonly, the quartz has entered brecciated zones in greywacke and has surrounded fragments, forming a vein breccia. The percentage of chalcopyrite in a vein varies greatly; considerable lengths are apt to be essentially barren whereas adjoining parts a few feet long are liberally spotted with specks and small masses of the sulphide. Occasionally, vugs are filled with chalcopyrite that is in part crystalline.

The greatest amount of work was done on a zone of quartz veins in lot 26, some 2,200 feet north of range-line VII-VIII. The zone was probed by drill holes, with unknown results, but the later surface work did not indicate an appreciable gold content. Six hundred feet to the southwest, on lot 25, a pit discloses an easterly trending zone about five feet wide that is veined by white quartz stringers containing a few small pockets of chalcopyrite and pyrite. One hundred feet to the north is a similar zone, three feet wide (Gunning, pp. 104-106).

Lots 27 and 28, Range IX, Joannès Township

A zone of mineralization in Blake River volcanics is indicated on Gunning's map 615*A* as extending easterly for a distance of 1,000 feet or more in lots 27 and 28, range IX. The western end of the zone is about 600 feet east of the Davidson Creek fault. The mineralization consists of pyrite and pyrrhotite, with minor chalcopyrite. The map also indicates what is presumably the eastward continuation of this zone in lots 33 and 34 and in lots 36 to 38.

Adjacent to Cadillac Shear Zone

(From west to east)

The Cadillac shear zone extends slightly north of east across Joannès township, lying in range VI except near the east boundary, where it passes into range VII. The rocks to the south of the zone are sediments of the Kewagama group, chiefly greywacke but with some interbedded conglomerate. In places along the zone these are intruded by sill-like bodies of quartz diorite, and elsewhere they are cut by narrow dykes of 'porphyrite'. In central and western Joannès, the Canadian National railway closely parallels the zone on the south or north. At various times, there has been much prospecting along and adjacent to the shear zone, and gold mineralization has been reported in numerous localities.

Harper and Mondoux Groups

These claims cover lots 10 to 19, range VI of Joannès township. In lot 10, at the west end of the shear zone and about 2,000 feet southeast of the mouth of Davidson creek, a lenticular quartz-tourmaline vein, in places as much as twenty-five feet wide and having a length of some 200 feet, occurs in sheared quartz diorite which outcrops on both sides of the railway. The vein is mineralized with pyrite and a little chalcopyrite and is reported to contain gold (Hawley, p. 71).

Eastward from here there are numerous veins in a large exposure on the railway between lots 11 and 12, and on lots 14 and 15 much faulted and jointed amphibolite (probably quartz diorite) and greywacke contain quartz-tourmaline veins with some sulphide mineralization. A pit here has exposed a strong shear, striking N.65°E., impregnated with tourmaline on the northwest wall and with quartz and pyrite on the southeast side (Hawley, pp. 72-74; Gunning, pp. 81-82).

These occurrences are on a group of claims which extend from lot 10 to or beyond lot 19. Some or all of the claims were formerly known as the Harper group, and on these a considerable amount of surface exploration was carried out by the Quebec Gold Mining Corporation. In more recent reports they have been referred to as the *Mondoux group*. In 1940, the Hollinger Exploration Company held an option on the nineteen claims comprising this group and put down five diamond-drill holes, aggregating 1,257 feet (Herring, p. 50).

Clerno Mines, Limited

In 1937, this Company did some surface work in lots 47 to 53, range VI, Joannès township, where quartz veins and zones of quartz stringers occur in amphibolitized greywacke. One quartz-tourmaline vein-zone in lot 51, a short distance north of the intersection of the highway and railway and about 1,500 feet south of the Cadillac shear zone, is twelve feet wide and has been stripped for a length of 120 feet. It is mineralized with pyrite and arsenopyrite and is reported to contain some gold.

Drusy quartz veins containing small amounts of pyrite, chalcopyrite, sphalerite, and galena, but little or no gold, occur north of the highway in lot 51, and south of the railway in lot 52 (Gunning, pp. 49, 75).

Cléricy Consolidated Mines, Limited

The property of this Company extends from lot 52, range VI, and lot 56, range VII, eastward to the Joannès-Bousquet boundary and includes most of the claims known as the Polson group.

Work on the property prior to 1937 included stripping and some diamond drilling to explore a quartz vein zone, upwards of fifteen feet wide, in sheared greywacke in lots 61 and 62, range VI. The drilling apparently encountered no mineralization of interest. This occurrence is near the east boundary of the township, 3,700 feet south of the highway and the Cadillac shear zone.

About a mile northwest of here, in lot 56, 300 feet south of the highway, a drusy quartz vein zone occurs in a north-south fault at the contact between greywacke and conglomerate. It was exposed by trenching and test-pitting, but was found to be only sparsely mineralized with sulphides (Taschereau, 1934, p. 105; Gunning, pp. 50, 75).

Northeast Corner of Joannès Township

Arrowhead Gold Mines, Limited

This property consists of several adjoining blocks of claims which extend from lot 50 to lot 58, ranges IX and X, near the northeast corner of the township. With the exception of two dykes of quartz gabbro and one of serpentinized lamprophyre, the claims are underlain by Blake River volcanics, chiefly andesite and dacite, which strike a little north of west. The rocks are in general massive and fresh looking, but along two zones in lots 53 and 54, just north of range-line IX-X, they have been converted to rusty weathering chlorite-carbonate schist, in which the two principal veins on the property occur.

The claims were first staked in 1923 and they were explored and developed successively by the Brownell Exploration Company, the Joannès Syndicate, and Arrowhead Consolidated Mines until 1932, and by Arrowhead Gold Mines in 1936 and 1937. Work on the property has included much trenching and test-pitting, some diamond drilling, and underground work on three levels at 200, 350, and 500 feet from a shaft put down in 1936-37.

Both veins consist of discontinuous lenses of white quartz with intergrown calcite and ankerite, and they generally contain tourmaline. Pyrite is the most abundant sulphide, with pyrrhotite less common and chalcopyrite in small amount in some places. Native gold occurs in relatively small shoots and, where seen, is usually in fractures in the quartz.

The veins strike east-west and have a very steep dip to the north. The more southerly is known as the *A* or *Shaft* vein: a prospect shaft, 32 feet deep, was put down near its west end during the early development work. It has been traced on the surface for a length of some 1,300 feet. The western part, for a length of 100 feet, was estimated to contain $35 in gold per ton across a width of one foot (gold at $20.67 per oz.), but over most of the remainder of the exposed length the vein is rarely more than a quartz stringer. This vein was developed by drifts on the 200-foot level, where it was estimated to contain about $5 in gold per ton across widths of 13 to 18 inches for a length of 290 feet. On the 500-foot level, a length of 30 feet averaged $12.50 across a width of ten inches.

The *B* vein is 175 feet north of the *A* vein. It has an exposed length of upwards of 1,000 feet but is represented only by stringers, or is discontinuous, over the greater part of this length. Diamond drilling and surface sampling indicated that a length of 400 feet at the east end of the vein contained $17.50 in gold per ton across a width of two feet. The mine shaft was sunk near the east end of this vein. The vein was opened in drifts on the 200-foot level for a length of 340 feet, but, apart from a 29-foot section averaging $9.61 across 21.3 inches, assays were reported to be below ore grade or the vein was very narrow and discontinuous. This vein was also followed by drifts on the 350-foot and 500-foot levels. On the latter, a length of 100 feet, in small shoots, is possibly of ore grade, with about 25 feet estimated to contain one ounce of gold per ton across a width of one foot.

A number of other veins have been found on the property. One of these, 900 feet northwest of the west end of *B* vein, has been stripped for a length of 115 feet. It is a quartz-tourmaline vein, up to 5½ feet wide, in schistose rhyolite (Bell, 1937, pp. 23-25; Taschereau, 1938, pp. 59-60; Gunning, pp. 54-57).

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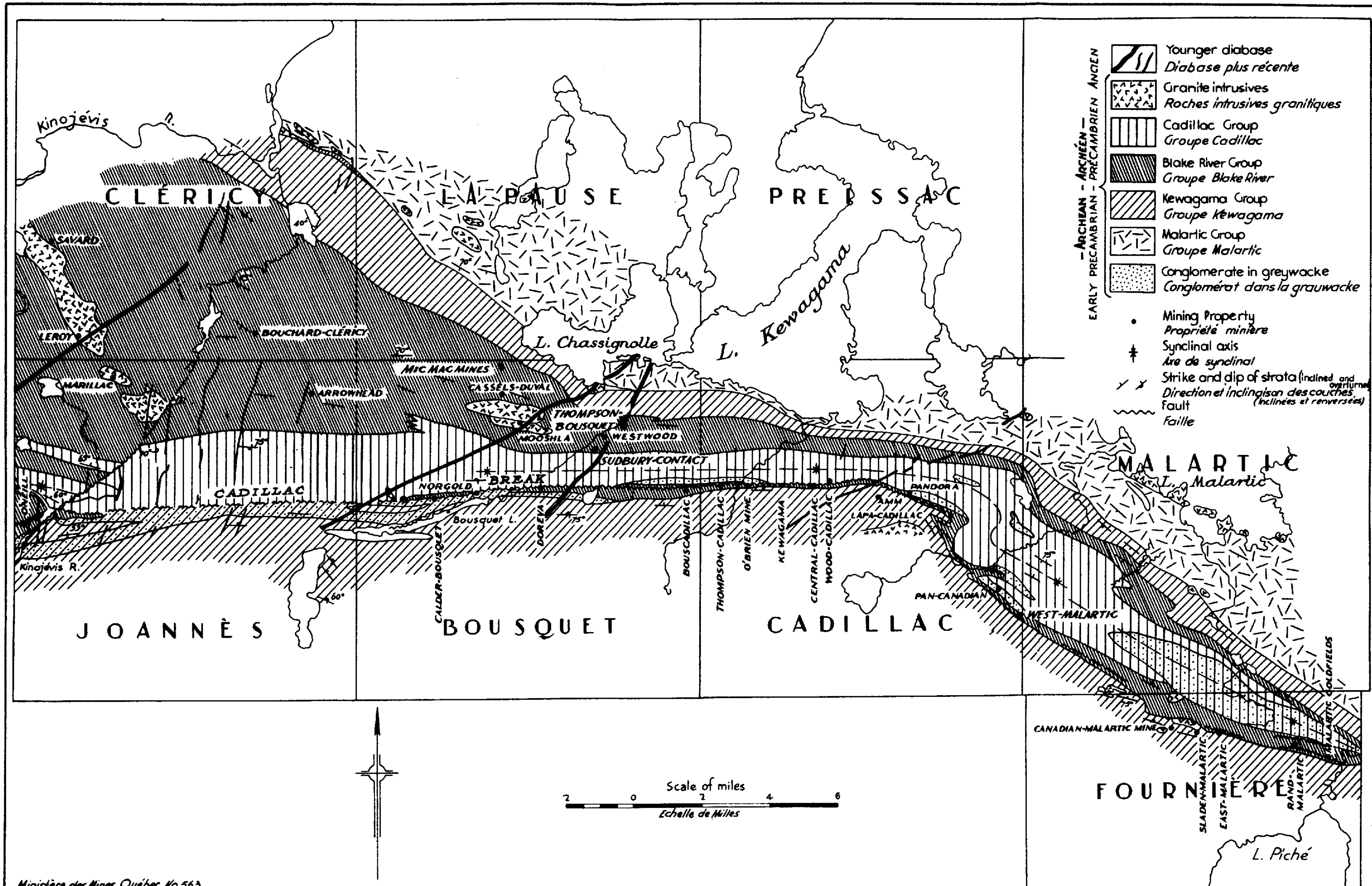

GEOLOGY OF Joannès, Bousquet, Cadillac and Malartic Townships and location of chief deposits.

Fig. 28

GÉOLOGIE DES cantons de Joannes, Bousquet, Cadillac et Malartic et emplacement des principaux gisements.

BOUSQUET TOWNSHIP

Outline of Geology

The synclinal belt of volcanic and sedimentary rocks continues with easterly trend from Joannès township across and beyond Bousquet. Sediments of the Cadillac group, chiefly greywacke, occupy the central part of the syncline. They form a belt which is about two miles wide in the western part of the township but narrows to one mile in the eastern half. Except for short lengths near its west end, this belt of sediments is flanked on the south by a width of 2,000 to 3,000 feet of Blake River volcanics, and the easterly trending Cadillac shear zone follows or is near the contact between the two formations, not far north of range-line VI-VII. The whole of the township southward from here is underlain by sediments of the Kewagama group (see Figure 28).

On the north flank of the syncline there is a wide development of the Blake River volcanics which, in the west half of the township, extend to and beyond the north boundary. Eastward, however, the belt narrows to about one mile, north of which the volcanics are succeeded in turn by Kewagama group sediments and Malartic group volcanics, which border the south shore of Chassignole lake, in the northeast corner of the township.

A body of granitic rock enters the southwest quarter of the township from Joannès. Apart from this, the largest mass of intrusive rock is a body of quartz diorite that extends east-west across the north-south centre-line for a length of some two and a half miles, about one mile south of the township boundary. On the south side of this is a smaller mass of albite alaskite. In the west part of the township, a few small bodies of granite are intruded along and near the Cadillac shear zone. Later gabbro is exposed in several localities, the outcrops apparently constituting two persistent northeasterly striking dykes which are about seven miles apart at the east-west centre-line and less than a mile apart where they outcrop at the east end of Chassignole lake (James and Mawdsley; Bell and MacLean; Gunning).

Extensive prospecting, particularly along and north of the Cadillac shear zone, has revealed widespread gold mineralization with, in some places, minor amounts of chalcopyrite and sphalerite (see Figure 28). Surface work, diamond drilling, and underground development has been carried out on numerous properties but, up to the present, there has been production from only two mines—the Mic-Mac and Mooshla mines.

North of the Cadillac Shear Zone

(From west to east)

Mic-Mac Mines, Limited

This Company holds a large acreage at the north boundary of Bousquet township, extending west and east of the north-south centre-line. The property is underlain by volcanics of the Blake River group, chiefly andesite and dacite flows with associated tuffs which, in the south claims, are intruded by the sill-like body of quartz diorite already referred to. Within the lavas and paralleling their bedding are some narrow, lenticular sheets of quartz porphyry which are thought to be flows but may be intrusive.

The auriferous deposits, which contain also copper, occur along a zone of shearing in the volcanics some 700 to 800 feet north of the diorite mass. On the west, the zone has an easterly trend with dip 60° to 80° south and has been exposed in cross-trenches for a length of about 300 feet. It contains one to several closely spaced quartz veins across a width of some five feet, and sampling is reported to indicate a commercial gold content across widths of two to five feet. Individual veins are rarely more than two inches wide. Several drill holes have intersected the zone at depth. It was in this West zone that the original discoveries were made in 1936.

The easterly and more important part of the zone, known as the East zone, trends southeast, cutting the strike of the volcanics at about 25 degrees. The dip is southward at 60 to 80 degrees. On the surface, the zone has been exposed for a length of 350 feet. The mineralization is similar to that in the West zone but has much greater width, from ninety feet at the northwest end to twenty-five feet at the southeast. This zone has been developed from a shaft sunk near its southeast end to a depth of 1,150 feet and a winze from the 1,050-foot level to a further depth of 324 feet, with a considerable amount of lateral work on several levels. It is reported that the average gold content of the zone is \$3 to \$6 per ton, with shoots of much higher grade.

A mill of 600 tons daily capacity was placed in operation in 1942, and in that year there was a production of 8,960 ounces of gold from 74,266 tons of ore milled. In the two years 1943 and 1944, production totalled 41,371 oz. gold, 1,625,124 lb. copper, and some silver, from 316,976 tons. About 40 per cent of the gold is recovered by amalgamation. The balance remains locked in the copper concentrate, which is shipped to the Noranda smelter for treatment (Gunning, pp. 71-74; Dufresne, p. 163).

The Mic-Mac mine is on ground formerly owned by Cassels Duval Mines, Limited.

Athlone Gold Mines, Limited

The claims of this Company are at the north boundary of Bousquet township, immediately east of the north-south centre-line and of the Mic-Mac property. Some surface work was done here in 1937 along a shear zone in greenstone and schist which contains lenticular quartz veins up to three feet wide. Where exposed in three trenches in a length of 500 feet, the zone is pyritized, in one place for a width of ten feet and in another across thirty feet, and it was reported to contain sphalerite at one point (Gunning, p. 58).

Mooshla Gold Mines Company (1937), Limited

The Mooshla property lies immediately south of Mic-Mac. The south part of the quartz diorite body extends from the latter property into Mooshla ground and is adjoined on the scuth by the smaller and later mass of albite alaskite, referred to earlier. This in turn, is intruded by a wide, northeasterly trending dyke of quartz gabbro. The main gold-bearing vein, known as the *A* vein, is in the alaskite, immediately west of the north-south centre-line of the township and about 2,500 feet south of its north boundary. It strikes a few degrees east of north and dips steeply west. The vein was developed and mined from a shaft sunk near its south end to a depth of 372 feet, with levels at 115, 230, and 345 feet, and from a winze carried to a depth of 32 feet below the third level. On the surface and in the underground workings, the vein was traced for a length of 80 to 90 feet, pinching out entirely at its south end just before reaching the quartz gabbro dyke. It had a width of one to several inches and consisted of a massive intergrowth of pyrite and pyrrhotite, with very minor amounts of chalcopyrite and sphalerite and almost no quartz. In general, both the width of the vein and its gold content decreased gradually toward the north. The adjacent wall-rock is speckled and seamed with sulphides and carries some gold.

Between August, 1939, and June, 1940, when operations were suspended, 6,284 tons of ore was taken from the mine. After sorting out 1,383 tons on surface, the balance of 4,901 tons was shipped to the Noranda smelter. Total gold recovery was 3,863.8 oz., or 0.79 oz. per ton.

A group of veins, known as the *B* veins, about half a mile northeast of the mine shaft, have been explored by trenching, diamond drilling, and in a short drift from the bottom of a 54-foot prospect shaft. The largest vein, cutting sheared quartz diorite, has been exposed at intervals over a length of 1,300 feet, with maximum width of four feet but averaging little more than one foot. It is of white quartz with some ankerite and in places much tourmaline, and is mineralized with pyrite, chalcopyrite, and minor pyrrhotite. Assays of more than one ounce in gold per ton are reported, but the average gold content is below commercial grade. A similar vein follows a narrow quartz porphyry dyke, along which it has been exposed for 100 feet.

A number of other quartz veins and mineralized zones have been found, both in the intrusive rocks and in the Blake River volcanics which underlie most of the property (Gunning, pp. 82-86; Taschereau and Herring, pp. 68-69; Herring, pp. 50-51).

Thompson (E. J.) Syndicate

The claims of this Syndicate extend eastward from the property of Mooshla Gold Mines to Bousquet river. The north part of the property is underlain by sediments of the Kewagama group and the south part by andesitic lavas of the Blake River group. During 1937 and 1938, surface work was carried out on two occurrences of sulphide mineralization in the volcanics. One of these, on claim A-59626, is about 2,000 feet west of the rapids on Bousquet river. Trenching here over a length of 450 feet has exposed a zone, striking about ten degrees north of west, along which the greenstone is heavily charged with pyrite, and some pyrrhotite, across widths ranging from a few inches to two feet. There is a little chalcopyrite and sphalerite in the zone, and some encouraging gold assays have been reported. About three-quarters of a mile to the northwest, quartz-tourmaline veins and siliceous replacements have been found in the greenstone at, and near, its contact with the sediments. One of these zones, exposed at intervals for a length of 500 feet, consists of pyrite, some pyrrhotite and chalcopyrite, and quartz-tourmaline veins across maximum widths of ten feet (Gunning, pp. 98-99).

These claims, totalling about 1,200 acres, are now (1947) held under development licenses in the name of Charles McCrea.

Warrenmac Mines, Limited

This property adjoins the holdings of the Thompson Syndicate on the south. It is underlain by the uppermost members of the Blake River group, chiefly rhyolite in the northern claims followed on the south by greenstone, agglomerate, and porphyritic andesite, and these in turn by siliceous lavas and agglomerate.

During 1938, a considerable amount of trenching and some diamond drilling was carried out to explore two gold-bearing veins. What is known as the South vein is a pyritic carbonate zone in sericite and chlorite schist, within which are veins of dark grey quartz containing pyrite and some tourmaline. The zone strikes N.80°W. and, commencing about 800 feet west of Bousquet river, has been exposed over a length of some 3,000 feet, with a width in some places of 25 feet. Samples taken in closely spaced trenches over a length of 380 feet in the central section, across widths of 5 to 22 feet, assayed from a 'trace' to $17.15 in gold per ton. In some parts of the zone there are veinlets of sphalerite and small amounts of chalcopyrite.

The North vein is 1,400 feet north of the west end of the South vein. It is a rusty shear, averaging about a foot wide, in greenstone, tuff, and porphyritic andesite, striking due east. The zone has been stripped for a length of 240 feet. It contains lenticular veins of quartz and tourmaline and is mineralized with pyrite and some chalcopyrite. Channel samples are reported to have given encouraging assays in gold (Gunning, pp. 102-103).

Westwood Cadillac Mines, Limited

This Company owns a block of claims (about 530 acres) extending southward from Bousquet river and lying between Warrenmac and Thompson Bousquet ground. The claims were explored by trenching and some diamond drilling in 1933-34, and additional surface work was done by O'Leary Malartic Mines in 1936. In that year, the Westwood company assumed control of the property. A shaft was sunk to a depth of 210 feet and some 800 feet of lateral work was completed at that horizon. Diamond drilling, both from surface and underground, was also carried out. Operations were suspended in 1938 but, in 1940, three diamond-drill holes totalling 1,385 feet, were put down on the property by O'Brien Gold Mines, Limited. The shaft is about 1,000 feet southeast of the rapids on Bousquet river.

The northern half of the property is underlain by Blake River group volcanics and the southern half by Cadillac group sediments, the contact between the two formations having an easterly trend. Gold has been found in a number of quartz veins and pyritic replacements in the volcanics. The original discovery, about 200 feet south of the present shaft, is a pyritized zone in carbonate-sericite schist. It has been exposed by closely spaced trenches for a length of 200 feet, with a width ranging from one to three feet and as much as five feet in one trench. It is accompanied by other, narrower veins to the north and south. Visible gold has been reported in some sections of the zone, but the overall gold content is below commercial grade. This is known as the South vein. Another vein, the North vein, immediately north of the shaft, has been exposed for a length of 180 feet on the north slope of a hill consisting chiefly of grey to green tuff, now altered to chloritic and sericitic schist and for the most part highly carbonatized. Within this are irregular quartz-tourmaline veins and scattered masses of coarsely crystalline pyrite, with minor amounts of chalcopyrite. Assays over a length of 180 feet are reported to be very erratic, with range from a 'trace' to $11.20 in gold per ton. Sampling of the underground workings indicated a similar erratic gold content for a length of forty feet.

A number of quartz veins, some of them mineralized with sulphides, cut greywacke in the southern part of the property, but none has been found to contain gold in substantial amount (Gunning, pp. 106-109; Herring, p. 51).

Thompson Bousquet Gold Mines, Limited

The Thompson Bousquet property extends eastward from Bousquet river and the north claims of Westwood Cadillac. It is underlain by volcanics of the Blake River group. These are chiefly andesitic lavas in the north half of the property, rhyolite and quartz-sericite schist in a central belt 500 to 600 feet wide, and, south of these, green to grey andesite and dacite flows and tuffs. The beds and the schistosity strike a few degrees north of west and dip 80° to 85° to the south.

The principal discovery on the property was made in 1937. This is a mineralized zone, up to 100 feet wide but with no well defined walls, in chloritic slate and schist about 800 feet south of the belt of rhyolite. The mineralization consists of seams and disseminations of pyrite along cleavage planes and narrow fissures in the schists. Trenching and diamond drilling in 1937 and 1938 is reported to have defined a body 1,300 feet long and 60 feet wide that averaged $3.05 in gold per ton, or $2.50 when some high erratic assays were reduced. Additional drilling was carried out by the Teck Exploration Company in 1939.

About 150 feet south of the east end of the main zone, similar schists are partly to completely replaced by fine grained pyrite, with minor chalcopyrite and pyrrhotite, across a width of two to six feet. This zone has been exposed almost continuously for 225 feet and assays of $5 to $8 in gold per ton are reported.

Quartz veins carrying pyrite have been found in the central belt of rhyolite. Visible gold was reported in a sample taken from a test pit on one of these veins (Gunning, pp. 100-102; Taschereau and Herring, p. 69).

Scott Chibougamau Mines, Limited

These claims adjoin the Thompson Bousquet property on the southeast and extend eastward to within about 3,000 feet of the boundary of the township. During 1937, a number of quartz-tourmaline veins cutting sheared volcanics of the Blake River group were investigated, by trenching and test-pitting. Some of the veins contain pyrite. The most encouraging zone has been exposed in four trenches spaced over a length of 300 feet, but individual veins are probably continuous for only a fraction of that distance. In a trench about 900 feet to the south, acidic lavas are impregnated with pyrite across a width of thirty-three feet. No assay results have been reported (Gunning, p. 95).

Brown Cadillac Mines, Limited

This property is about 2,300 feet south of the Scott Chibougamau claims and is adjoined on the south by Bouscadillac ground. It extends westward for about a mile from the east boundary of the township. The claims are underlain by sediments of the Cadillac group. At the south there is a width of some 500 feet of conglomerate in the central claims, but this apparently narrows rapidly to the west. North of this, the scattered outcrops are all greywacke which, in the northeast claims, is intruded by two or more dykes of diorite. Thin magnetite beds occur in places in the greywacke. The sediments strike nearly due east and have an approximately vertical attitude.

A number of quartz veins or vein-zones have been found in the greywacke, paralleling its strike. Many of them contain tourmaline and some pyrite, and in two of the veins there is considerable arsenopyrite. These occurrences were investigated in 1937 by trenching, test-pitting, and some diamond drilling. One zone, from ten inches to ten feet wide, is exposed for a length of fifty feet, and intermittent outcrops suggest that it continues for at least another 110 feet. Where exposed in a 12-foot pit at the west end of the stripped area, the zone, for a width of six to seven feet, consists of irregular, flat-lying veins and lenses of quartz containing a fair amount of pyrrhotite and lesser arsenopyrite, pyrite, and chalcopyrite. Grab samples from the pit were reported to contain some gold. A diamond-drill hole put down to explore the possible downward continuation of the vein below the pit failed to intersect it. Farther north, joint planes in greywacke and in a diorite dyke that intrudes it are filled with veins of quartz and tourmaline, with some arsenopyrite. The largest vein is two and a half feet wide (Gunning, pp. 67-68).

ADJACENT TO THE CADILLAC SHEAR ZONE

(From west to east)

Calder Bousquet Gold Mines, Limited

This Company was incorporated in 1936 to develop a block of claims which, commencing rather more than a mile from the west boundary of Bousquet, extend north of east for about two miles, paralleling and a few hundred feet north of Kickkick (Bousquet) lake. The two most easterly claims touch the lake shore. The eastern half of the block was formerly known as the Clement-Manning group, and the western half was controlled in turn by M. J. O'Brien interests and Minefinders, Limited.

Traversing the property centrally along its length is the east-west trending Cadillac shear zone, which in most places marks the contact between greywacke of the Cadillac group, to the north, and greywacke and conglomerate of the Kewagama group, to the south. In the central claims, however, there are some exposures of Blake River volcanics adjacent to the shear zone, and near the western end of the property some small bodies of albite granite are intruded along and near the zone. Where cut by diamond-drill holes, the shear is 100 to 150 feet wide and consists of serpentine and soft schist.

Gold and sulphide mineralization was discovered on the property in 1932 near the contact between Blake River volcanics and Kewagama sediments immediately south of the shear zone and, following exploration by trenching and diamond drilling, a prospect shaft was sunk in 1936 and a small amount of lateral work was done on levels at 70 and 125 feet. The mineralization occurs in quartz veins and lenses in the sediments and has been exposed by several trenches for a length of 140 feet with a maximum width of 15 feet. The diamond drilling indicated two zones, one about 300 feet long and up to 40 feet wide, the other, to the northeast, 180 feet long with maximum width of 25 feet. Some of the veins contain pyrite, pyrrhotite, arsenopyrite, and chalcopyrite, with visible gold in places. Sampling in the workings on the 70-foot level is reported to have indicated a moderate content of gold over a fairly substantial width.

East of the shaft some 4,500 feet, zones up to eight feet wide in carbonatized greywacke are well mineralized with disseminated pyrite and arsenopyrite, but apparently contain little gold. One of these has been traced for a length of 500 feet and is known to continue eastward on the adjoining Norgold property.

A number of small quartz veins have been found in the sediments, and also in the granite, in the western section of the property. Some of them are gold bearing and contain pyrite, pyrrhotite, chalcopyrite, and arsenopyrite (Gunning, pp. 69-71; Bell, 1937, p. 27).

Norgold Mines, Limited

This Company owns a small block of claims extending for 2,600 feet eastward from the Calder Bousquet property. A prospect shaft was sunk here in 1936 to investigate a narrow vein-zone in greywacke 400 feet south of the Cadillac shear zone. The zone, which has been traced for 700 feet along its strike, N.75°E., contains lenses of grey quartz, seldom more than a few feet long, mineralized with small amounts of sulphides. Some of them are reported to contain gold. The zone continues eastward into the adjoining Doreva property, and it has been intersected by two diamond-drill holes 700 feet west of the shaft.

About 200 feet north of, and westward from, the shaft a similar mineralized zone has been exposed for short lengths and has been cut in two diamond-drill holes. It apparently is the eastward continuation of the zone, already referred to, on the adjoining Calder Bousquet property.

A number of large quartz veins, barren or very sparsely mineralized with sulphides, have been found cutting conglomerate, which occupies a width of about 550 feet in the south part of the claims.

Norgold also owns, or formerly owned, a large block of claims adjoining the property of Mooshla Gold Mines on the west (Gunning, pp. 87-88; Bell, 1937, p. 29).

Doreva (Quebec), Limited

(Subsidiary of *Doreva Gold Mines, Limited*)

The Doreva property extends eastward from Norgold ground for nearly four miles, or from the east end of Kiekkiek (Bousquet) lake to two and a half miles east of the centre-line of the township. In the eastern part of the property, the claims extend northward from the east-west centre-line for a width of some two and a half miles.

The chief development has been on a claim half a mile east of the centre-line and immediately south of the Cadillac shear zone, where, following a considerable amount of surface work and diamond-drilling, a shaft was sunk to a depth of 210 feet and some 300 feet of lateral work was done on a level at 150 feet. The south half of the claim is underlain by conglomerate and greywacke of the Kewagama group. These are followed on the north by Blake River volcanics and the latter by conglomerate and greywacke of the Cadillac group, which lie immediately south of, and continue far to the north of, the Cadillac shear zone.

The shaft was sunk in the Cadillac conglomerate to investigate a vein zone which is reported to have contained spectacular free gold at the surface. To the south of this conglomerate, on the 150-foot level, a strong shear zone in sericite schist and phyllite, representing greywacke of the Cadillac group, contains lenses and veins of quartz and is erratically mineralized with disseminated arsenopyrite, pyrite, and pyrrhotite, small amounts of which occur also in the quartz. The Company reported that substantial amounts of gold were encountered in drifting on the zone, but no assay results are available.

North of the shaft some 4,000 feet, narrow bands of magnetite occur in the greywacke across a width of twenty-five feet. Fractures in the rock are filled with pyrite which, in places, is auriferous.

In 1934, Golden Quebec Mines, Limited, did some work in the most westerly claim, into which, as already noted, the Norgold vein zone extends. This was explored by an adit driven into a hillside for a distance of 270 feet. This and the adjacent claims were formerly held by Sagamore Mines, Limited (Taschereau, 1935, p. 96; Gunning, pp. 76-77; Bell, 1937, p. 29).

Sudbury Contact Mines, Limited

This property lies between Bousquet river and the highway. Its west end, two-thirds of a mile east of the centre-line of Bousquet township, is bordered on the north, west, and south by Doreva ground, and from here it extends eastward for about two miles. Norman lake is about midway along its length, near the south boundary. The east-west Cadillac shear zone traverses the property from end to end, about centrally.

From Norman lake eastward, the property is drift covered and outcrops are extremely sparse. The broad geological features, however, are similar to those elsewhere along the synclinal belt. North of the shear zone, and in places for a short distance southward from it, the rocks are sediments of the Kewagama group, chiefly greywacke. South of these is a belt, up to perhaps 1,000 feet wide, of andesitic flows and tuffs of the Blake River group, and these are succeeded in turn by sediments of the Malartic group, first conglomerate and then greywacke. Cutting these rocks near the west end of the property is a northeasterly trending dyke of quartz gabbro.

The only extensive work on the property has been on the most westerly claim where, about 1,000 feet east of the Doreva shaft, an easterly trending zone, up to ten feet wide, in sheared and carbonatized andesite, contains lenticular quartz veins in which, as also in the adjacent rock, there are small quantities of pyrite and arsenopyrite. The zone has been stripped for 600 feet and has been investigated at one place by a prospect shaft twenty feet deep. It is reported that the vein zone contains only a small amount of gold. About 400 feet to the south, near the contact of the volcanics with the Kewagama conglomerate, a similar zone contains lenses and discontinuous veins of quartz and moderate amounts of pyrite, arsenopyrite, and pyrrhotite. It has been exposed at intervals for a length of about 600 feet (Gunning, pp. 96-97).

Brown Bousquet Mines, Limited

This property adjoins Sudbury Contact ground on the east. It is for the most part covered with swamp or deep overburden. A number of mineralized quartz veins had been investigated by stripping and test-pitting prior to 1937, when a programme of diamond drilling, aggregating 6,142 feet, was carried out.

The drilling probed the Cadillac shear zone over a length of 1,750 feet from the east boundary of the property. It showed that the zone follows closely the contact between Blake River volcanics (to the north) and sediments of the Cadillac group, the latter chiefly greywacke with some bands of conglomerate. The sediments have a width of some 300 feet and are followed to the south by Blake River volcanics. Along and to the north of the shear zone there are a number of small, irregular intrusive bodies of quartz syenite porphyry and related rocks. The drilling intersected several narrow quartz veins in the greywacke and also in the porphyry, some of them containing tourmaline, pyrite, pyrrhotite, and arsenopyrite, and two of them, in greywacke, showing particles of visible gold.

The earlier work had investigated mineralized quartz veins in andesite south of the sediments. The principal vein is near the contact and is reported to be gold-bearing. In places, the porphyritic andesite is more or less completely replaced over widths up to twenty feet by pyrite and pyrrhotite, with little or no silicification, but such zones appear to contain little if any gold (Bell and MacLean, pp. 61-63; Gunning, pp. 65-67). Later, Brown Bousquet Mines, Limited, sold their holdings in Bousquet township to the *Interprovincial Mining Corporation, Limited.*

Bouscadillac Gold Mines, Limited

The Bouscadillac property extends eastward from Brown Bousquet ground for nearly a mile and a half to the Bousquet-Cadillac boundary line, where it is adjoined by the Thompson Cadillac claims, in Cadillac township. Gold mineralization was discovered on the property in 1924 and from then until 1929, and again during 1934, development work was carried on by the Graham Bousquet Mining Corporation. In 1936, the property was acquired by Bouscadillac Gold Mines. Development continued until late in 1937, when all operations were suspended. Work on the property has included extensive trenching and diamond drilling and the sinking of a shaft to a depth of 525 feet, with some 3,500 feet of drifting and cross-cutting on four levels. The shaft is about 2,200 feet from the east boundary of the property.

The formational succession across the synclinal belt is similar to that on the Brown Bousquet property, but the band of Cadillac group greywacke south of the shear zone narrows gradually from 300 feet to about 150 feet in the western claims. The principal gold-bearing veins occur in sheared and carbonatized porphyritic andesite immediately south of the sediments. They are lenticular and narrow, individual veins being rarely more than a few tens of feet long or more than two feet wide. In addition to vertical veins paralleling the east-west shearing there are some that are nearly flat-lying. The veins contain tourmaline in places and are mineralized with pyrite, pyrrhotite, and a little chalcopyrite. Very rarely, they contain visible gold. The sulphides are most abundant along the walls of the veins and as disseminations or along planes of schistosity in the adjacent rock.

The original discoveries were known as No. 1 and No. 2 veins or vein zones. The latter is at the andesite-greywacke contact, and No. 1, on which the shaft was sunk, is about eighty feet to the south of it. In the underground workings, other, parallel veins were intersected, most of them twenty to thirty feet south of the contact but some as much as 120 feet south. The mineralized zones were explored for lengths of 900, 450, 100, and 600 feet on the first and successively lower levels. Sampling in a cross-cut northward from the shaft on the first level showed that the zone averaged $4.00 in gold per ton across a width of seventy feet, with appreciably richer sections up to twelve feet wide, but the extensive lateral work on the lower levels, and also diamond drilling, indicated that material approaching this grade was more or less restricted to a narrow zone at the andesite-greywacke contact.

In re-sampling the mine in 1937, the best results were obtained in a drift on the first level which followed a quartz vein between stations 130 feet and 320 feet west of the shaft. The vein ranges in width from a stringer to about two feet and is sparingly mineralized with sulphides but in places contains visible gold. Sulphides are fairly abundant in the adjacent sheared andesite. Assays are reported to average $5.07 in gold per ton across three feet for a length of 110 feet.

In 1937, the andesite-greywacke contact was probed by thirteen diamond-drill holes spaced at 75- to 300-foot intervals from 400 to 2,600 feet west of the shaft. Substantial widths of quartz with associated arsenopyrite and chalcopyrite mineralization were cut in several of the holes, and gold assays, ranging up to 0.61 oz. per ton, were obtained in every hole but one. Three holes drilled between the shaft and the east boundary of the property encountered only narrow widths with very low gold content (Cooke *et al*, pp. 264-265; Bell and MacLean, pp. 57-61; Gunning, pp. 59-65).

South of the Cadillac Shear Zone

(From west to east)

Decoeur Bousquet Claims

These claims are immediately east of the west boundary of the township, extending northward from Kiekkiek (Bousquet) lake. They are 1,500 to 4,500 feet south of the Cadillac shear zone and are underlain by sediments of the Kewagama group, largely conglomerate in the north and greywacke in the south. An easterly trending shear in carbonatized greywacke 800 feet north of the lake has been investigated by trenching and, in 1938, by several diamond-drill holes. Over a length of 650 feet and across widths up to fifteen feet, the greywacke is veined by quartz and mineralized with sulphides, including arsenopyrite.

About 1,000 feet to the north, a pit has exposed a width of four feet of quartz stringers in schistose greywacke which is well mineralized with pyrite and arsenopyrite. Some gold has been reported in this material (Gunning, pp. 75-76).

Paquin Claims

The Paquin claims adjoin the Decoeur Bousquet claims on the east. A zone of quartz veins and sulphide mineralization in much contorted and sheared conglomerate has been exposed at intervals for a length of 500 feet. The sulphides are arsenopyrite and pyrite, with minor pyrrhotite and chalcopyrite, and free gold is present in some of the quartz stringers. It is reported that a sample weighing 300 pounds taken across fifteen feet at the west end of the stripping assayed 0.25 oz. gold per ton and that one of 50 pounds across five feet returned 0.5 oz. Average assays, however, were low (Gunning, pp. 94-95.)

Ouellette Claims

Some trenching and test-pitting has been done on these claims, which are a mile and a half southwest of the centre point of Bousquet township. They are underlain by easterly striking greywacke of the Kewagama group, and along a zone up to 200 feet wide the rock is rust-stained at the surface and is impregnated with sulphides. Along the south side of part of the zone the greywacke is intruded by a basic, greenish rock, which appears to be gabbro. The sulphides present along the zone are pyrite and pyrrhotite, but frequent green staining indicates that some chalcopyrite also is present (Bell and MacLean, pp. 65-66).

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CADILLAC-MALARTIC-FOURNIERE BELT

General Note

The closely compressed synclinal belt of sedimentary and volcanic rocks continues from Bousquet township across Cadillac, first eastward and then southeastward, with which trend it crosses the southwest quarter of Malartic and the northeast corner of Fournière to enter Dubuisson township. As elsewhere along its length, the Cadillac shear zone, or 'break', lies within or close to the belt of Blake River volcanics on the south flank of the syncline, these being bordered on the north by the conformably overlying Cadillac sediments, forming the trough of the syncline, and on the south by the underlying Kewagama (Fournière) sediments. In Cadillac township, this belt of Blake River volcanics has been termed the 'Cadillac belt' (Gunning, p. 11). It is of particular economic importance because along or near it lie most of the known and developed gold deposits of the area.

The belt of sediments and volcanics is flanked at some distance to north and south by large batholiths of granitic rock, and the rocks of the belt itself are invaded by dykes, sills, and stock-like bodies of various types which in some places constitute as much as 40 per cent of the volume of the belt. In the eastern part, these minor intrusives are chiefly diorite and quartz diorite which generally are highly altered and easily confused with volcanic flows. Acidic intrusives also are common and characteristically they have low potash content.

In addition to faults and shear zones paralleling the bedding and the main Cadillac 'break', minor faults having other trends are not uncommon. In the west and central parts of Cadillac township, two sets of these faults strike northwest and northeast, and similar faults with small displacement have been described at the East Malartic property in Fournière township. In eastern Cadillac, in the vicinity of the Lapa Cadillac mine, there are north-south trending vertical faults which are correlated with the northwest faults farther west.

The gold deposits in Cadillac township are in general of a different type, and have had a different origin, from those occurring farther east, in Malartic and Fournière townships. The two may be distinguished conveniently as the 'Cadillac' type and 'Fournière' type, respectively.

Cadillac Type.—These are lenticular and generally narrow—seldom more than three to four feet wide—veins of auriferous dark grey quartz, some of which are remarkable for spectacular shoots of free gold. They are closely associated with intrusions of albitite and quartz albitite and in many instances they approach the latter in composition, indicating that the veins and albitite are emanations from a common magma. Also, in some of the deposits, the wall-rock adjacent to the veins is highly silicified, mineralized, and auriferous. The characteristic sulphide mineral in all the deposits is arsenopyrite. Pyrite and pyrrhotite are usually subordinate, and very minor amounts of chalcopyrite, galena, and sphalerite may be present. Non-metallic minerals occurring in the veins and wall-rock include black tourmaline, biotite, chlorite, sericite, albite, scheelite, and ankeritic carbonate. Gunning (p. 39) concluded that the deposits of this type were formed at great depth, where the temperature gradient of the ascending mineralizing solutions was low, and that, consequently, no sudden changes in the type of mineralization should be expected at depth.

Fournière Type.—The gold deposits in Fournière township present considerable diversity, but typically they are large, low-grade bodies in which the gold is very finely divided and which are 'sweetened' by the presence of richer quartz and pegmatite veins. Pyrite is the principal sulphide mineral. Pyrrhotite is rare, and arsenopyrite is entirely absent in most of the deposits. The presence of gold tellurides has been reported in some of the orebodies, and, rarely, small amounts of galena and sphalerite. The Fournière deposits are associated with, and probably genetically related to, albite granite, quartz syenite porphyry, and similar intrusive bodies, which are not found in the vicinity of the deposits of the Cadillac type. Gunning and Ambrose (1940, p. 57) distinguished five main types of gold occurrence:

(1) In pegmatite veins, which in some occurrences grade into ordinary quartz veins and are believed to be the end phase of the quartz syenite porphyry.
(2) In quartz veins.
(3) In silicified and pyritized country-rock, commonly either greywacke or porphyry.
(4) In sheared and pyritized 'diorite' traversed by narrow auriferous quartz veins. The 'diorite' may be an intrusive rock (dyke or sill) but more probably is hydrothermally altered schist or tuff.
(5) As free gold in the dark chloritic schist of the Cadillac 'break'.

Two or more of these types of ore may occur in the same orebody. It is probable that they all belong to the same period of mineralization and that the diversity in type is due merely to differences in the country rock encountered by the ore-bearing solutions.

Supporting the conclusion that the mineralization in the Cadillac and Fournière deposits originated from different sources is the fact that the Cadillac type of ore yields a bullion containing much less silver than does that of the Fournière type.

CADILLAC TOWNSHIP

THOMPSON CADILLAC MINING CORPORATION

This property is at the west boundary of the township, immediately north of the east-west centre-line. Gold mineralization occurring in quartz veins and in the adjacent Blake River volcanics a few hundred feet south of the Cadillac shear zone has been developed underground from two shafts, one having a depth of 620 feet with four levels at 150-foot intervals, and the other, 900 feet to the east, 100 feet deep.

There are two main easterly trending veins. No. 1, on which the shafts were sunk, is in porphyritic andesite and has been opened in the underground workings for a length of more than 1,000 feet. No. 2, about 100 feet to the north, is in brown micaceous schist. It has been developed for upwards of 600 feet. At their east ends, the two veins are well defined, but westward they tend to converge, with several lenses of quartz intervening between them. In places, the veins attain a width of four feet and more, but they average much less than this. They are mineralized with sulphides, chiefly arsenopyrite, which extend into the silicified wall-rock for widths up to twenty feet. One body of such well mineralized rock on the 150-foot level, in the vicinity of the main shaft, assayed 0.35 oz. gold per ton across an average width of 12 feet for a length of 182 feet, and, in the westerly workings on the same level, another persistent zone carrying gold was intersected. Free gold is confined to the quartz, and locally it was present in spectacular amount.

A mill with a capacity of 150 tons per day was in operation from 1936 until the end of 1939, during which period it treated 172,935 tons of ore with recovery of some 15,040 ounces of gold. No ore was mined after that year, but from 1940 until 1943 the mill treated ore from the Central Cadillac mine.

The original discovery on the Thompson Cadillac property was made in 1924 and consisted of a wide mineralized zone in greywacke some 800 feet south of the later discoveries. Underground investigation of this occurrence gave disappointing results (Bell and MacLean, pp. 53-57; Cooke *et al.*, pp. 265-267; Gunning, pp. 48-49).

O'BRIEN GOLD MINES, LIMITED

This property adjoins Thompson Cadillac on the east, in which direction it extends for about 7,500 feet along the Cadillac shear zone. The claims were staked in 1924, and in the following year a shaft (No. 1) was sunk on the discovery, or No. 1, vein. Other veins, and in particular what is known as No. 4 vein, were encountered underground, and in 1930 a second shaft, now the main shaft, was put down 300 feet east of No. 1. This shaft had reached a depth of 3,035 feet in 1944, with extensive lateral work on several levels. A mill was erected and has been in continuous operation since early in 1933. To the end of 1944, it treated 591,791 tons of ore and concentrates with recovery of 285,902 ounces of gold; to this production should be added 4,782 ounces extracted from ore obtained previously (1926 to 1933) during the initial development work. Appreciable shipments of white arsenic have also been made from the property. Ore reserves at the end of 1944 were estimated at about 200,000 tons, averaging 0.424 oz. gold per ton.

There are few outcrops on the property and most of the information concerning the geology and structure has been obtained from underground workings and diamond drilling. Immediately south of the Cadillac shear zone is a belt of volcanics (Blake River group), the southern part of which, for a width ranging from 15 to 60 feet, consists of porphyritic andesite. This is followed on the south by a continuous band of conglomerate (Cadillac group), ranging in width from 25 feet at the east end of the property to 100 feet in the western part, and forming the centre of the general synclinal belt. Blake River volcanics, which include a narrow band of porphyritic andesite, follow to the south and are succeeded in turn by sediments of the Kewagama group. The mine workings extend along the strike of the belt for a length of about 1,900 feet.

No. 1 vein follows closely the contact between the conglomerate and the greenstone to south of it. Owing to the fact that it strikes somewhat more south of east than this contact, and also has a slightly less steep dip (to the south), the eastern part of the vein is in conglomerate and the western part in greenstone. On the 500-foot level, the vein intersects the contact just west of No. 2 shaft. The vein is up to twelve feet wide but averages much less than this. The greatest widths have been found where it traverses conglomerate but, on the other hand, wall-rock mineralization is wider in the greenstone than in the conglomerate. In 1935, the vein had been developed on the third level for a length of 1,350 feet, of which 715 feet in three sections westward from No. 2 shaft was of ore grade over stoping width, and an additional length of 375 feet at the western end of the workings was of somewhat lower grade. This vein has been intersected in workings on the 13th (1,514-foot) level.

No. 4 vein lies within, or at the north margin of, the band of porphyritic andesite north of the conglomerate. In the upper, eastern, workings it is 50 to 60 feet north of No. 1 vein, and in the western drifts at intermediate depths the two veins are 120 or more feet apart. By the end of 1937, this vein had been explored on all levels from the surface down to the 13th (1,514-foot) horizon. A high-grade shoot was encountered east of the shaft from the surface down to the 5th (500-foot) level. From the latter to the 10th (1,138-foot) horizon, the vein was of good grade over a length of 220 feet, with extremely high grade ore along a central 35-foot section. This shoot is some 200 feet west of the high-grade ore developed on the upper levels. It did not persist to the 11th level. East of the shaft, from the 6th to below the 9th level, a length of 440 feet of gold-arsenopyrite ore, with stoping widths above the average for the vein, was encountered. On the 13th (1,514-foot) level, the vein remains very persistent, with even greater widths than on the upper levels, but no high-grade ore has been found within 500 feet east of the shaft.

The results of development to date encourage the belief that the main section of the mine will be productive at still lower levels, and that other veins or orebodies of similar grade will be found to east and west of the present mine workings.

In both veins, quartz is the most abundant gangue mineral. Metallic minerals present include, in addition to gold and associated silver, arsenopyrite and pyrrhotite (chiefly), pyrite, and, locally, minor amounts of chalcopyrite and galena. Sphalerite, in minute specks, has also been noted (Gunning, pp. 49-54; Bell, 1937, pp. 34-35; Taschereau, pp. 70-72).

Kewagama Gold Mines, Limited

This property, adjoining O'Brien on the east and originally owned by Cartier Malartic Gold Mines, Limited, was acquired in 1931 by Canadian Gold Operators, Limited, who, during the two following years carried out a considerable amount of development work, including diamond drilling, the sinking of a shaft to a depth of 125 feet, and approximately 1,500 feet of lateral work at that horizon. The shaft is 4,800 feet east of the main shaft of the O'Brien mine.

In 1936, Kewagama Gold Mines was incorporated to continue development of the property. The shaft was deepened to 525 feet, and from the 500-foot level, at a point 400 feet east of the shaft, a winze was sunk to the 700-foot horizon. Lateral work was carried out on four levels from the shaft and on three sub-levels from the winze. Although interesting gold assays were obtained from material encountered, especially on the lower levels, the ore of commercial grade was not in sufficient quantity to assure a profitable venture and all operations were suspended early in 1939.

Geology and Mineralization

The gold mineralization occurs in rocks of the Cadillac belt, south of the Cadillac shear zone, which here strikes east-west and dips at 80 to 85 degrees to the south. North of the shear zone is a considerable width of tuffs and agglomerates. In the vicinity of the mine workings, the highly sheared rocks of the Cadillac belt have an aggregate width of 320 to 420 feet, the succession from north to south being as follows: greenstone, 50 to 80 feet; 'North' porphyry, 10 to 30 feet; conglomerate, 40 to 50 feet; greenstone and tuff, 10 to 25 feet; 'South' porphyry, 10 to 30 feet; and greenstone, about 200 feet.

The only gold mineralization of particular interest disclosed by the extensive underground workings is in the winze, in a 25-foot raise above the winze, and in the sub-levels driven from the winze. These workings disclosed an ore shoot with a vertical extent of 225 feet and an east-west length of 15 to 80 feet, in which irregular and discontinuous stringers of blue quartz carry free gold. The majority of these veins are parallel and are in the 'North' porphyry near its north margin, but some continue into the greenstone north of the porphyry. Individual veins are rarely more than a few inches wide and a few tens of feet long; occasionally, two or three are parallel to one another or overlap for part of their length. Some sections of these narrow veins are decidedly high grade, but in any stoping operation there would be considerable dilution.

The Kewagama ore shoot occurs in the same belt of rock as the high-grade shoot in the No. 4 vein at the OBrien mine and resembles it in its short lateral, as compared with vertical, extent, and in having the same type of blue quartz and associated minerals. It differs from the O'Brien shoot in that it does not follow one definite fracture but consists of a series of irregular, overlapping stringers, and in being of much lower grade as a whole (Bell, 1937, p. 35; D. R. Derry, personal communication, 1940).

Central Cadillac Mines, Limited

The Central Cadillac property extends eastward from the northern part of the O'Brien property, lying immediately north of Kewagama ground, which it borders also on the east. Various interests have controlled or held options on the property since exploration of the claims commenced in or about 1929. This early work included diamond drilling by Canadian Enterprises, Limited.

The present Company, after completing a diamond-drilling programme which indicated gold mineralization of interest, particularly in the eastern claims, sank a shaft to a depth of 200 feet and from this level put down a winze to the 450-foot horizon. Mining has been carried on on four levels. Production commenced in 1939 and has come chiefly from workings eastward from the shaft. West of the shaft, work has been confined largely to the 200-foot level, where the ore shoots encountered were relatively small. Late in 1939, the Thompson Cadillac mill was leased for treatment of the ore. Up to the time operations were suspended in 1943, owing to war conditions, total gold production had amounted to some 31,030 ounces, recovered from 204,565 tons of ore treated, or rather more than 0.15 oz. gold per ton. In 1945, adjoining property was acquired by the Company and preparations were made for resumption of work, which was then carried on until 1949 when the combined properties were again closed.

The shaft is near the south margin of the 'Cadillac belt' of sheared greenstone, which here is unusually wide. A cross-cut on the 200-foot level gives the following section from south to north, starting 500 feet south of the shaft: greywackes grading into impure quartzites, with some slaty beds indistinguishable from tuffs, 450 feet; sheared greenstones, probably in large part tuffs, the southernmost members of the 'Cadillac belt', 200 feet; two intrusive bodies, one cherty aplite (quartz albitite), the other feldspar or feldspar-quartz porphyry, which appears to be the younger, 90 feet; conglomerate, 23 feet; sheared rocks of the Cadillac 'break', 87 feet; greenstone, 45 feet; banded iron formation, with some beds grading into magnetite-rich tuffs, 35 feet, followed northward by greenstone with minor amounts of iron formation. The main bed of iron formation has been traced from the cross-cut east to the boundary of the property.

Nearly the whole of the ore mined came from shoots in the eastern section of the mine, on both sides of the main band of iron formation. One body, at the east boundary of the property, had a length of 230 feet on the 100-foot level, averaged more than drift width, and extended above the level for 24 to 40 feet. The grade of the ore was well above the mine average. Another body, on the south side of the band of iron formation, had a length on the 200-foot level of about 400 feet, a width up to 40 feet, and a vertical height above the level of 25 to 30 feet. This ore was of average mine grade or somewhat below. Several similar, but smaller, ore shoots were encountered on all four levels in the eastern section of the mine.

Some of the production came from quartz veins, up to a few inches wide, in the western section of the mine, north of the shaft. In places these contained visible gold and could be stoped over shoot lengths. Similar veins were encountered in the sediments south of the shaft, or in the greenstones immediately north of these sediments, and also in the conglomerate north of the shaft, but although interesting gold assays were obtained from some of them, no shoots of ore grade were found. The veins, some of which were traced for a considerable length, are usually somewhat lenticular, narrow, and consist of glassy quartz.

Tourmaline, in veinlets or distributed through the adjacent wall-rock, is closely associated with the gold mineralization and in the main is older than the quartz. Arsenopyrite is present in appreciable amount in some of the eastern orebodies, and is found occasionally in those west of the shaft, but is everywhere subordinate to pyrite which in places forms as much as 70 per cent of the eastern orebodies. In some occurrences south of the shaft, the pyrite is sheared and older than the quartz, but elsewhere it veins the quartz or is disseminated through it and also through the adjacent wall-rock. It was found, however, that the presence of pyrite in the veins does not necessarily indicate that they are gold-bearing. Pyrrhotite and chalcopyrite are of very rare occurrence.

Coarse gold occurs in places in some of the veins, especially in those encountered in workings west of the shaft, but in general it is very finely divided and not visible to the naked eye. There is definite evidence that the gold is later than the quartz, and later than the northeast trending faults and slips which are common throughout the mine. In at least two places, films of gold were seen on slip planes in schists adjacent to quartz veins, indicating that the gold is not closely related to the quartz (Bell, p. 35; J. H. Evans (1939) and D. R. Derry (1940), personal communications).

Wood Cadillac Property (Now part of *Central Cadillac* holdings)

Wood Cadillac Mines, Limited was incorporated in 1928 to develop a group of claims, totalling 459 acres, extending eastward along the Cadillac shear zone from the southeast corner of the Central Cadillac holdings. Adjoining properties on the north and east are Pandora Cadillac and Amm Gold Mines.

The claims are heavily drift covered, but surface exploration and extensive diamond drilling, commenced in 1934, indicated gold mineralization of interest and in 1937 a three-compartment shaft was sunk to a depth of 522 feet. In that and succeeding years, development and mining were carried out on levels at 250, 375, and 500 feet. In 1939, a mill with a capacity of 225 tons per day was erected, and production of gold commenced in December of that year. In 1941, a winze was sunk from the 500-foot level of the mine to the 1,000-foot horizon and levels were opened at depths of 625, 750, and 875 feet, but results of development on these levels proved disappointing and all operations were suspended in June, 1942. At that time, the mill had treated some 180,000 tons of ore for a recovery of 27,113 ounces of gold, or an average of 0.15 oz. gold per ton. Production in 1942 included a small amount of scheelite.

The main orebodies in the mine are closely associated with a band of iron formation, 6 to 21 feet wide, which is the eastward continuation of the band in which the main orebodies of the Central Cadillac mine occur. On the Wood Cadillac property, it has been followed in the underground workings for a length of 1,600 feet. The best ore was found irregularly distributed along and near the north margin of the band and consisted chiefly of flat-lying veins of quartz cutting the iron formation and mineralized with pyrite, arsenopyrite, and tourmaline. In the richer sections of some of the veins, gold may be seen filling fractures in the quartz.

Similar flat-lying quartz-tourmaline veins occurring in greenstones between the iron formation and the Cadillac shear zone to the south of it have been investigated in the underground workings, as also have occurrences of quartz and sulphide mineralization in the vicinity of dykes of quartz gabbro which cut greywacke south of the shear zone (Gunning, pp. 58-60; J. E. Jerome, personal communication, 1941).

Pandora Cadillac Gold Mines, Limited

The property of this Company, successor in 1936 to Canadian Pandora Gold Mines, Limited, extends eastward from Wood Cadillac ground for rather more than two miles, crossing the north-south centre-line of Cadillac township. The original claims were staked in 1923. Surface exploration and diamond drilling in the following years revealed several gold-bearing veins of interest, including what is now known as the No. 5 vein, which was discovered in 1929. This was stripped and diamond-drilled, and in the following year sinking of a three-compartment shaft, north of the Cadillac shear zone, was commenced. The shaft was completed to a depth of 500 feet in 1933, and underground development was carried on on four levels until early in 1935, when operations were suspended. In 1936, following reorganization of the Company as Pandora Cadillac Gold Mines, Limited, active development of the mine was resumed, and in 1937-38 a new shaft was sunk, south of the shear zone, to a depth of 400 feet, with levels at 250 and 375 feet. In 1940, a new Company, Pandora, Limited, was formed to take over the development of both the Pandora property and that of Amm Gold Mines, which adjoins it on the south, and ore from the Pandora dump and underground workings was then trucked to the Amm mill, half a mile distant, for treatment. Production continued until August, 1942, when, due to the serious shortage of labour, it was found necessary to suspend operations. Total gold production by Pandora, Limited, to that time had amounted to 17,642 ounces, recovered from 122,368 tons of ore milled, an average of about 0.16 oz. gold per ton.

On this property, the schistose greenstones of the 'Cadillac belt' appear only as small and sparse outcrops which, in the vicinity of the Amos highway, 2,500 feet east of the centre-line of the township, are distributed over a width of about 250 feet. However, drilling has proved the continuity of the belt for 2,600 feet along its easterly strike. To the south are strong ridges of Kewagama (Fournière) group sediments, chiefly greywacke, and to the north similarly well exposed sediments of the Cadillac group. These also are chiefly greywacke, but at the east end of the property they are flanked on the south by narrow beds of conglomerate, and, north of the highway about 1,000 feet, they include some interbedded iron formation, the most prominent bed being 20 to 30 feet thick. Intruding the Kewagama greywacke near its contact with the Cadillac belt greenstones is a sill-like body, up to 100 feet thick, of quartz albitite. All the rocks are broken by regional northeast and northwest faults, generally of small displacement. However, a northeast trending fault which passes immediately west of the body of albitite has offset the beds it traverses 60 to 100 feet, with relative movement of the east wall northward.

The main shaft was sunk at the eastern side of the quartz albitite body, at its contact with the greywacke which, in turn, is here in contact with the greenstones of the Cadillac belt. The mine workings are chiefly in the north half of a sharp, westerly plunging syncline, so that the greenstone lies below the sediments, both of which are injected by the albitite. The *No. 5*, or *Discovery vein* lies in, or at the north margin of, this body. It is lenticular in character, with width ranging from a mere stringer up to four feet. It consists of very dark grey quartz, and associated with it, but mostly in the wall-rock and particularly where this is greywacke, are arsenopyrite, pyrite, pyrrhotite, and, rarely, a small amount of chalcopyrite. Black tourmaline, also, is usually present. Free gold, generally in the quartz, has been noted at many places along the vein. North of this vein, in the greywacke, is another, known as the *Bell vein*. It contains more pyrite and pyrrhotite, but rather less arsenopyrite, then the No. 5 vein. Both veins have been developed on all four levels of the mine.

A number of other veins have been found in the sediments, both to north and south of the Cadillac belt. The great majority of these are small and of no economic interest. The four considered the most important have been designated Nos. 1 to 4.

No. 1 vein is really a zone of more or less parallel quartz veins and lenses spaced across widths up to five feet in somewhat schistose greywacke about 2,500 feet southwest of the main shaft. The veins contain tourmaline and ankerite, and minor amounts of arsenopyrite and pyrite. The sulphides are more abundant in the wall-rock than in the quartz. The vein zone has been stripped for a length of 1,100 feet and it has been explored underground by a very limited amount of lateral work from the bottom of a 100-foot shaft.

No. 2 vein, 25 to 50 feet north of No. 1, consists of a narrow, lenticular, and in places discontinuous body of albite porphyry which intrudes greywacke and is veined by quartz, near which it is mineralized with very coarse arsenopyrite and lesser pyrite.

No. 3 vein is 800 feet north of the main shaft, in greywacke fifty feet south of the band of iron formation. It is a lenticular quartz vein, up to five feet wide, mineralized with pyrite. It was explored at the surface and in a pit 14 feet deep. Later, it was encountered on the 250-foot level in a cross-cut northward from the new shaft and was explored in a drift for 600 feet west from the cross-cut.

No. 4 vein or vein zone is in the band of iron formation or in the sediments adjoining it on the south, which are veined irregularly by quartz across a width of several feet. Pyrite is abundant in places, together with some arsenopyrite, and assays are reported to have shown the presence of gold (Bell and MacLean, pp. 43-47; Bell, 1931, pp. 11-14, 1937, pp. 36-37; Gunning, pp. 60-66; Taschereau and Herring, p. 76).

AMM GOLD MINES, LIMITED

This property is at the centre of Cadillac township, extending eastward from the southeast corner of Wood Cadillac ground and bounded on the north by Pandora. The Company was incorporated in 1936. Following a programme of surface exploration and diamond drilling, which revealed several gold-bearing veins of promise, a shaft was sunk to a depth of 525 feet and underground development and mining was carried on on four levels. A 150-ton mill was erected and went into operation in March, 1939. During that and the following year it treated 74,138 tons of ore for a recovery of 9,296 ounces of gold, an average of about 0.125 oz. per ton. In 1940, the Amm and adjoining Pandora property were merged and a new Company, Pandora, Limited, was formed to operate them. Thereafter, ore from the Pandora mine was treated in the Amm mill (see page 202). The mill is half a mile south of west of the Pandora main shaft.

The Amm claims are underlain by greywacke (Kewagama group) which, in the vicinity of the shaft, is intruded by numerous small bodies of albite porphyry, the largest about 60 feet wide and 260 feet long (Figure 29). Underground workings have shown that, from the surface to the bottom level of the mine, this body has a nearly vertical attitude, pitching slightly to the north. Gold-bearing veins have been found along shear zones in the greywacke in the vicinity of this porphyry, and some also in fractures in the porphyry itself.

The most important orebodies, known as No. 2*A* and No. 4, consist of parallel quartz lenses and stringers occupying shears in the greywacke. No. 2*A*, which is about 100 feet north of the shaft, has a length of 280 feet and an average width of 9 feet on the first two levels but is much shorter and narrower than this on the two lower levels. No. 4 is just south of the shaft. It has about the same length as No. 2*A*, and its width on all levels is fairly uniform, two to three feet at its east end, widening in one place to seven feet, and tapering to less than one foot at its west end. It is of somewhat higher grade than the No. 2*A* body.

No. 3 orebody, also in sheared greywacke, passes 35 feet north of the shaft. It has a length, on the surface, of 225 feet, terminating on the east at its contact with the body of porphyry and merging into the No. 2*A* body on the west. On the 135-foot level its length is only 100 feet and the grade is lower, and on the second level the zone of shearing is quite narrow and unmineralized.

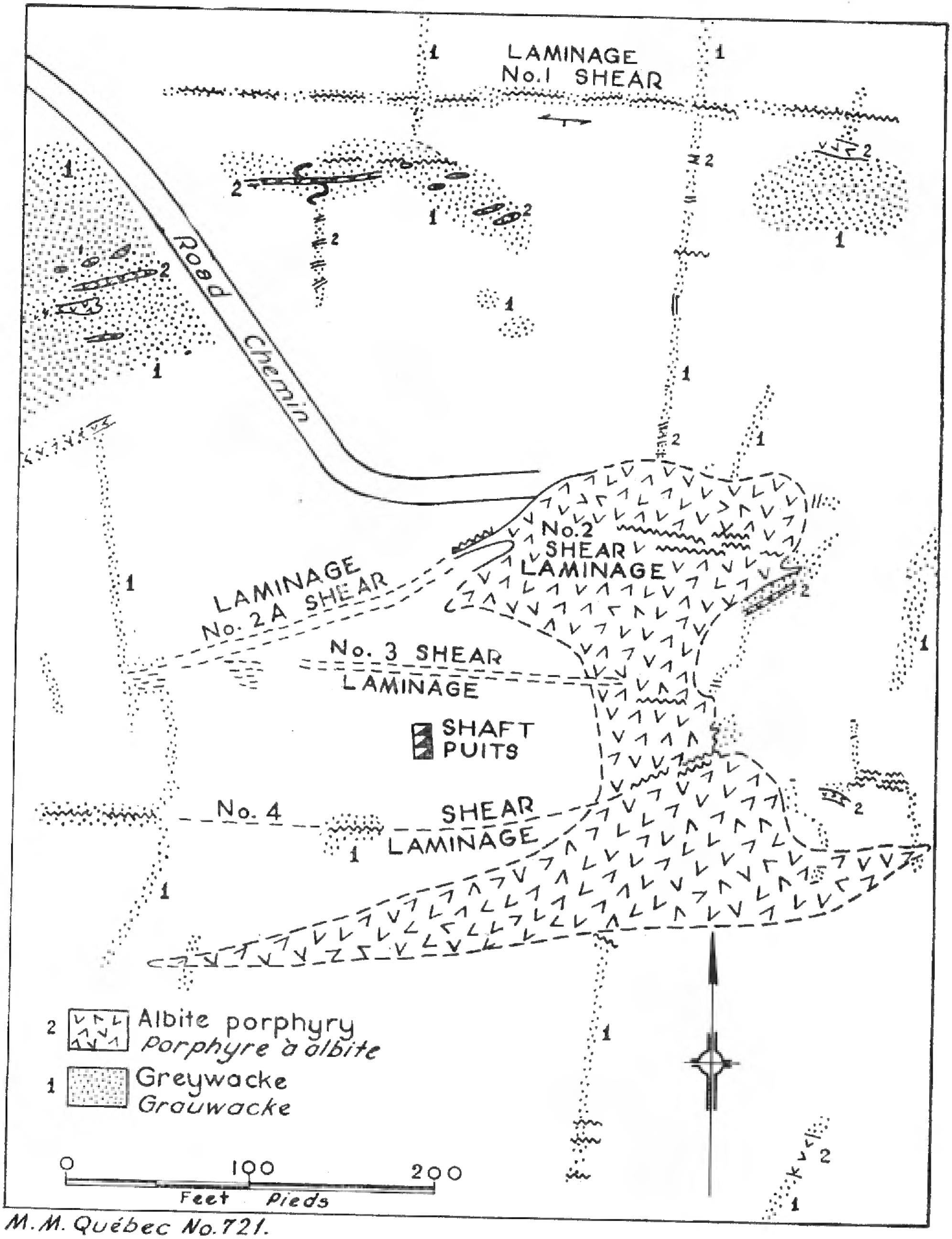


FIGURE 29.—*Amm mine, surface geology.*

No. 2 orebody consists of mineralized quartz veins in the porphyry, some 50 feet south of its north margin and immediately east of the east end of No. 2*A* orebody. On the surface, the mineralization extends over a length of 75 feet, with a width of 10 feet.

No. 1 orebody, or vein zone, is 350 feet north of the shaft, where quartz veins occur across a width up to eight feet in sheared greywacke. The zone has been traced on the surface for a length of 350 feet, but the gold mineralization is apparently below commercial grade.

Mineralogically, these bodies resemble those found in other mines along the western part of the 'Cadillac belt'. The most common sulphide mineral is arsenopyrite, in scattered crystals or 'nests' in both the vein quartz and wall-rock. In some narrow gold-bearing veins in the porphyry it is almost massive and veined by quartz. Pyrite is present in much lesser amount and favours the wall-rock rather than the quartz. Negligible amounts of chalcopyrite, galena, and sphalerite are common in No. 4 vein-zone and in certain arsenopyrite-rich stringers, and usually these sulphides are accompanied by gold. In general, however, they are rarely seen. Visible gold occurs in the veins, along their slickensided walls, and along partings in the sheared wall-rocks. Where seen in the quartz, it usually lines fractures. The evidence indicates that it was the last mineral to be deposited, with the exception of carbonate (Taschereau, p. 69; Taschereau and Herring, 1939, pp. 73-74, 1940, p. 73).

Tonawanda Mines, Limited

This Company, incorporated in 1929, owns a group of claims east of the Pandora Cadillac property and north of Lapa Cadillac. Exploration to date has been limited to surface work, the sinking of a prospect pit or shaft, and a small amount of diamond drilling.

The formations underlying the claims are the eastward continuation of those on the Pandora property. Schistose greenstones and tuffs of the Cadillac belt extend across the southwest corner of the property and are followed northward first by a band of conglomerate, 400 to 500 feet wide, and then by greywacke. There are numerous quartz veins in the greywacke, some of them carrying small amounts of pyrite. The band of interbedded iron formation, referred to in describing the Pandora property, continues eastward to Tonawanda's east boundary. Its width is variable but averages about 20 feet. At many places, particularly along its south side, it is cut by quartz veins which usually contain some pyrite. Some of these veins are reported to carry gold.

In the southernmost claim, a narrow pyritized quartz vein in the conglomerate has been exposed for a length of 75 feet, and 500 feet farther west, about on the strike of this vein, a narrow zone of siliceous greywacke in conglomerate is cut by quartz stringers and mineralized with arsenopyrite across a width of several inches. A prospect shaft was sunk on this vein in 1935, and some visible gold was found in the vein. A diamond-drill hole put down in the south part of this claim cut Cadillac belt schists carrying some quartz and pyrite (Gunning, pp. 66-67).

Lapa Cadillac Gold Mines, Limited

The property of this Company adjoins that of Pandora, Limited, on the east, in which direction it extends to within about a mile of the east boundary of the township, lying at and to the north of the east-west centre line. It is adjoined on the north by Tonawanda and on the south by Maritime Cadillac ground.

The property is largely drift covered, and no mineralized rock is exposed. It was explored by extensive diamond drilling, which intersected a number of gold-bearing quartz veins, and, to develop and mine these, a shaft was put down to a depth of 690 feet, with lateral workings on five levels. Several gold-bearing veins and ore shoots, most of them lying within a 200-foot-wide zone of biotite schist, were encountered in the underground workings and in 1938 a 250-ton mill was completed and placed in operation. Production was continuous from August of that year until June, 1943, when all operations were suspended. In those years, the mill treated a total of 380,544 tons of ore with recovery of 47,263 ounces of gold, an average of 0.1242 oz. per ton.

Gunning, who mapped the property before underground work had started, inferred (p. 69), from the meagre evidence afforded by the few outcrops and the preliminary diamond drilling, that the Cadillac belt of rocks was here 500 feet thick and sharply drag-folded into a *Z*-like structure similar to that on the Pandora Cadillac property. Also, that a strong, wide shear zone striking east to south of east crossed this structure. The underground development, however, has shown that the structure is an open fold, or abrupt flexure, along which the trend of the belt swings from southeast to due south.

The rocks of the belt are interbedded tuffs, greywacke, and lavas, with the tuffs and greywacke predominating. Outcrops of some of the wedge-like greywacke bands, which range from a few feet to upwards of 150 feet in width, were originally interpreted as infolded sediments of the Kewagama (Fournière) group and Cadillac group, which regionally lie, respectively, to the south and north of the Cadillac greenstone belt. The width of the Cadillac belt on this property is comparable to the local thickenings, up to 2,000 feet, present on the Central Cadillac and western part of the Pandora properties, to the west.

The Cadillac shear zone, where cross-cut in the mine, has a width of approximately 400 feet and lies in about the centre of the belt. It pitches at about 70 degrees in a direction N.25°W., and the limbs dip between 75 and 80 degrees. From his examination of the mine workings, Flaherty concluded that the shearing took place along a belt of fine grained tuffs which, as the result of hydrothermal action, are now represented by talc-chlorite and biotite schists. Several bands of such schist lie within the Cadillac belt. One of them, about 500 feet north of and parallel to the 200-foot wide zone with which the main orebodies are associated, has a width of 100 feet or more and has been followed for a length of at least 1,200 feet.

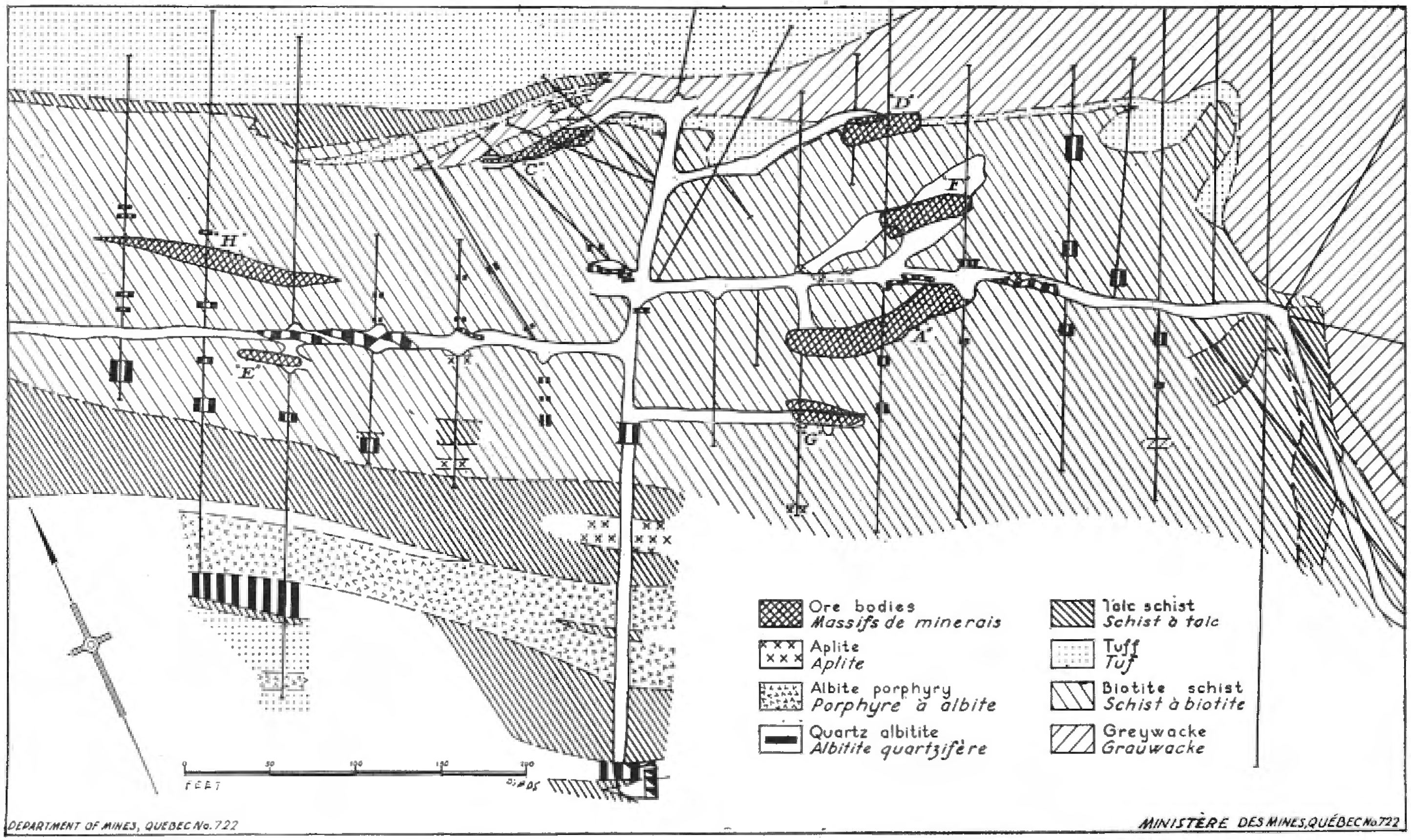


FIGURE 30.—*Lapa Cadillac mine, 540-foot level.*

Orebodies

With the exception of one, all the orebodies so far found are in the main biotite-schist zone, whose strike they parallel. They are irregularly spaced across it over a length of 500 feet or more, northwesterly from the bend in the zone. They are mineralized bodies of massive greywacke, quartzose sediments, and, in two cases, massive lava. In plan, they are lenticular, from 40 to 140 feet long and 5 to 25 feet wide, probably averaging over 10 feet. Their vertical extent is usually considerable. For instance, *A* and *C* bodies, whose lengths are 50 to 120 feet and widths 7 to 20 feet on the upper levels, maintain these dimensions to the lowest, or 690-foot, level. These bodies are in greywacke. *D* orebody has a similar pipe-like form, partly in greywacke and partly in a long, irregular band of quartzose sediments along the northeast margin of the shear zone. Apparently the bulk of this quartzose sediment was too resistant to shear and thus did not afford openings along which mineralization could be emplaced. In *F* orebody, the gold mineralization occurs around a lens of lava in close association with intrusive albitite, which also has been heavily mineralized. It is a short, lens-like body and is known to extend from the first to the 690-foot level. *G* orebody, also adjacent to greenstone, is about 50 feet long and 15 feet wide, and is known to have a vertical extent of at least 150 feet above the 690-foot level.

The typical ore consists of rock finely veined with quartz, along sheet jointing which parallels the trend of the containing greywacke and neighbouring schist. Locally, carbonate is present in small patches as well as some tourmaline, and the latter occurs also in separate veinlets. Pyrite is the most abundant sulphide and is usually accompanied by pyrrhotite, arsenopyrite, and chalcopyrite. These are all fine grained. In places, the ore contains visible native gold (Bell, p. 37; Gunning, pp. 68-71; G. F. Flaherty, Report to Company, 1939).

DUNLOP CONSOLIDATED MINES, LIMITED
and
MARITIME CADILLAC GOLD MINES, LIMITED
(Both inactive since 1940)

The northwestern claims of Dunlop Consolidated Mines lie between the Lapa Cadillac (on the north) and Maritime Cadillac properties. The Cadillac belt of altered volcanic rocks, bounded on either side by greywacke (chiefly) and other sediments, continues southward from Lapa Cadillac ground across these Dunlop claims and the northeastern Maritime Cadillac claims and there turns southeastward, in which direction it crosses the property of Pan Canadian Gold Mines.

Diamond drilling on the Dunlop claims in 1936 encountered gold-bearing mineralization similar to that on the Lapa Cadillac property along two distinct zones. It is associated with fine grained sodic intrusives in the schists of the belt. This property was acquired by Henri Crépeau in 1940.

On the Maritime Cadillac property, gold mineralization has been found in quartz stringers in highly sheared volcanics of the Cadillac belt and also along a wide zone of quartz veins and silicified rock in faulted and much contorted greywacke and conglomerate along the east side of the belt. The sulphides present include arsenopyrite, pyrite, and very minor galena, and native gold has been reported. These occurrences have been explored by diamond drilling and by a limited amount of lateral work from a shaft 160 feet deep. All work at the property was suspended in 1938 (Bell, p. 38; Gunning and Ambrose, 1937, p. 353).

Pan-Canadian Gold Mines, Limited

This Company was incorporated in 1935 to develop a large group of claims lying south of the Maritime Cadillac and Dunlop Consolidated properties, in the southeast quarter of Cadillac township. The Cadillac belt of volcanic rocks crosses the property, with southeast trend.

Trenching and diamond drilling in 1935 in the eastern part of the property established the presence of an orebody of substantial size, with moderrate to low gold tenor, at the south margin of the belt. This section of the property was acquired by West Malartic Mines, Limited, in 1939 (see below).

In 1936, a narrow, high-grade quartz vein was discovered about three-quarters of a mile to the northwest of this orebody. This vein is on the northern side of the volcanic belt and it passes westward from conglomerate into the volcanics, intersecting the contact at 15 degrees. Surface sampling at that time yielded assays of about one ounce gold per ton over a width of 18 inches and a length of 105 feet. Finely divided gold was abundant in fractures in the quartz and, associated with arsenopyrite, along and near the vein walls. Pyrite, pyrrhotite, and chalcopyrite were also present in small amount. Trenching indicated that the vein had a length of at least 1,300 feet.

This vein was mined on two levels from a shaft sunk in 1937 to a depth of 300 feet. Early in 1938, a mill with a capacity of 100 tons per day was completed and during that year it treated 5,837 tons of ore with recovery of 1,072 ounces of gold, or about 0.184 oz. per ton. Operations were then suspended, but in 1940 and 1941 further diamond drilling was done on the property by Siscoe Gold Mines, Limited (Bell, p. 38; Gunning and Ambrose, 1937, p. 354; Min. Ind. Que., Ann. Rep'ts, 1938-41).

West Malartic Mines, Limited

This Company acquired, in 1939, what was formerly the eastern part of the Pan Canadian property, on which an orebody had been discovered in 1935. The body occurs in a vertical shear zone, 100 feet wide, at the southern margin of the Cadillac belt of volcanic rocks, which here are intruded by albite porphyry. Metallic mineralization consists chiefly of pyrite, with some arsenopyrite and pyrrhotite. The gold-bearing sections are pod-like in shape. A shaft, commenced in 1939, was sunk on the orebody and by 1941 it had attained a depth of 723 feet, with lateral workings on five levels. In that year, erection of a 300-ton mill was started, and production commenced in 1942. To the end of 1943, a total of 148,395 tons of ore had been treated, with a production of 18,240 ounces of gold, an average recovery of 0.123 oz. per ton (Min. Ind. Que., Ann. Rep'ts, 1939-43).

MALARTIC TOWNSHIP

Parbec Malartic Gold Mines, Limited

The property of this Company, wholly owned subsidiary of Partanen Malartic Gold Mines, Limited, is in ranges I and II of the township, about a mile and a quarter from its west boundary. The Cadillac belt of schists and volcanic rocks, about 3,300 feet wide, crosses the northern claims with trend S.60°E. It is bounded on the north by greywacke of the Cadillac group and on the south by greywacke of the Kewagama group. A talc-chlorite shear zone, some 200 feet wide, closely follows the southern contact, and along this zone a number of dykes and irregular bodies of feldspar porphyry and albite granite, up to 400 feet long and 8 feet wide, have been injected. Near these, the greywacke has been albitized, and both it and the intrusive rocks are in places veined by quartz and mineralized with pyrite and minor pyrrhotite, arsenopyrite, and chalcopyrite. Gold, where present, is in a fine state of division and is associated with the pyrite, but there is no quantitative relationship between the two.

Between the years 1937 and 1941, the property was explored by stripping, trenching, and some 30,000 feet of diamond drilling, which revealed a number of gold-bearing bodies along the talc-chlorite shear zone. The most interesting of these is in greywacke about fifty feet north of a body of porphyry. It has an estimated length of 300 feet and width of 8½ feet, and the gold tenor is reported to average 0.23 oz. per ton. However, dilution in mining would materially reduce this grade. Nearby are four other bodies, indicated, by drilling, to have lengths of 150 to 300 feet and widths of 3 to 30 feet, with gold content ranging from 0.07 to 0.26 oz. per ton (Bell, p. 43; Gunning and Ambrose, 1940, pp. 107-109; G. F. Flaherty, personal communication, 1940).

Amphi Gold Properties, Limited

(Since 1940, *East Amphi Gold Mines, Limited*)

This property, held under development licenses, is at the south boundary of Malartic township. It is adjoined on the west by Parbec ground and on the south by Sladen Malartic (in Fournière township). Surface work and diamond drilling were done on the property by various interests between the years 1923 and 1941, and in 1928 Cartier Malartic Gold Mines, Limited, sank a shaft on one of the southern claims and did a small amount of lateral work at the 100-foot level. This shaft is at the northeastern end of an *S*-shaped body of albite granite, up to 450 feet wide, the largest of a number of bodies and dykes of this rock that here intrude greywacke (Kewagama group). Joints in the granite are traversed by veins, up to two feet wide, of quartz. The granite is mineralized with pyrite and, in places, minor galena and chalcopyrite, but most of the quartz veins are barren; some contain small amounts of ankerite and tourmaline.

Farther north, in range III, a quartz vein, up to four feet wide, has been exposed in a trench for a length of 200 feet. It lies in a shear zone, ten feet wide, which cuts across the contact between volcanic and sedimentary rocks. The vein carries little if any sulphides, but the wall-rock contains finely divided pyrite, biotite, and a little tourmaline (Gunning and Ambrose, 1940, pp. 65-67).

FOURNIERE TOWNSHIP

Canadian Malartic Gold Mines, Limited

The property of this Company lies on either side of the north-south centre-line of the township, with its northern limit about half a mile south of the Fournière-Malartic boundary. It is adjoined on the west and north by Sladen Malartic ground and on the east by the Sladen Malartic and East Malartic properties. It was the discovery and development of gold deposits on the Canadian Malartic claims in 1923 and subsequent years that started and encouraged exploration along the present gold producing Malartic-Fournière belt.

A number of orebodies have been discovered on the property along and near contacts between greywacke (Kewagama group) and intrusive feldspar porphyry, and chiefly in the greywacke. They have been developed and mined from three shafts, the workings from which are connected on various levels, the deepest of which is at 1,125 feet. Production commenced in 1935 on completion of a 150-ton mill, and mine output and milling capacity were steadily increased until, at the end of 1940, about 1,000 tons of ore was being milled daily. From the start of production until the end of 1944 a total of 2,466,915 tons of ore had been treated with recovery of 288,620 ounces of gold, an average of 0.117 oz. per ton. Ore reserves at the end of 1944 were estimated at 1,690,000 tons, averaging 0.123 oz. gold per ton.

The property is underlain by sediments, chiefly greywacke, of the Kewagama group, except in the northeast corner, where they are succeeded northward by the overlying volcanics of the Cadillac belt. The sediments are fairly well bedded, have a prevailing strike slightly south of east, and dip at about 70 degrees to the north. Intruding them are two small stocks, as well as numerous dykes, of pink feldspar porphyry. The larger of the stocks outcrops over an east-west width of about 1,200 feet at the eastern side of the property and continues, with tapering, in that direction onto Sladen Malartic ground. Its north-south width on Canadian Malartic ground is also about 1,200 feet, with the northern margin 1,000 feet south of the volcanics of the Cadillac belt. This stock pitches westward at about 17 degrees.

The other stock, or boss, outcrops about 2,200 feet to the west of the first and extends westward for some 1,200 feet with north-south width of 300 feet. Its east end pitches eastward at 65 degrees.

Where not altered by hydrothermal solutions, the porphyry is composed of closely packed phenocrysts of feldspar with a relatively small amount of groundmass consisting of feldspar and biotite. The phenocrysts are dominantly plagioclase, near albite in composition; about one-quarter of them are orthoclase, and one-tenth microcline.

Silicification, either of the greywacke or porphyry, is confined to zones which have been involved in brecciation and shearing. Such zones are mainly on the south side of the eastern porphyry body and at the eastern nose of the smaller boss.

There are two principal ore zones on the property. The north ore zone, with very regular easterly trend, closely follows the greywacke-porphyry

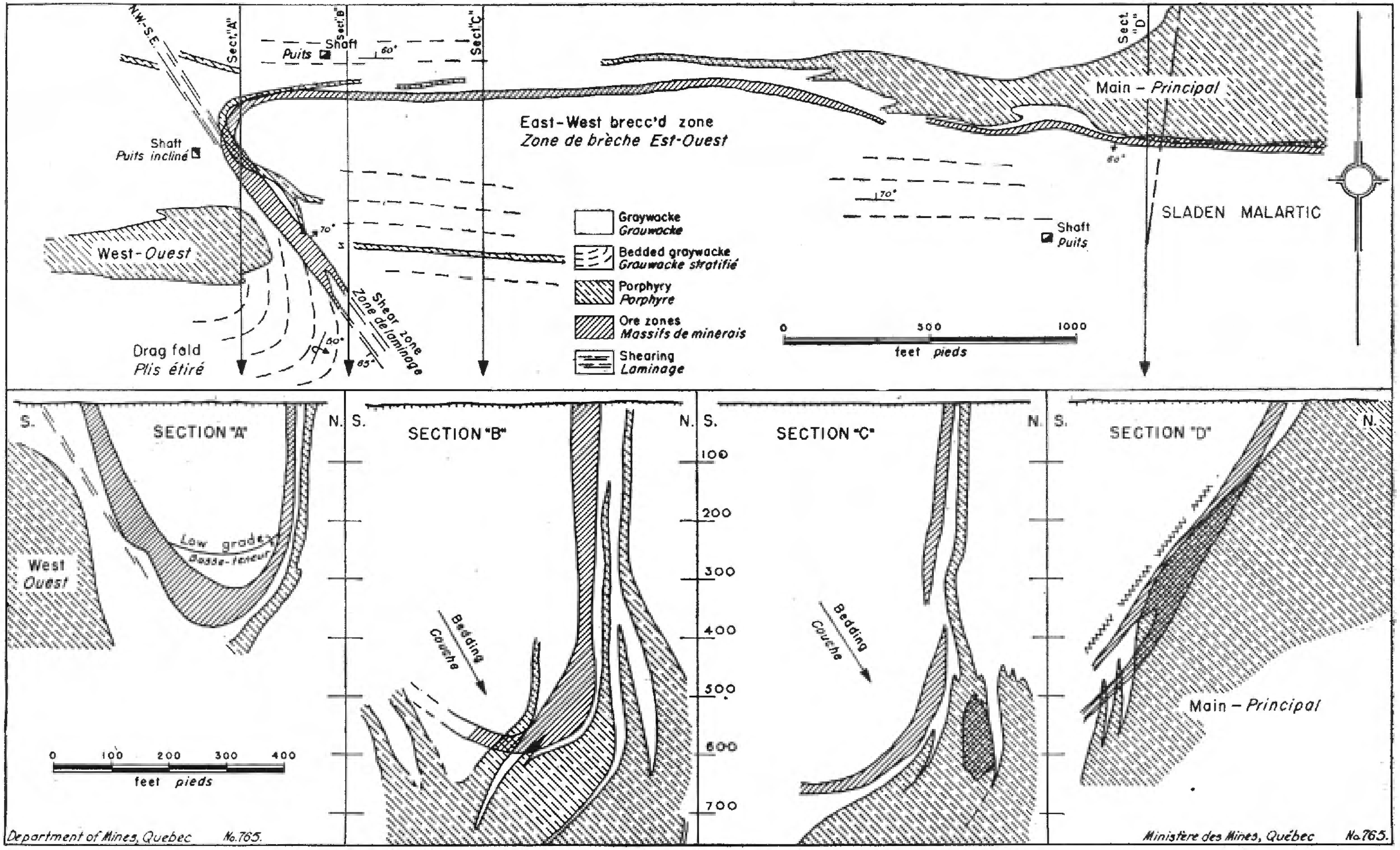


FIGURE 31.—*Canadian Malartic mine, surface plan and section.* (Jr. Econ. Geol. No. 5, 1939, Fig. 2, p. 499).

contact along the south margin of the larger stock. Eastward, it has been traced for a length of 9,000 feet, crossing the adjacent Sladen Malartic and East Malartic properties; westward, it merges with the South ore zone. This latter is *S*-shaped, with the lower hook of the *S* curving around the east nose of the small porphyry boss.

No. 1 shaft was sunk in greywacke about 2,000 feet west of the larger porphyry stock; it is near the point where the North and South ore zones merge. No. 2 shaft is 600 feet to the southwest, in greywacke on the west side of the South ore zone and immediately northwest of the east nose of the smaller boss of porphyry. These shafts were put down to develop and mine the North and South ore zones, respectively, and, as already mentioned, the underground workings from them were later connected on various levels, including the bottom level at 1,125 feet.

A well marked fault parallels the porphyry-greywacke contact of the North ore zone, in some places forming the hanging-wall of the ore, in others lying within the zone. The movement along this fault appears to have been relatively small. Where cut by mine workings at and below the 500-foot level, the continuity of the porphyry was found to be interrupted by a series of chloritic seams, up to five feet wide, resembling dykes. The western part of the North zone has a nearly vertical attitude from the surface down to the 400-foot level, but below this it dips southward, following the flattening porphyry-greywacke contact. The eastern part of the zone has been developed from No. 3 shaft, which is about 2,600 feet east of No. 1. The ore zone here dips, with the contact, at 60 degrees to the south, at least to the 600-foot horizon, at which the shaft bottoms.

On some of the mine levels, ore was almost continuous from the east end of the South ore zone northwest to its junction with the North zone, and eastward from there for upwards of 850 feet along the latter, with width ranging from 30 to 70 feet and averaging about 40 feet. The great bulk of the production has come from 'greywacke' ore. This consists of silicified greywacke traversed by fine grained quartz in irregular stringers and patches and mineralized with evenly disseminated pyrite and, in places, minor chalcopyrite, sphalerite, and galena. Gold is rarely visible and there appears to be no relationship between the amount of gold present and the silicification or other alteration of the greywacke, or the amount of pyrite.

The orebodies found in the porphyry are markedly different both structurally and mineralogically from those in the greywacke. The gold-bearing quartz veins occur almost exclusively in unsilicified porphyry and usually in the vicinity of greywacke inclusions, or of the chloritic seams referred to earlier. In general, stoping widths of the veins or vein zones are narrow, individual veins are short, and steep dips are rare. Superficially, the veins rather resemble pegmatite, with an abundance of red feldspar at their margins. The larger veins commonly contain, also, small amounts of chlorite, biotite, tourmaline, pyrite, and gold, the last rarely visible. Less common are calcite, scheelite, rutile, and muscovite, and rare constituents include molybdenite, fluorite, galena, specularite, tellurides (?), and, probably due to downward percolating water, selenite and soft red hematite. It has been noted that there is a tendency for the gold content to be highest in veins

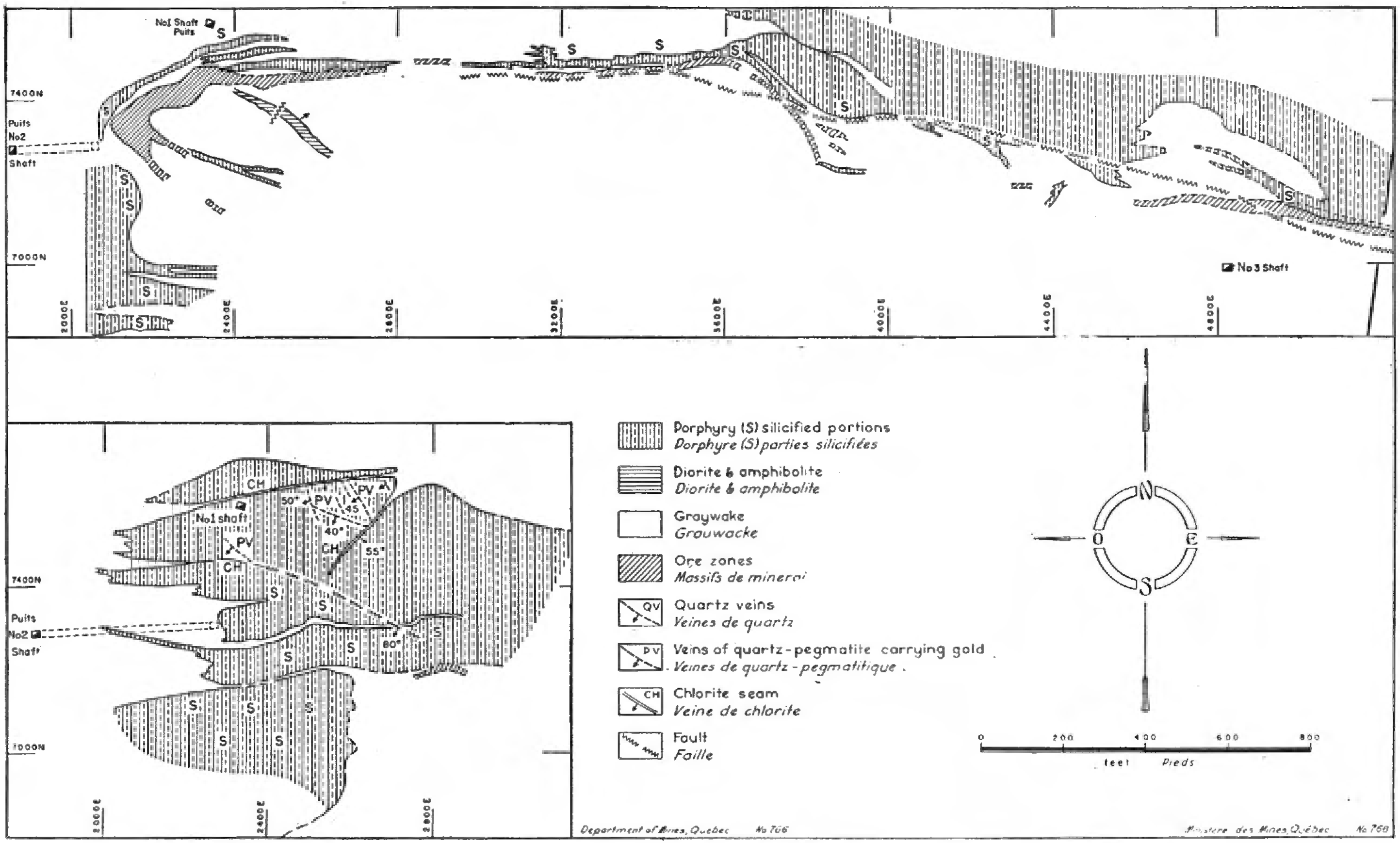


FIGURE 32.—*Canadian Malartic mine, generalized geology, 3rd and 6th levels* (only), with symbols. (Jr. Econ. Geol. No. 5, 1939, Fig. 3, pp. 504-505).

high in quartz and low in feldspar, but the gold tenor does not appear to be directly related to the presence or amount of any of the vein forming minerals. The evidence available indicates that the gold was one of the latest minerals to be deposited. Derry is of the opinion that it was deposited at the end of the same period, and from the same solutions, as the quartz and other pegmatitic minerals.

It is of interest to note that the gold in the greywacke ore differs greatly in 'fineness' from that in the porphyry ore, the gold-silver ratios being, respectively, 1.9 to 1 and 6.28 to 1 (O'Neill; Neelands and Millenbach; Derry, 1939, and personal communication, 1940).

Sladen Malartic Mines, Limited

This property is at the north boundary of Fournière township, along which it extends eastward for more than three miles to just beyond the north-south centre-line. It surrounds Canadian Malartic ground on the west, north, and east, and is bounded on the east by the National Malartic and East Malartic properties. The orebodies that have been, and are being, mined are in the eastern block of ground between the Canadian Malartic and East Malartic mines.

The claims were originally staked in 1923 and 1924, but muskeg and heavy overburden made prospecting difficult and it was not until several years later that extensive diamond drilling established the presence of important orebodies in the eastward continuation of the ore zone from the Canadian Malartic property, both near the latter property and farther eastward, at the Sladen Malartic-East Malartic boundary. To develop and mine these orebodies, a shaft (No. 1) was sunk in 1936 some 300 feet from the west boundary of the property, and in 1938 a second shaft (No. 2) was put down 400 feet from the east boundary, the shafts being 2,400 feet apart. By 1944, these shafts had attained depths of 1,200 feet and 1,750 feet, respectively, with the workings continuous from one to the other on three levels. A mill was erected and started operating in 1938. To the end of 1944 it had treated 1,460,685 tons of ore with recovery of 149,731 ounces of gold, an average of rather more than 0.10 oz. per ton. Ore reserves at that time were estimated at 530,000, tons with a gold tenor of 0.1171 oz. per ton.

The large feldspar porphyry stock in the eastern part of the Canadian Malartic property tapers rapidly where it enters Sladen Malartic ground and terminates after a length of some 1,800 feet on the latter property. This stock intrudes and is surrounded by sediments of the Kewagama group, chiefly greywacke. A few hundred feet eastward from the end of the stock these sediments are in contact with volcanics of the Cadillac belt, the contact trending S.60°E. across the eastern Sladen Malartic claims and the adjoining East Malartic property. A persistent easterly trending fault zone, thought to have a length of as much as 9,000 feet, closely follows the porphyry-greywacke contact and, beyond that, the greenstone-greywacke contact. It is along this zone that the main Sladen Malartic orebodies, as also those of the Canadian Malartic mine to the west and the East Malartic mine to the east, occur. The rocks within and adjacent to the zone are intruded by numerous dykes and irregular bodies of quartz syenite porphyry, particularly in the vicinity of No. 2 shaft, where they strike southeasterly and terminate abruptly at the greenstone-greywacke contact. The greenstones are also cut by a few diorite dykes which are believed to be older than the syenite dykes. Some ore occurs in one of these diorite dykes.

No. 1 shaft was sunk in the greywacke about 150 feet south of the ore zone and midway between two orebodies, designated the West orebody and the East, or Intermediate, orebody, about 600 feet apart. The *West orebody* has a length of 220 feet with widths up to 65 feet. It dips 50 degrees south on the 200-foot level and steepens to 60 degrees on the 725-foot level. The ore consists of irregular masses of mineralized greywacke and porphyry lying north of the fault. Some sections of this body are completely silicified and consist of yellowish to bluish-white, cherty, fine-grained material. The gold content was about 0.23 oz. per ton at the 200-foot horizon but decreased with depth to about 0.085 oz. per ton at the 725-foot level.

The *East, or Intermediate, orebody* has been mined from its top, which is 350 feet below the surface, to the 725-foot level. It has an average length of 350 feet and width of 50 feet. The ore is adjacent to the fault on its south side, and consists of mineralized greywacke and porphyry which follow the westward pitching intersection of the porphyry and fault zone. On the 500-foot level, the west end of this body is about 650 feet east of the West orebody, and on the 735-foot level the distance between them is 550 feet. Silicification is not as marked in this as in the West orebody. From the 400- to the 500-foot horizon, the gold content was about 0.085 oz. per ton, and below that about 0.145 oz. per ton.

What is known as the *24-3 orebody* lies along the footwall of the fault, dips 73 degrees south, and its east end is about 500 feet west of the No. 2 shaft. It is 250 feet long and varies in width from 15 to 40 feet; it has a rake east of about 80 degrees. This body has been developed from the 350- to the 725-foot level and has an indicated gold tenor of 0.115 oz. per ton. The ore is largely in mineralized greywacke which, in large part, is highly silicified. Syenite porphyry dykes also form part of the ore.

The *Diorite orebody* is the mineralized portion of a fractured dyke. It is an oval or circular pipe of ore, 15 to 20 feet in diameter, plunging to the southeast at 50 degrees. It has been developed from the 150- to the 725-foot level. The grade of the ore is well above mine average.

The bulk of the ore hoisted from No. 2 shaft has come from the *22-2* orebody, which lies to the northeast of the shaft. This body has a length of 450 feet on the 150-foot level but it tapers with depth and is only 50 feet long on the 725-foot horizon. Stoping widths are about 50 feet and the grade averages 0.10 oz. gold per ton. Five to ten feet of the stoping width along the north side of the body, and at its western end the entire width, is in a zone of talc-chlorite-carbonate schists intruded by narrow dykes of altered and mineralized diorite and syenite porphyry. The remainder of the orebody, which is of somewhat lower average grade, is in variously altered and mineralized greywacke. This greywacke ore resembles that present in the No. 1 shaft area.

The East orebody of National Malartic Gold Mines—whose property projects into the east side of Sladen Malartic—passes at depth into Sladen Malartic ground, where it is cut in mine workings north of the *22-2* orebody. It is in greenstones of the Cadillac belt.

Mineralogically, the Sladen Malartic orebodies are similar to those of the Canadian Malartic and East Malartic mines. Very fine pyrite is a common mineral in the ore and may amount to 15 per cent of it by weight. Pyrrhotite, chalcopyrite, and magnetite are present in minor amount, and sphalerite, galena, and hematite are sparse or local constituents. The gold occurs both free and in tellurides—the ore in one section of the mine is designated the 'telluride' orebody or zone. Sylvanite is the principal telluride present but there is at least one other, probably petzite. According to Gunning and Ambrose (1942, p. 120), "native gold, as tiny specks and rare, minute, isometric crystals, is principally in sylvanite and petzite or free in quartz. None was found in pyrite".

Pegmatitic quartz veins have been noted in some of the orebodies. They are similar to those occurring on the Canadian Malartic property (Gunning and Ambrose, 1940, pp. 114-123; C. C. L. Hogg, Mine Geologist, personal communication, 1941).

National Malartic Gold Mines, Limited

The claims of this Company are near the north boundary of the township of Fournière, lying between those of Sladen Malartic on the north and west, and East Malartic on the south and east. They are almost entirely drift covered, but the rocks exposed by deep trenching, and the known geological features of the adjacent properties, indicate that the northern part of the property is underlain by greywacke and conglomerate of the Cadillac group, and the southern part, for a width of about 2,500 feet, by volcanic rocks of the Cadillac belt, succeeded, in the extreme southwest corner, by greywacke of the Kewagama group. The volcanics are intruded in places by dykes of feldspar porphyry.

The trenching, carried out chiefly in 1934, revealed sulphide mineralization in several places. Most of the work was along and adjacent to the north bank of Malartic river, some 3,000 feet northeast of the southwest corner of the property, where schistose and highly altered rocks, in large part at least of volcanic origin, are cut by a syenite porphyry dyke up to 25 feet wide. The dyke parallels the schistosity, which strikes N.75°W. Where it has been exposed, the dyke is much fractured, sericitized, and pyritized, and is traversed by numerous veins of quartz and ferruginous carbonate, and in some of the veins, and also within the porphyry itself, there are small pockets of galena. The volcanics on both sides of the dyke are carbonatized and in places are replaced along seams and planes of schistosity by fine grained pyrite and very minor amounts of pyrrhotite and chalcopyrite. Mineralization of this type has been exposed at intervals over a length of 1,700 feet, but it is reported that, although sampling indicated the presence of gold over considerable widths, assays were all below commercial grade (Gunning and Ambrose, 1940, pp. 75-76).

East Malartic Gold Mines, Limited

This Company controls a large area in the northeast quarter of Fournière township, extending eastward for about a mile and three-quarters from the property of Sladen Malartic Gold Mines, Limited. The northern part of the property is underlain by sedimentary rocks of the Cadillac group, chiefly greywacke, with some conglomerate. The central zone is occupied by the Cadillac belt of Blake River volcanics, which strike about S.75°E. and have a width of 2,000 to 2,400 feet. These are followed on the south by greywacke of the Kewagama group. Intruding the rocks of the Cadillac belt, and also the Kewagama group sediments, are dykes and small bodies of syenite porphyry and diorite.

The main orebodies occur along and in the vicinity of the south margin of the Cadillac belt, both in the greenstones and in the intrusive bodies that cut them. The original discovery was in the eastern part of the property, some 2,500 feet from the boundary, and in 1936 a shaft (No. 2) was sunk here to explore and develop the deposit. In the same year, No. 1 shaft was put down 3,000 feet to the west, where further discoveries had been made. Exploration was then concentrated on the western claims. This work established the eastward continuation of the ore zone from the Sladen Malartic property onto East Malartic ground, and in 1937 a third shaft, No. 3, was put down about 1,000 feet from the property line and 3,000 feet west of No. 1 shaft. This is a four-compartment shaft and in 1940 it had reached a depth of 1,769 feet, with extensive workings on ten or more levels. Practically the whole of the production has come from these workings, which extend eastward from the property line for upwards of 2,000 feet. In 1943-44, a new deep-level incline shaft was raised from the tenth (1,540-foot) level to the surface.

Production commenced in 1938, and from then until the end of 1944 the mill treated 2,532,201 tons of ore with recovery of 394,748 ounces of gold, an average of about 0.155 oz. per ton. At that time, ore reserves above the 1,540-foot level were estimated at 2,634,259 tons carrying 0.208 oz. gold per ton.

The description that follows is based on the Geological Survey report by Gunning and Ambrose (1942) and on a report by E. A. Goranson, geologist for the Company.

The rocks of the Cadillac belt are chiefly basic volcanics, with some tuffs. Intensive shearing has converted them to biotite, chlorite, and hornblende schists which have steep to vertical dip, and, particularly in the vicinity of the orebodies, they have been profoundly altered as the result of intrusion by dykes and irregular bodies of syenite porphyry and diorite and by the mineralizing solutions from which the ores were deposited. Within the ore zones, they have usually been converted into soft talc schists, talc-chlorite schists, and amphibolite schists. No primary structures have been recognized underground in the greenstones, but pillows have been noted in an outcrop on Sladen Malartic ground. Along the greenstone-greywacke contact, the greenstone may be converted into an amphibolite schist up to a few feet in thickness. At No. 2 shaft, irregular bands of fine grained slaty

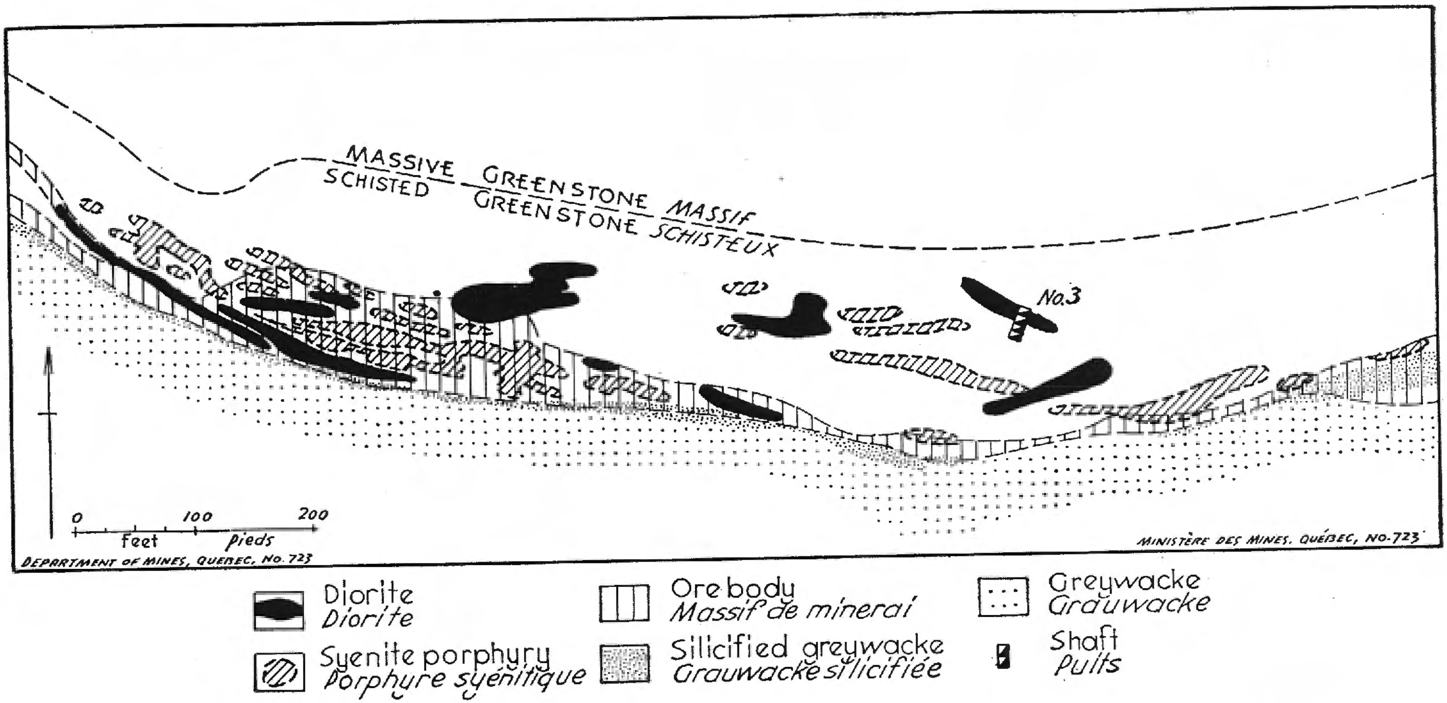


FIGURE 33.—*East Malartic mine, 485-foot level.*

sediments, up to 15 feet in width, are apparently intercalated with the greenstones.

The Cadillac group lying north of the belt is here upwards of 6,000 feet wide and is a sedimentary assemblage. Near the ore zones, the beds are chiefly greywacke and tuff, in part altered to mica schist, phyllite, chlorite schist, and amphibolite. Farther north, conglomerate beds are common.

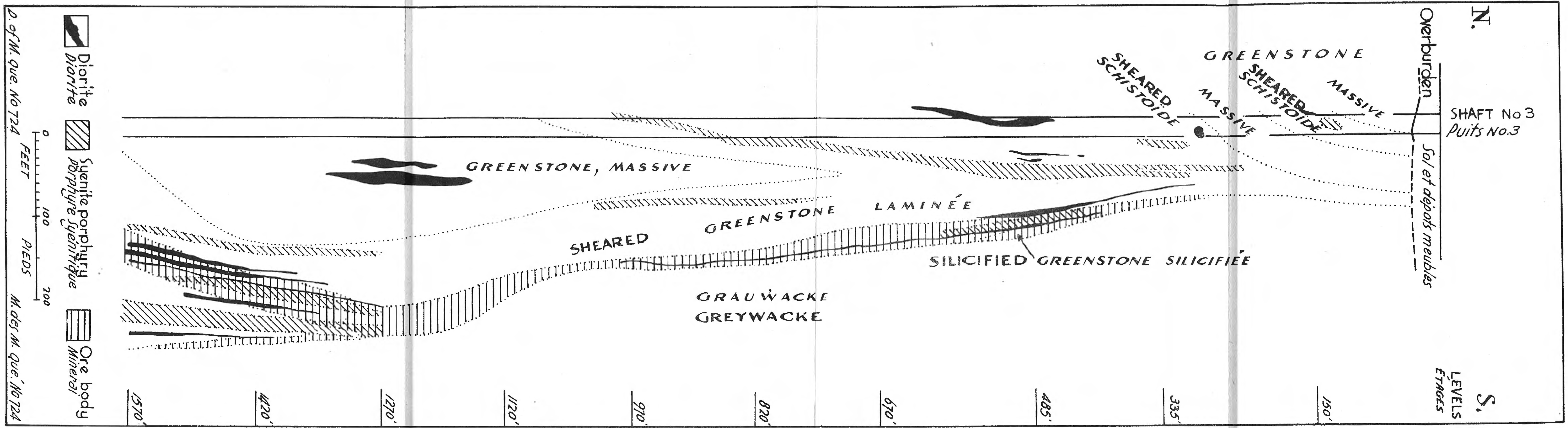
To the south of the Cadillac belt is the older Kewagama (Fournière) group of sediments, chiefly greywacke. In the No. 3 shaft area, these sediments form part of the south margin of the ore zone. South of the orebody, the greywacke is generally fine grained, contains biotite, and is visibly stratified, but, as the contact is approached, the bedding disappears and the rock becomes chloritic and massive. Generally, along the contact, the greywacke has been changed into a hard, structureless rock, sometimes termed 'silicified greywacke'. Similar rock on the Canadian Malartic property has been described by Derry (p. 497), who found that, there, the 'silicification' is confined mainly to narrow quartz stringers, and that the dense texture of the rock is almost entirely the result of cementation of brecciated fragments by dissolved and re-deposited feldspathic constituents of the greywacke itself, accompanied by addition of some silica and a good deal of carbonate.

The acidic intrusives cutting the volcanics of the Cadillac belt along and in the vicinity of the ore zone are of various types, chiefly syenite porphyry, syenite, feldspar porphyry, and quartz-feldspar porphyry. They occur as stock-like masses, sills, and dykes, and may represent more than one period of intrusion. Dyke-like bodies of diorite are also fairly numerous. Goranson estimates that intrusive rocks form up to 40 per cent of this section of the belt.

Acidic intrusives are found also cutting the adjacent Kewagama sediments, and within these are a few bodies of relatively basic rock, probably similar in composition to the diorite bodies in the greenstones of the belt. Usually, they have about the same strike as the enclosing sediments.

In common with most of the other deposits of note in this district, the East Malartic orebodies are closely associated with the Cadillac belt and particularly with strong faults and shears that have affected the rocks of the belt or those adjacent to it. This belt is on the southern limb of a tightly folded syncline that, regionally, pitches gently westward. The regional persistence of these pronounced structural features naturally supports the belief that they and their related ore zones have great vertical extent.

In the western part of the property, in the vicinity of the main workings, the greenstone-greywacke contact, along which the No. 3 orebody occurs, is somewhat arcuate in form, the strike changing gradually from S.65°E. near the Sladen Malartic boundary to slightly north of east, until, after a length of 2,300 feet, it reverts to its southeasterly trend. The contact is marked by a shear zone, about 700 feet wide, which is mainly in greenstone and along which the greenstone has been converted into soft, thinly-laminated schist with the schistosity striking either parallel to, or



VERTICAL SECTION THROUGH No3 SHAFT EAST MALARTIC MINE COUPE VERTICALE AU PUITS No3

Fig. 34

slightly more northerly than, the trend of the contact. Horses of fractured, unsheared greenstone occur within the shear zone and the fractures are filled with white carbonate.

In few places along the contact, the greywacke has been sheared to a biotite-carbonate schist, but usually it has been recrystallized into the hard, dense, massive 'silicified greywacke' already referred to.

Within the greenstones at and adjacent to the contact are numerous irregular dykes of acidic, and also relatively basic, rock; very few such bodies have been found in the greywacke. Usually, the dykes about parallel the contact and plunge at 50° to 65° to the east. In the western section of the mine, it has been noted that, with depth, there is a gradual increase in the amount of intrusive material along and near the contact. Generally, these igneous bodies have blunt ends and, where their original character has not been destroyed by metamorphism, they exhibit 'chilling' effects at contacts with their host rocks.

Within the ore zone, the basic dykes, termed 'diorite', are considerably altered and in places sheared, but away from the ore zone their contacts with the sheared greenstones are clean-cut. In diamond-drill core, and to a certain extent in underground workings, a gradual decrease in alteration of the diorite can be seen as the dyke passes from the ore zone to the greenstone on the outskirts of the shear zone.

The acidic dykes are younger than the basic dykes. In places, they are found cutting the latter.

Small *Z*-shaped drag folds, a few inches across, are found in the greenstone schists and in a few places have affected the acidic and diorite dykes; they plunge at 50° to the east and the indicated movement is north side to the east and up and south side to the west and down.

A number of fractures with slight or no apparent displacement strike across the orebody. Broadly considered, these fall in two main groups, those striking N.50°-80°W. and those striking N.50°-80°E. They all have a vertical attitude or very steep dip to north or south. The fractures are more numerous in the greywacke than in the greenstones; usually they stop at the contact. They cut, and may displace, all the rock types within the mine with the exception of some carbonate veinlets, which in places occur within the fractures.

Less common are fractures in the greywacke that strike northwest and are relatively flat-dipping, 15° to 30° southwest. Along these, for a width up to six inches, the rock is much shattered, but the displacement along them seems to be *nil* or slight.

Quartz of two different types occurs as veins within the ore zone: a medium-grained quartz, and a later coarse-grained pegmatitic quartz. The former type generally forms long, narrow veins with matching walls, and individual veins have been traced for lengths of 100 feet. The pegmatitic quartz generally occurs as irregular patches within the greywacke and the acidic dykes, and to some extent in gash-veins with regular walls in the greywacke.

The Orebodies

The *No. 3 orebody* is apparently the easterly continuation of the Sladen Malartic ore zone. On East Malartic ground, at the end of 1940, a continuous length of 2,000 feet of ore having an average width of 24 feet had been developed on the 485-foot level. On other levels, exploration had not then been extended so far eastward.

The western part of the mine, from surface to the 670-foot level, has produced the major part of the tonnage milled and the better grade ore. In the east section, intrusives are fewer and the bulk of the ore so far developed is in the greywacke, where ore of commercial grade is usually restricted to salients of 'silicified' greywacke which jut into the greenstone. One of these salients has been traced from about the 335-foot level to the 870-foot level. Like the intrusives, it plunges at 63 degrees to the east. In these salients, the greywacke is believed to have been more fractured than along other parts of the contact and hence rendered more permeable to the ore-forming solutions. In a *V*-shaped section of barren rock on the upper levels, the greywacke shows no indications of pre-ore fracturing.

The orebody consists of a number of rock types — sheared greenstones, acidic and basic intrusives, and greywacke — which, in the ore zone, all contain some gold, with widths up to 90 feet of commercial ore along and near the greenstone-greywacke contact. In general, the width of the ore on the greenstone side of the contact depends on the distribution and size of the intrusives. Where these are not present, widths are narrow or ore is lacking. The better grade sections occur where the intrusive bodies are less than about 15 feet wide and are separated from one another by narrow bands of greenstone, and they generally occur at greenstone contacts with the harder rocks and decrease rapidly away from the contacts.

The average ore contains about 5 per cent by volume of vein quartz which is chiefly localized in the acidic intrusives and, in lesser amount, in the diorite and greywacke. The gold content of the vein quartz is erratic but generally below that of the host rock. The most conspicuous sulphide present in the ore is pyrite, which averages about 3 per cent by weight of the ore. The quartz generally carries only a few specks of sulphide.

The gold, and also the pyrite, content of the diorite is usually fairly constant in amount and also higher than in the other rocks. Pyrite may form as much as 20 per cent by weight of the diorite ore and, in general, the greater the amount of pyrite, the higher the grade of the ore. In the acidic intrusives, both gold and pyrite are of very erratic occurrence and there seems to be no relationship between the gold content and the pyrite content of the ore. In greenstone, as previously mentioned, gold is confined chiefly to the vicinity of contacts with harder rock and does not persist very far from the contacts; it is usually accompanied by a minor amount of pyrite. In the greywacke, the gold is generally found in the 'silicified' greywacke, at its contact with the greenstone. Usually, the higher grade ore is localized within 10 to 15 feet of the contact, but irregular streaks of high gold tenor in places make low-grade ore over widths up to 50 feet from the contact. Pyrite is of erratic occurrence in the greywacke, and there is no quantitative relationship between the pyrite and the gold content. Where a zone of quartz replacement occurs in the greywacke along the contact, it is usually of lower grade than the greywacke next to the silicification.

In the west section of the mine, on the upper levels, a diorite dyke, striking at an angle of 15 degrees to the greenstone-greywacke contact, makes ore to a depth of 485 feet over a strike length of 300 feet. In this orebody, it has been found that the grade becomes lower with increasing distance from the greenstone-greywacke contact.

The orebody about No. 1 shaft occurs along a fracture zone within a stock-like body of syenite porphyry, which intrudes the central part of the Cadillac belt. It has been traced for upwards of 1,300 feet along the strike and its width ranges up to more than 900 feet. The syenite porphyry is in contact with talc-chlorite schists and a body of quartz-feldspar porphyry which is more than 500 feet long and up to 250 feet wide. The quartz-feldspar porphyry is similar in appearance to the syenite porphyry except for the presence of quartz in visible grains.

The fracture zone has been traced for a length of 400 feet in the underground workings. It is irregular in strike, from N.50°-70°E., and also in dip, which is 50°-75° southwest.

The orebody consists of a silicified replacement zone along a number of closely spaced fractures in the syenite porphyry. The silicification shows all gradations from cherty material to medium-grained quartz and ranges in width from a few inches to six feet. The zone has been traced along the strike for 400 feet and down the dip for 350 feet. Mineralization is sparse along and within the zone and consists of a small amount of pyrite, and, in places, specks of native gold.

The orebody first discovered and which was explored from No. 2 shaft consists of several mineralized diorite dykes in soft talcose and chloritic schists about 150 feet south of the contact between the Cadillac group sediments (to the north) and the Cadillac belt. The dykes are concordant with the strike and dip of the schistose greenstones. They are up to 100 feet in length and 15 feet wide and usually have blunt ends. Some bands of slaty sediments, the widest not more than 30 feet, lie shortly north of the dykes, in the sheared greenstones. A few small acidic igneous bodies occur near the diorite dykes and appear to strike parallel to them.

This orebody is made up of a number of highly altered and pyritized lens-like bodies of diorite in the schistose greenstone. These bodies are generally 100 feet or less in strike length and average about 5 feet in width. Traversing them are narrow quartz veinlets which in places carry gold. The diorite contains up to 20 per cent by weight of pyrite, but in the quartz veinlets there are only occasional specks of this mineral.

Mineralization

All the orebodies contain essentially the same minerals, but there is some variation in the relative amounts of these minerals in the different types of ore. Thus, some minerals that are associated with the pegmatitic type of quartz, which occurs chiefly in the acidic intrusives and the greywacke, have not been found in the diorite or greenstone.

The most conspicuous metallic mineral present in the ore is pyrite; it is more abundant in diorite than in the other rock types. The pyrite crystals range in size from half-inch cubes to minute grains; in places, the mineral is massive. Other metallic minerals present in small amount are magnetite, specular hematite, pyrrhotite, galena, chalcopyrite, sphalerite, and molybdenite. Assay of a composite sample of the No. 3 orebody showed that it contained arsenic.

Rutile, tourmaline, graphite, scheelite, beryl, coarse biotite, and feldspar have been found in some of the orebodies, chiefly in quartz of the pegmatite type.

Gold is sparingly seen in all the orebodies and may occur either in minute cracks in quartz or along fractures, joints, or vugs in the several rock types, with no apparent relationship to quartz. It has been found along fracture planes in the acidic intrusives, diorite, and greywacke, and along planes of schistosity in the greenstone, with no associated minerals other than the rock-forming constituents. Under the microscope, gold may be seen in fractures within pyrite grains and also surrounding pyrite grains. Micron-sized blebs of gold have been noted in the interior of pyrite grains with no apparent relation to fractures or grain boundaries. At one point in the No. 3 orebody, gold occurs within a carbonate veinlet, replacing the carbonate. The diversity in the mode of occurrence and mineral associations of the gold indicates that the bulk of it has been introduced late in the sequence of events and that its distribution is not dependent on the distribution of the quartz or pyrite but mainly on fracturing which occurred after introduction of these minerals.

The silver distribution in the three orebodies appears to be low and erratic. No silver minerals have been recognized in any of the bodies. Galena, which is present in small amount, carries a low percentage of silver, and may be the source of the silver in the ore (Gunning and Ambrose, 1940, pp. 81-88; E. A. Goranson, Geologist for East Malartic Gold Mines, Limited, Company report).

Rand Malartic Mines, Limited

This Company was incorporated in 1937 to develop a group of claims lying between those of East Malartic (on the west) and Malartic Gold Fields. These claims originally formed the 'East group' of the holdings of Sladen Malartic Mines, Limited.

The Cadillac belt of volcanic rocks crosses the property with trend S.70°E. It has a width of at least 2,000 feet and is followed on the north by greywacke and conglomerate of the Cadillac group, and on the south by greywacke of the Kewagama group, which underlies the extreme south part of the property. Within the Cadillac belt are numerous intrusions of porphyry and some of diorite. Between 1936 and 1941, the claims were explored by extensive stripping and trenching and a considerable amount of diamond drilling, and in 1938 a shaft was sunk to a depth of 40 feet. This work revealed a number of occurrences of gold mineralization of interest at, and adjacent to, both the north and the south margin of the belt.

The first discoveries of gold were near (south of) the north margin of the Cadillac belt, in a band of 'albite phyllite', which, it is thought, may be altered sedimentary rock. This band has been exposed by trenching over a length of 400 feet. It is 20 feet wide, bordered on either side by intrusive porphyry. The rock contains much disseminated pyrite with, locally, a small amount of arsenopyrite, and is cut by narrow quartz veins which carry pyrite, tourmaline, and, in places, visible gold. The drilling indicated that similar mineralization persists to a depth of at least 150 feet. It was reported that no gold assays of commercial grade were obtained from the drill cores but that bulk samples of material from the trenches returned assays averaging 0.2 to 0.3 oz. gold per ton across widths of five and six feet. Some small mineralized quartz veins were found also in the greywacke and conglomerate to the north of the belt of volcanics.

Overburden and swamp conceal the southern contact zone of the Cadillac belt, but extensive diamond drilling in holes spaced over a length of some 800 feet indicated a zone about 200 feet wide along which the volcanic rocks of the belt are sheared and intruded by porphyry and diorite. Encouraging, but erratic, gold assays were reported from drill cores, which in places contained coarse native gold (Bell, 1937, p. 47; Ross and Asbury, p. 33; Gunning and Ambrose, 1940, pp. 111-113).

FOURNIERE AND DUBUISSON TOWNSHIPS

MALARTIC GOLD FIELDS, LIMITED

The property of this Company extends eastward from Rand Malartic ground to the Fournière-Dubuisson township line and for some 6,600 feet in ranges VIII and IX of the latter township. Over most of the property, bed-rock is deeply buried beneath clay and swamp, but much has been learned of the essential geological and structural features as the result of exploration, principally since 1935, by magnetometric surveys, a limited amount of trenching, many thousands of feet of diamond drilling, and, following the sinking of a shaft in 1939, by underground development. This work has shown that the Cadillac belt of volcanic rocks, with a width of some 2,400 feet, extends eastward (about S.70°E.) completely across the property, with greywacke and conglomerate of the Cadillac group on its northern side and greywacke of the Kewagama group on the south. Adjacent to the contacts, the greenstones of the belt are strongly sheared and are cut by dykes and irregular bodies of porphyry and, particularly near the northern contact, diorite.

The early drilling was confined largely to probing the south part of the belt over a length of about 3,000 feet eastward from the Rand Malartic property, that is, on claims in Fournière township. It was reported that this drilling indicated a mineralized zone with a length of 1,100 feet and that gold was found in the core from many of the holes, particularly in porphyry, one dyke of which has a width of 200 to 300 feet. Gold-bearing quartz veins were also cut in the conglomerate to the south of the belt. There has been little, if any, work done in this part of the property since 1939.

In 1938, a very extensive diamond drilling programme was carried out along and adjacent to the northern margin of the belt in the eastern (Dubuisson township) part of the property. The drilling revealed very encouraging gold mineralization associated with a number of diorite dykes cutting the greenstones. In the following year, a shaft was sunk and underground development and mining of the orebodies commenced. A 400-ton mill was erected, and by the end of the year it had treated 5,354 tons of ore with recovery of 1,224 ounces of gold. The mine has been in continuous production since that time. To the end of 1944, the mill had treated 1,062,632 tons of ore with recovery of 213,232 ounces of gold, or 0.2 oz. per ton. The shaft, which is about 1,300 feet from the east boundary of the property, had reached a depth of 1,870 feet, with workings on twelve levels, and the capacity of the mill had been increased to 1,000 tons per day.

In 1942, a second shaft was put down 3,000 feet west of No. 1 to develop and mine a number of orebodies which had been discovered in that section of the property in the previous year. At the end of 1944, this shaft had a depth of 1,500 feet and on the 1,200-foot level the workings were connected with those from No. 1 shaft. Work in the No. 2 mine has been confined almost entirely to development.

Estimated reserves of fully developed ore at the end of 1944 were as follows: No. 1 mine, above the 1,200-foot level, 429,735 tons averaging

0.18 oz. gold per ton; No. 2 mine, above the 450-foot level, 939,175 tons averaging 0.24 oz. gold per ton.

The orebodies consist of mineralized diorite dykes which intrude the volcanic rocks of the Cadillac belt, whose trend they parallel. In No. 1

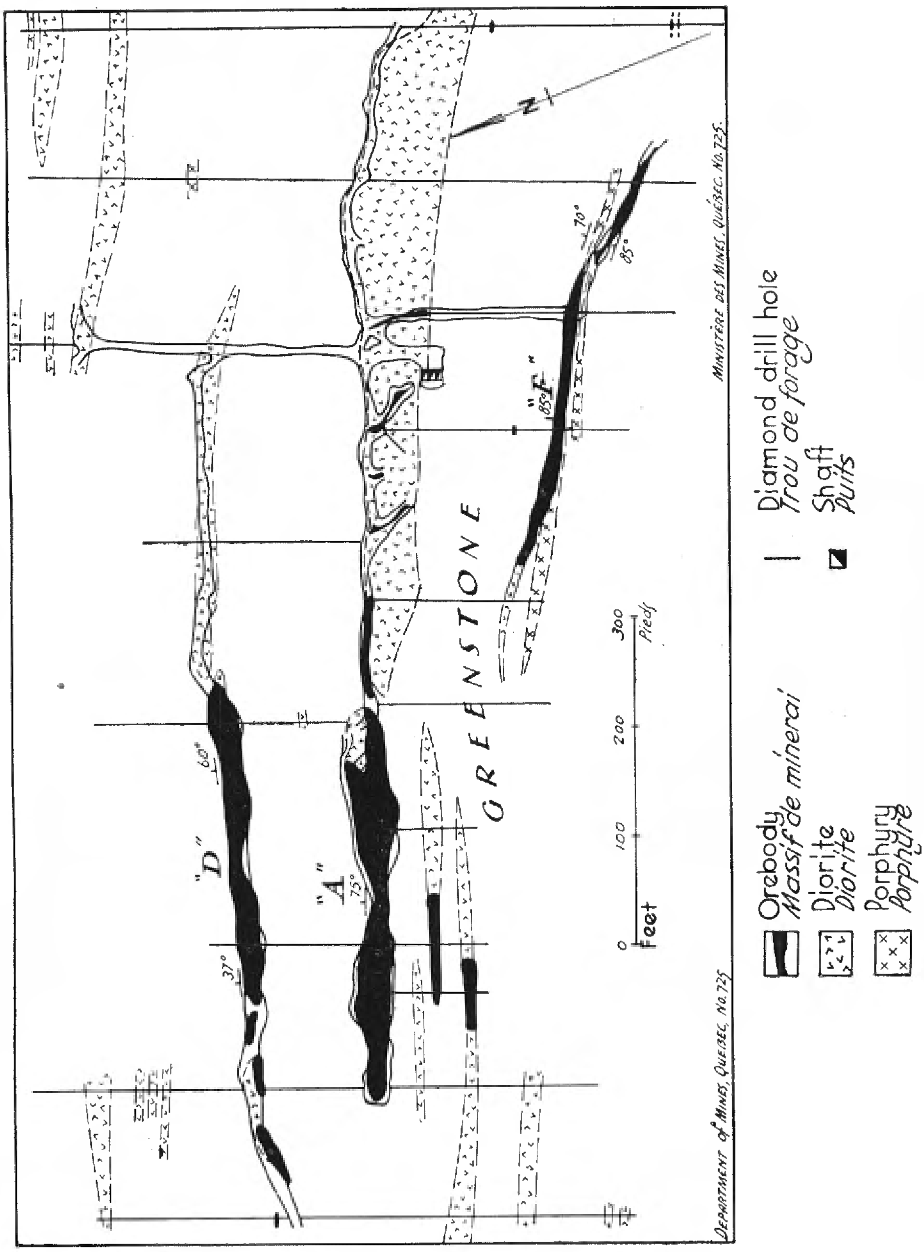


FIGURE 35.—*Malartic Gold Fields mine, diagram of part of 300-foot level.*

mine there are four such major bodies within a cross-sectional width of 260 feet, and there are four also in No. 2 mine, with several subsidiary and outlying lenses. Underground development has shown that these bodies persist to the lowest levels with no appreciable change in size or grade. Where the dykes are relatively narrow, not over 30 feet wide, the full width of the dyke constitutes ore (*A* and *B* orebodies, No. 1 mine; *F* orebody, No. 2 mine). These dykes are traversed by a multitude of white to nearly black quartz veins, some containing a little tourmaline, which occupy fractures having quite random directions and attitudes, with the majority striking about N.30°E. and dipping 45 degrees west. They are commonly from one to six inches wide, rarely as much as two feet, and they form possibly 15 per cent of the bulk of the orebody. Pyrite, in grains from one-sixteenth to one-eighth of an inch in diameter, is present both in the veins and the wall-rock and may form as much as 15 per cent of the ore. Arsenopyrite is relatively rare, the average ore containing only one-tenth to one-fifth of one per cent of arsenic, and chalcopyrite is present in very minor amount. The bulk of the gold is closely associated with the pyrite but some occurs in the quartz, in which it may sometimes be seen along fractures.

In the wider dykes, the ore occurs in lenticular or 'ropy' shoots, 30 to 100 feet long and 5 to 6 feet wide, many of which are continuous from one side of the dyke to the other, with strike north or a few degrees west of north, and vertical or nearly vertical dip. They are commonly spaced 30 to 40 feet apart. Mineralogically, they are similar to the orebodies in the narrower dykes, but the gold content of the ore mined from them is higher than in the latter as there is less dilution by waste rock (Bell, 1937, p. 48; Ross and Asbury, p. 33; Gunning and Ambrose, 1940, pp. 95-96; Min. Ind. Que., Ann. Repts, 1937-44).

Dubuisson Goldfields, Limited

This property adjoins that of Malartic Gold Fields on the east. It is almost entirely drift covered. Between 1936 and 1939, a geophysical survey was made of the claims and a programme of nearly 8,000 feet of diamond drilling was completed. This work revealed that the Cadillac belt extends eastward across the property, with bodies of diorite intruding the volcanics, as on Malartic Gold Fields ground. One of the holes drilled in the western part of the property intersected 8 feet and 10 feet of mineralized diorite which gave average assays of 0.144 oz. and 0.044 oz. gold per ton, respectively (Ross and Asbury, pp. 39-40)

This property is near the east end of the Cadillac-Malartic-Fournière belt. There has been very little exploration eastward form here.

Deposits Adjacent to the Cadillac-Malartic-Fournière Belt

The discovery of the numerous important gold deposits, and the development of producing mines, along the easterly trending Cadillac belt led to a vast amount of prospecting and exploration in the county to north and south of the belt. Gold mineralization has been reported in many places, but up to the present no deposit promising a successful operation has been discovered, even in the immediate vicinity of the belt. It is possible, however, that with more intensive development and a fuller knowledge of their geological characteristics, some of these occurrences, or others that might be found nearby, may prove of economic importance. Some of the more interesting are described briefly in the paragraphs that follow. They are grouped according to the formation in which they occur, from south to north of the Cadillac belt.

Deposits in Fournière (Kewagama) Sediments

The Fournière (Kewagama) sediments lie immediately south of, and are believed to underlie, the volcanics of the Cadillac belt. They are chiefly greywacke but include a minor amount of interbedded conglomerate and, locally, highly altered volcanics. Southward across this belt of sediments, granitic intrusives, outliers of great batholithic masses, become increasingly numerous and the intruded rocks are progressively more metamorphosed.

Valco Cadillac Mines, Limited, did some 5,000 feet of diamond drilling during 1937 on a group of ten claims on range-line VI-VII, Cadillac township, immediately south of the O'Brien and Kewagama properties (Taschereau, 1938, p. 74). It was reported by the Company that the drilling intersected two mineralized zones but that assays of the material cut yielded low returns in gold.

St. Pierre Cadillac Gold Mines, Limited, whose claims are near the centre of Cadillac township, immediately south and southwest of the Amm property, reported the presence of visible gold in some quartz veins exposed by stripping and trenching (Bell, 1937, p. 40). Subsequently, the Company abandoned its charter.

Don Malartic Gold Mines, Limited. This property, formerly known as the Gouldie claims, is in the north-central part of Fournière township, immediately south of Canadian Malartic ground. About a mile and a quarter southeast of the Canadian Malartic No. 1 shaft, the Fournière greywacke is intruded by a stock of feldspar porphyry, some 800 feet long (east-west) and 400 feet wide. At its east end, the greywacke is highly silicified and fractured across a maximum width of 30 feet, and in some places visible gold has been found in the fractures. The 'vein' has been traced eastward by trenching for about 1,900 feet. It is well mineralized with pyrite, but for the most part the gold tenor is low.

Some 1,200 feet north of here, similar gold mineralization was found in the silicified greywacke adjacent to dykes and small masses of porphyritic syenite.

Between 1924 and 1930, a considerable amount of trenching was done on the claims, as well as a few thousand feet of diamond drilling, and a shaft was sunk to a depth of sixty feet (Cooke *et al.*, p. 282).

Deposits in Cadillac Sediments

The Cadillac sediments occupy the centre of the major syncline. They thus form a belt paralleling and immediately north of the Cadillac belt of altered volcanics, which underlie the sediments and appear on the south limb of the syncline. In Cadillac township, the belt of sediments has an average width of 4,000 feet. In southwest Malartic it is more than 12,000 feet wide, but from there eastward through Malartic and Fournière townships it progressively narrows and finally pinches out in western Dubuisson.

The sediments are chiefly greywacke. Conglomerate forms lenticular beds near the south side of the belt, especially in its western part, where also there are many bands or iron formation. Interbedded tuffs or volcanics are rare.

With the exception of later diabase dykes, which cut across the sediments, intrusive rocks are almost absent. Quartz veins, most of them small and discontinuous, are common. In general they are barren, but associated with some are such minerals as arsenopyrite, pyrite, and tourmaline, and a few contain gold.

Candalaca Gold Mines, Limited, formerly La Reine Mines, Ltd., owns a group of claims in western Cadillac township, mostly in range VII, adjoining and north of the O'Brien property. Trenching has disclosed several quartz veins in greywacke, some of them sparsely mineralized with sulphides. Farther south, near the north boundary of the O'Brien property, a number of narrow quartz-tourmaline veins containing sulphides cut conglomerate and greywacke (Bell and MacLean, p. 63).

Rubec Mines, Limited, explored a group of claims in range VII, Cadillac township, extending from about 2½ miles to within 1 mile of the east boundary of the township. They adjoin the Tonawanda property on the east and north. Several quartz veins were uncovered in the greywacke at various points. They are poorly mineralized and are apparently of no commercial interest (Bell, 1937, p. 41).

Deane-Cadillac Mining Corporation did some surface work and diamond drilling in 1936 and 1937 on claims near Heva river, where it crosses the Cadillac-Malartic boundary just south of the centre line of the townships. Some gold was found at the contact of a sill of feldspar porphyry with altered tuffs, and at least two quartz veins with arsenopyrite cutting greywacke were found to carry gold (Gunning and Ambrose, 1937, p. 354; Q.B.M., Min. Ind., 1936-37).

Dempsey Cadillac Gold Mines, Limited.—This property adjoins Deane Cadillac on the south. During 1936 and 1937, a considerable amount of diamond drilling was done and a shaft was sunk to a depth of 255 feet, with lateral work on two levels, to explore a gold-bearing quartz-arsenopyrite vein cutting conglomerate. To a depth of 80 feet at least, it has a width of two feet. Further drilling was carried out by the Teck Exploration Company in 1940. In 1944, the property was acquired by Dominion Malartic Gold Mines, Limited (Gunning and Ambrose, 1937, p. 354; Q.B.M., Min. Ind., 1936-37-40-44).

Lartic Mines, Limited.—Between 1927 and 1929, this Company did some diamond drilling and sank a shaft, with lateral work on two levels, on a mineralized shear zone in greywacke about three and a half miles north of the south boundary of Malartic township and three-fifths of a mile from the west boundary. The zone was exposed in trenches for a length of 400 feet. Within it, over a maximum width of 40 feet, the greywacke is silicified, contains narrow quartz stringers, and is mineralized with arsenopyrite,

pyrite, and pyrrhotite. Assays are reported to have shown the presence of gold (Dufresne and Taschereau, p. 143).

Deposits in Blake River Volcanics

Volcanics of the Blake River group form a belt to the north of the Cadillac-group sediments, on the north flank of the syncline. They are believed to be equivalent to the volcanics of the 'Cadillac belt' on the south side of this structure. At the west boundary of Cadillac township, the belt has a width of about 6,000 feet, but it thins eastward until, at the north boundary of Fournière, it is less than 700 feet wide.

In Cadillac township, the belt is made up of three recognizable units: andesite and basalt flows; a narrow band of rhyolite flows; and agglomerates and tuffs. Except for a few 'later diabase' dykes, intrusive rocks are rare in this belt.

The rhyolite member has been investigated at various times. On what were formerly the Murray claims, at and eastward from the west boundary of Cadillac township, in range VIII, trenching has exposed a six-foot band of rusty-weathering rhyolite in contact with agglomerate. The rhyolite is cut by parallel stringers of pyrite and the agglomerate is mineralized to some extent with pyrite and pyrrhotite and minor sphalerite and chalcopyrite, usually in narrow stringers but also disseminated through the rock. The rusty zone appears to extend for a considerable length (Bell and MacLean, pp. 63-64).

During 1936 and 1937, some surface work and diamond drilling was carried out by *True Fissure Mines, Limited,* on a group of claims near the east boundary of Cadillac township, at range-line VII-VIII. The volcanics here are cut by several quartz veins, one of which contains abundant tourmaline and pyrite, but apparently the gold content of these veins is negligible (Bell, 1937, p. 41).

In the western part of Malartic township, in ranges V and VI, the volcanics at the northern margin of the belt are in places intensely carbonatized and mineralized with pyrite and pyrrhotite across widths up to sixty feet. On two properties, formerly owned by *Thompson Malartic Mines, Limited,* and *Malrobic Mines, Limited,* the volcanics along this zone are cut by quartz veins which carry visible gold, and low gold assays have been reported from the adjacent carbonatized rock. The main workings on the Thompson Malartic property are in the south part of range VI, about a mile and a half east of the west boundary of the township, where, in addition to surface work, a prospect shaft was sunk. Some diamond drilling was also done on these claims by O'Brien Gold Mines and, in 1936, by Dunlop Consolidated Mines (Bell, 1937, p. 43). Malrobic Mines, whose property is in range V, a short distance southeast of the Thompson Malartic claims, sank a shaft in 1928 to a depth of 260 feet and did more than 800 feet of lateral work on two levels (Taschereau, 1929, p. 119). In 1934, the shaft was unwatered and 2,000 feet of diamond drilling was carried out from the underground workings (Taschereau, 1935, p. 101). Some surface work was also done along this mineralized zone on the claims of the

Panamint Gold Syndicate, which adjoin the Malrobic property on the west (Bell, 1937, p. 44).

Deposits in Kewagama Sediments

Sedimentary rocks of the Kewagama group form a belt paralleling and north of the belt of Blake River volcanics. They are considered to be the equivalent of the Fournière sediments on the south side of the syncline. Apart from occasional beds of tuff, the rocks are fine grained greywacke, which includes quartzitic, arkosic, and grey argillaceous types. In places, metamorphism and shearing have converted the sediments to biotite and chlorite schists. In the western part of the belt at least, near its northern margin, there are small intrusions of feldspar porphyry and occasional bosses of diorite. Particularly in the vicinity of these, the sheared sediments are much fractured and traversed by lenses and small veins of quartz, but up to the present no mineralization of commercial interest has been found.

Deposits in Malartic Volcanics

Presumably older than the Kewagama sediments and extending many miles to the north of them is a wide zone of volcanic rocks known as the Malartic volcanics. Deposits of interest found in the southern part of this zone are confined to Malartic township.

The Malartic volcanics are chiefly of the 'greenstone' type, but they include some basic and acidic lavas as well as interbedded tuffs and agglomerates. Shearing and minor faults are common, and in some localities the beds, and particularly the tuffs, are strongly contorted.

In the western part of Cadillac township, the contact between the volcanics and Kewagama sediments is heavily sheared and is intruded by feldspar porphyry and granitic dykes, which also have suffered some shearing. Despite these favourable features, no gold or other mineralization of interest has been found in this western section of the southern margin of the Malartic volcanics.

In Malartic township, gold mineralization has been found in the volcanics at a number of localities, particularly in the vicinity of the south shore of Malartic lake, along which there extends a body of granodiorite having a length of some five miles and an outcrop width of one mile, with south-southeasterly trend, and also adjacent to smaller bodies of similar intrusive rock which lie within the volcanics a short distance south of the lake. The gold mineralization is thought to be related to these intrusive bodies.

On the *Ledoux* claims and on the property of *Malartic Lake Shore Mines, Limited*, which adjoins them on the south, several quartz veins have been found in the volcanics and adjoining Kewagama greywacke. One of these veins is mineralized with pyrite, galena, sphalerite, pyrrhotite, and chalcopyrite, and a picked sample taken by Gunning and Ambrose assayed 0.25 oz. gold per ton (Gunning and Ambrose, 1937, p. 358). These claims are in the northwest quarter of Malartic township, in ranges VI and VII, extending from the southwest bay of the lake southward to the east-west centre-line.

Farther eastward, at the southeast corner of the lake, in range V, some surface work and diamond drilling was done in 1936 and 1937 on claims held by *Bayside Malartic Mines, Limited.* The volcanics here, immediately south of their contact with the granodiorite mass, are in places sheared and silicified, and are traversed by a network of quartz-tourmaline lenses. These lenses contain a little pyrite, and erratic gold assays have been reported (Gunning and Ambrose, 1940, p. 67).

A considerable amount of surface work, some diamond drilling, and a magnetometer survey was carried out in 1936 and 1937 on a group of claims held by the *Celta Development and Mining Company, Limited,* in ranges II to IV, Malartic township. About 1,600 feet north of the intersection of range-line III-IV and the north-south centre-line, a strong southeasterly trending shear zone marks the contact between Malartic volcanics (to the northeast) and Kewagama greywacke. It has been traced by trenching and diamond drilling for a length of 2,500 feet and the magnetometer indicated a length of at least 3,300 feet. Within and on both sides of the shear zone there are some small granitic stocks as well as granite, aplitic porphyry, and diorite dykes. Gold mineralization has been found in pyritized and silicified tuffs in the shear zone; in sheared and altered aplitic porphyry dykes, especially those between the two main granitic stocks; in fracture zones in a large diorite dyke south of the shear zone; and in altered and fractured sections of the granitic stocks, particularly near their margins closest to the shear zone. Pyrite is present in fair abundance and with it are negligible amounts of pyrrhotite, arsenopyrite, chalcopyrite, and molybdenite. Quartz, in the form of veins or otherwise, is not common, but, locally, iron-bearing carbonate is prominent. Gold is occasionally present in visible particles. Intersections returning low gold assays across widths of as much as thirty feet were obtained in the diamond drilling, with appreciable assays over lesser widths, and disseminations of gold over fair widths, with local high assays, were found in the granitic rocks. The limited amount of work carried out indicated, however, that the distribution of the gold is very erratic (Ross and Asbury, pp. 29-30; Gunning and Ambrose, 1940, pp. 71-27).

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DUBUISSON-BOURLAMAQUE-LOUVICOURT DISTRICT

General Note

Dubuisson, Bourlamaque, and Louvicourt townships extend eastward, in the order named, from Fournière township (see Figure 36). The contact between Keewatin-type volcanics (to the north) and Temiscamian-type sediments extends somewhat south of east across the three townships from a point about two and a quarter miles south of the north boundary of Dubuisson on the west to a point a mile and a half north of the south boundary of Louvicourt on the east. The volcanics are intruded by a batholith of granodiorite, the Bourlamaque batholith, which occupies much of the north part of Bourlamaque township and extends eastward for some distance into Louvicourt and westward into Dubuisson as far as de Montigny lake, in the north-central part of that township. The earliest discoveries of gold in the district were on the shore of de Montigny lake and on a nearby offshore island, on the property now held by Siscoe Gold Mines, Limited, from which production has been continuous since 1929. Since that time, gold, and also base-metal, mineralization has been found at numerous localities in the area, and several producing mines have been developed. Nearly all of the deposits are in the volcanics or in the granodiorite that intrudes them.

The geology and ore deposits of the district have been studied by several investigators, whose reports, listed under *References* at the end of this chapter, form the basis for the description that follows. In addition, much information on individual deposits has been furnished by officials of the mining companies concerned.

The volcanic rocks are of various types. They are chiefly lava flows, but locally they include great thicknesses of tuff beds, both fine and coarse grained. Outcrops are very sparse, but determinations indicate that throughout the greater part of the area, at least, the beds strike approximately east-west and have steep to vertical dip.

In surface outline, the Bourlamaque batholith is rudely pear-shaped, with the narrow stem at the east shore of de Montigny lake. Eastward from there it widens to a general maximum of about seven miles, but near its eastern side a lobe extends southward for some five miles to the contact of the volcanics with the sediments. The batholith, which has an east-west length of fourteen miles, thus lies wholly within the volcanics.

Although commonly referred to as 'granodiorite', the batholith is composed for the most part of relatively basic rock and may originally have had the composition of quartz gabbro. Its mineral constituents are generally highly altered, and much of the quartz it contains has a distinctive opalescent appearance and is secondary (Gussow, pp. 134-144). What is evidently an outlier of the main batholith outcrops a mile or so to the west, on Siscoe island, near the east shore of de Montigny lake. This is known as the Siscoe stock (see p. 240). In many respects, these intrusive bodies are similar to those which, farther westward, in Rouyn and neighbouring townships, have been designated 'older gabbro'. In the present area, there are some masses of diorite or gabbro that, possibly, are closely related in origin and in time to the 'granodiorite' bodies. Younger than the latter are dykes of various types, including aplite, 'porphyry', syenite, and diorite.

The ore deposits of the district are, in many instances at least, related to zones of shearing and faulting and lie within or not far from them. The tendency is for such structures to be localized at contacts between the intrusive rocks and the greenstones. It was therefore in these brittle rocks, or in those least liable to be made schistose, that the ore-bearing structures were chiefly formed. But, with few exceptions, the deposits of commercial size and grade in the granodiorite batholith are close to its margin and not toward the centre, where the mass, owing to its uniform nature, was less liable to become fractured.

In the district to the west, most of the important ore deposits occur within the 'Cadillac belt', along or near the persistent zone of faulting and shearing designated the 'Cadillac break'. Here, the pattern is not so simple: there are several more or less independent fault systems.

A series of faults and shear zones, striking south of east, occur over a north-south width of at least four miles between the north side of Siscoe island and Piché river. It is probable that the Siscoe and most of the other ore deposits in this vicinity are related to them. The Piché River fault is the eastward continuation of the zone of shearing and faulting with which, farther west, the 'Malartic' orebodies are associated. What appear to be equivalent structures occur farther eastward, along the east and south margins of the Bourlamaque batholith, on the Perron and Golden Manitou properties, respectively. All of these structures have relatively steep dips. In some parts of the district there is pronounced jointing and shearing with east-west trend and dip steep to north or south. The Lamaque and Sigma orebodies, in the western part of Bourlamaque township, occur in vein systems of this type. A strong zone of shearing and faulting trends south-westerly along the west side of Blouin lake and may continue in that direction to and along Lemoine lake. Faults having this trend are apparently rare in the district, but examples of faults having a somewhat more northerly strike than this are found at the Shawkey mine, on the south shore of de Montigny lake, and at the Perron mine, in the southwest corner of Pascalis. The great diversity of structure may be explained by postulating that the rocks were subjected to a succession of compressive stresses in a more or less north-south direction, but that the direction of relief was different in different localities.

FIGURE 36.—*Part of Dubuisson-Bourlamaque-Louvicourt District, General Geology and Structure, and Location of Chief Mines and Deposits:*

Dubuisson and Vassan Townships: 1. Siscoe Mine, 2. Sullivan Mine, 3. Shawkey Mine, 4. Gale Mine, 5. Greene Stabell Mine (Jacola), 6. Dorval-Siscoe, 7. Siscoe-Extension, 8. West Siscoe, 9. Kiena, 10. Wisik, 11. Crossroads.

Bourlamaque Township: 1. Payore Mine, 2. Lamaque Mine, 3. Sigma Mine, 4. Golden Manitou Mine, 5. Harricanaw Amalgamated, 6. Numaque, 7. Bidlamaque, 8. Standard, 9. Wildor, 10, Val d'Or, 11. Lamaque Contact, 12. Wolverine.

Pascalis and Louvicourt Townships: 1. Perron Mine, 2. Beaufort Mine, 3. Pascalis Mine, 4. Cournor Mine, 5. Senore, 6. Beaucourt, 7. Louvicourt, 8. Fleming, 9. Obaska, 10. Metcalf.

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The local pattern of competent and incompetent rocks, and also pre-existing fractures, resulted in the development of orebodies with dissimilar attitudes in neighbouring mines, and even in the same mine. Thus, although the chief orebodies of the Perron and Cournor mines are in the granodiorite batholith near its eastern margin, less than two miles apart, and were probably formed at the same time, they dip in opposite directions. And in the Siscoe mine, there are two systems of persistent veins, one older, dipping east and the other, younger, dipping west.

Mineralization

The orebodies of the district are of two types: gold-bearing quartz veins and sulphide deposits.

Gold Deposits

The gold-bearing veins consist of quartz, usually white, which may be of more than one age. Tourmaline is present in many of the veins, and in those of the Siscoe mine it appears to be associated chiefly with the late quartz. Feldspar, carbonates, sericite, chlorite, and fuchsite (chromiferous mica) are occasional minor constituents.

All the veins contain pyrite, which is common also in the wall-rock. That it is later than at least some of the quartz is evident, since in some veins it has been deposited along fractures in that mineral. A small amount of chalcopyrite generally accompanies the pyrite and, more rarely, a little pyrrhotite, sphalerite, and magnetite.

An interesting constituent of some of the veins is scheelite. Where present, it is usually in negligible amount, but during the war years, when tungsten was in great demand and unobtainable from the usual peace-time sources, small amounts of scheelite were recovered from the ores of the Lamaque, Sigma, Perron, and Sullivan mines (Dufresne, p. 44).

Gold is present chiefly in the uncombined state, but important amounts occur as gold tellurides, notably in the Lamaque veins. It may be in close association with the sulphides or 'free' in the quartz. In most of the veins or orebodies it is clearly seen to be one of the last, or actually the last, mineral to have been deposited. Spectacular high-grade ore has been encountered in some of the mines.

The wall-rock for varying widths on either side of the veins is usually much altered, the secondary minerals present including quartz, tourmaline, carbonates, albite, sericite, and, more rarely, epidote, chlorite, and talc.

Sulphide Deposits

In the sulphide bodies, pyrite generally predominates and may be accompanied by important amounts of sphalerite or chalcopyrite, or both these minerals. Less common, and in minor amount only, are arsenopyrite, galena, and tennantite. The arsenopyrite, and most if not all of the pyrite, is believed to have been formed prior to the other sulphides. Some of the sulphide bodies carry appreciable amounts of gold and silver, but the distribution of the gold is generally erratic.

The sulphide bodies of economic interest occur in strong and persistent zones of shearing. The most important deposit of this type so far developed is that on the property of Golden Manitou Mines, Limited, in the west part of Louvicourt township (see p. 441).

SISCOE GOLD MINES, LIMITED

The property of this Company includes Siscoe island, the adjacent area covered by the waters of de Montigny lake, and a section along the mainland to the northeast of the island. The Vassan-Dubuisson township-line passes (E.-W.) almost centrally across the lake and also across the northern part of Siscoe island. The island is near the east shore of the lake and, rudely oval in shape, has a length, north-south, of about 4,700 feet and a width of nearly 4,000 feet.

Gold was discovered on the mainland claim, in Vassan township, in 1911, and a few years later more important discoveries were made on the northern part of Siscoe island. Exploration was carried out by the Siscoe Mining Syndicate until 1923, when Siscoe Gold Mines, Limited, was organized to develop the property and bring it to production. Underground work was carried on from four shafts on the island, a mill was erected, and production started in 1929. Early in 1930, sinking of a fifth shaft was commenced at a point about midway between the east and west sides of the island and 1,500 feet from its north shore. This became the main operating shaft and by 1939 had reached a depth of 2,475 feet with workings on nineteen levels. To the end of 1945, the mill had treated 2,943,238 tons of ore with recovery of 815,551 ounces of gold, an average of 0.277 oz. per ton.

The northern part of Siscoe island, to about one-third of its length, is occupied by a stock of 'granodiorite' which is evidently an outlier of the nearby Bourlamaque batholith. The principal gold deposits occur within this stock. The whole of the island to the south of this is underlain by Keewatin-type lavas of 'greenstone' type which in many places exhibit pillow structure. The contact between the two formations strikes S.65°E., with dip about 80° toward the north. Along this contact is a faulted and sheared belt, designated the *K* zone, which contains some important orebodies.

In outcrop, the stock has a length, east-west, of rather more than 5,000 feet and a width that gradually increases from about 800 feet near the west end to a maximum of 2,000 feet near the east end. It presents a variety of rock types that differ both in texture and composition and in general are highly altered. The description that follows is based largely on that given by A. E. Moss in a doctorate thesis (McGill University, unpublished).

The stock is composite, consisting of two intrusive bodies. The earlier of these forms the west, the other the east, half of the mass. Each presents two or more facies, which are believed to have developed in part as the result of assimilation during emplacement and in part by the action of ascending hydrothermal solutions. The two principal facies in the western and more basic body, believed originally to have had the composition of granodiorite or diorite, have been termed the 'porphyritic' and 'intermediate' types. Those in the eastern body have been designated the 'quartz-albite' (or 'silicified') type and the 'main ore zone' (or 'chloritic') type. Broadly, the distribution of the several types, as exposed at the surface, is as follows:

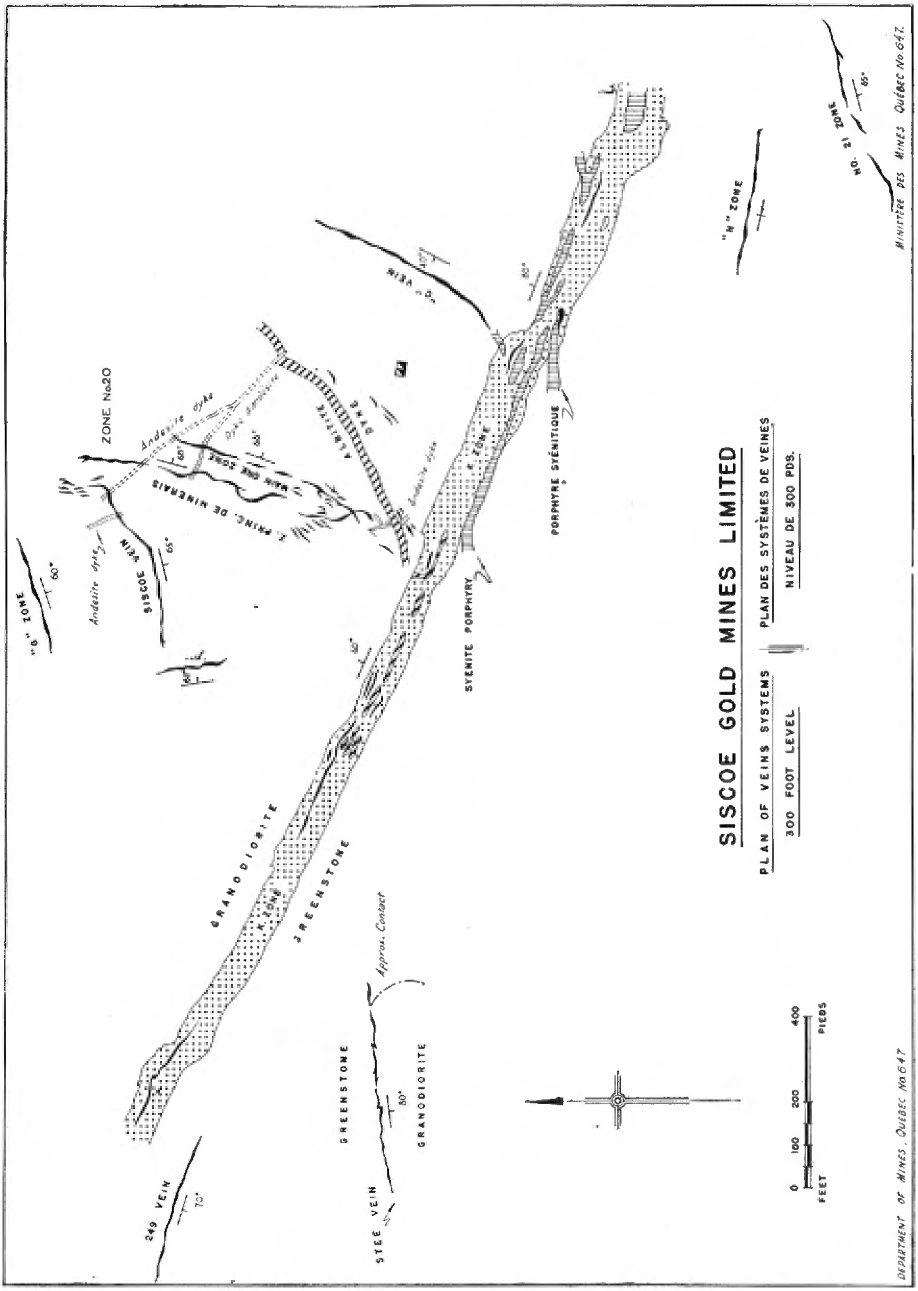


Fig. 37

FIGURE 37.—*Siscoe mine, 2nd or 300-foot level.* (Que. Dept. Mines, G.R. 17, 1947, Fig. 4).

Along the south side of the stock, immediately north of the *K* shear zone, the rock is 'porphyritic' granodiorite. In the west half of the stock, this has a width up to 500 feet, but in the east half it is uniformly narrow, about 100 feet. It merges into, and continues around the east nose of the mass as a similarly narrow width of the 'intermediate' type. In the west half of the stock, the rock northward from the porphyritic granodiorite is of the 'intermediate' type. Centrally across the stock this is in contact with the second (later) of the two intrusive bodies, the contact having a trend a few degrees east of north and a dip of about 50° east. For a width of some 375 feet, the rock is the 'main ore zone' type and eastward beyond that, for 1,500 feet, it is the 'quartz-albite type. Near the eastern end of the stock there is a second zone, about 375 feet wide, of rock of the main ore zone type, beyond which is the narrow band of the 'intermediate' type of the earlier intrusive that rims the eastern nose of the stock

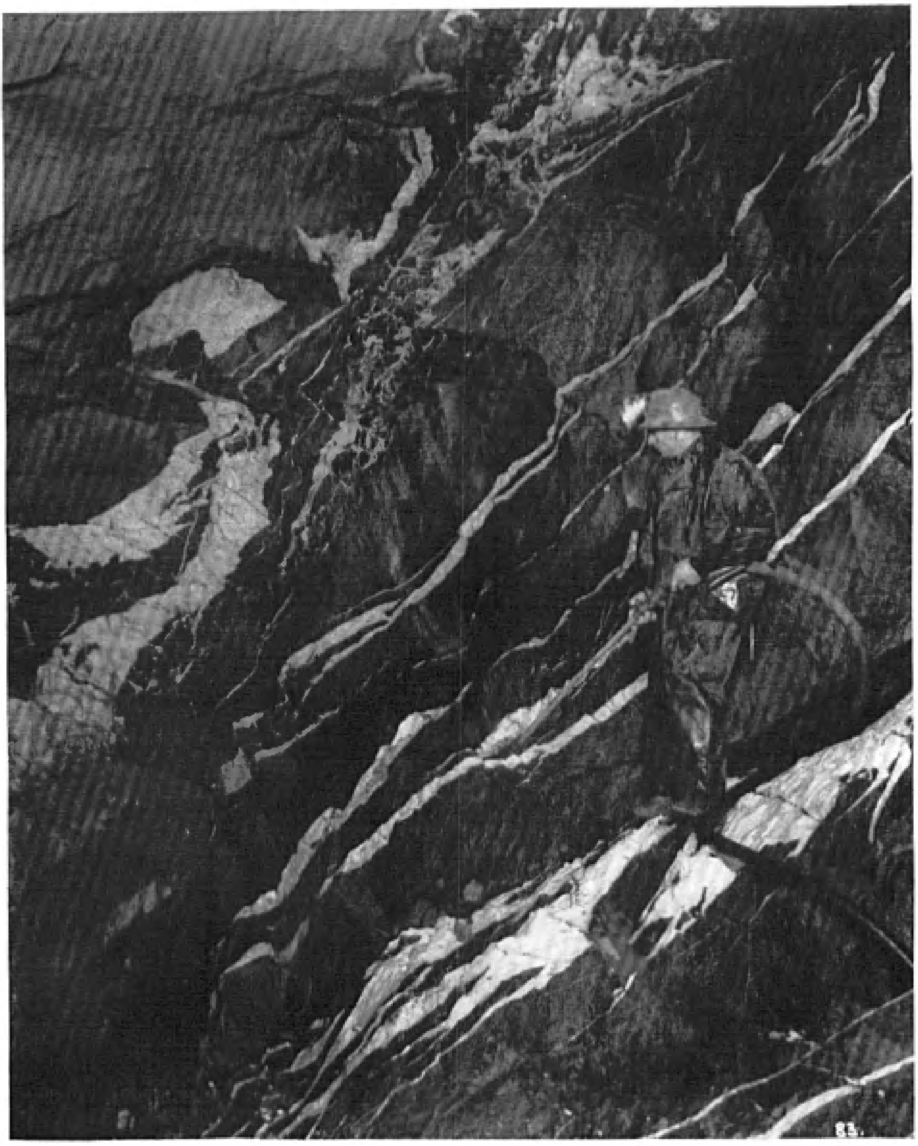
Analyses of typical rock from each of these zones show that the 'quartz-albite' type has a much higher silica content, and contains more soda and less lime, than the other types, which are characterized not only by low silica but also low potash and soda.

In the 'porphyritic' type, white phenocrysts, originally feldspar but now completely replaced by clinozoisite and epidote, are distributed through a groundmass of pale green chlorite (penninite) with some quartz, calcite, epidote, and actinolite. The 'intermediate' type is similar mineralogically to the porphyritic type, of which it appears to be merely a finer grained and more altered facies. In thin section, the rock is seen to contain minute phenocrysts of feldspar, now altered to epidote. The rock of the 'main ore zone' is fine grained, dark green, and consists of chlorite with minor amounts of the same minerals that form the groundmass of the porphyritic type of the earlier intrusive. The 'quartz-albite' type contains phenocrysts, or more probably porphyroblasts, of quartz and albite but otherwise is similar to the 'main ore zone' type, from which it may have been produced by silicification and albitization.

Dykes of granodiorite cut the greenstones to the south of the Siscoe stock. Presumably they are genetically related to the stock. A variety of younger dykes cut the granodiorite in the vicinity of the orebodies and also cut the greenstones to the south. Gillanders* (personal communication) places these, and the veins with which they are associated, in the following order, from oldest to youngest: Main ore zone and Siscoe veins, and probably the *K* zone; syenite porphyry and feldspar porphyry; albitite; *C* veins; diorite.

Andesite dykes of at least two ages have been recognized. They are rarely as much as three feet wide. Such dykes have been found cutting veins in the *K* ore zone. The syenite porphyry and feldspar porphyry dykes are believed to be contemporaneous. Syenite porphyry dykes up to 500 feet long and 70 feet wide have been encountered in the *K* zone, where they cut andesite dykes. An albitite dyke cuts a feldspar porphyry dyke in the greenstones south of the *K* zone. The largest albitite dyke met with to date is in the granodiorite north of the *K* zone. It has been intersected on several

*Geologist of Siscoe mine.



Siscoe mine, veins in a stope on main ore zone of the mine levels and has a length of more than 1,000 feet and an average width of 17 feet. Diorite dykes are relatively rare. Like the andesite dykes, they are narrow.

The *K* shear zone, which follows the contact between the Siscoe stock and the volcanics to the south, has a general trend S.65°E. with dip 80°N. to vertical. It has been traced for a length of some 5,000 feet along the strike, beyond which, at both ends, it feathers out, and it is known to extend vertically downward for at least 2,500 feet. The width ranges from 30 feet to 200 feet, with average about 75 feet. The rocks within the zone are predominantly talcose — both massive talc rock and talc-chlorite schist — with lesser amounts of actinolite and sericite schist. These were formed probably by intense hydrothermal alteration of the volcanics. Intruding them are dykes of granodiorite, albitite, and syenite. The zone contains a number of high-grade ore shoots as well as a large tonnage of marginal and low-grade material.

Some 300 to 400 feet south of the *K* zone, and more or less paralleling it, is a much weaker shear zone in the greenstones in the southeastern part of the mine. This has been designated the *N* zone.

Field evidence indicates that the numerous gold-bearing veins on the property were emplaced in fractures that opened in tension, transverse to the direction of elongation or stretching that the enclosing rock underwent. In many cases, the rock is massive or not perceptibly sheared. The veins are lens shaped and do not coalesce. They are often arranged *en échelon.* In trend and attitude, they fall into at least four major sets. The fact that the fractures they occupy show such diversity in trend might indicate a considerable difference in age between the veins of one set and those of another. Actually, evidence for at least two ages of vein formation is afforded by the occurrence of two types of quartz, or quartz and tourmaline, and also by the age-relationship of the veins to the dykes associated with them.

In this connection, it is of interest to note that the gold in the several veins is not all of the same 'fineness'. In most of them it has rather a deep yellow colour. In the *C* type veins it is for the most part pale yellow, and both pale and deep yellow gold are found in the veins of the Main ore zone.

The Gold-bearing Veins

Some of the principal veins of each of the four major sets are described below.

(*a*) *Strike E.-W. or a few degrees N. of E.; dip S.*

Siscoe Vein.—Actually, this 'vein' consists of a series of more or less parallel quartz lenses, individually a few inches to eight feet wide, which cut the 'intermediate' type granodiorite north of the *K* shear zone. The vein is in the northwestern part of the mine and strikes easterly toward the northerly trending Main ore zone, but at some distance from the latter the strike swings northward to approximately parallel the Main ore zone. This vein has been traced for a length of 1,000 feet on the 725-foot level, and it extends to a vertical depth of at least 1,475 feet. The dip ranges from 35° to 80° south.

The Siscoe vein is composed of white and bluish quartz. It contains sparse sulphides and tourmaline, irregularly distributed and in cross bands of the *C* vein type. Where there is much tourmaline, the grade is usually low. Aggregates of scheelite are sparingly present.

Stee Vein.—This vein is in the western part of the mine. It strikes a few degrees north of east and dips steeply to the south, following a fault at the margin of a boss of granodiorite or coarse greenstone. The fault has been traced for a length of 500 feet, but although some quartz is found along its entire length it is wide enough to make ore over only about half the total length.

The Stee vein consists of white banded quartz mineralized with pyrite and minor amounts of chalcopyrite, sphalerite, and galena.

No. 21 vein and *A vein* are in greenstone in the southeastern section of the mine. They strike N.60°E. and dip southward.

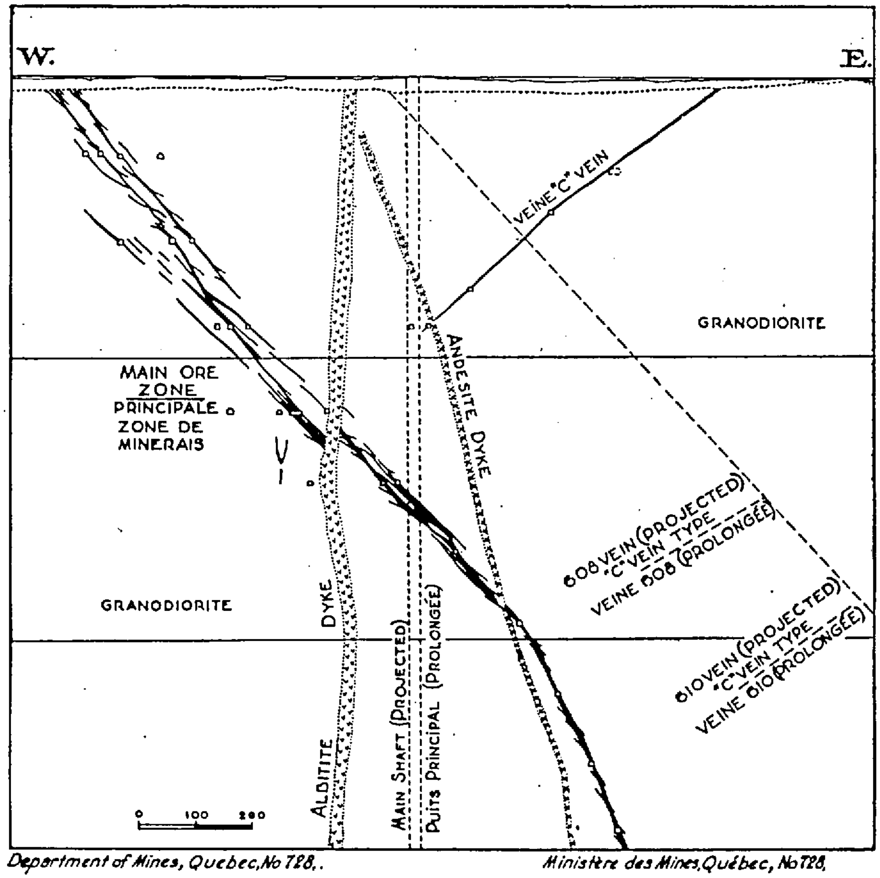


FIGURE 38.—*Siscoe mine, vertical section through Main ore zone.* (Geology of Siscoe Gold Mine, O. L. Backman, Can. Min. Journal, Vol. 57, p. 466).

(b) *Strike a few degrees E. of N.; dip E.*

Economically important veins with this trend and dip have been found only in the main ore zone type and intermediate type of granodiorite north of the *K* shear zone. Chief among them are the ore shoots in the *Main vein zone* which, commencing near the *K* shear zone, extends northward for 900 feet, where it 'feathers out' and terminates. The zone strikes N.15°E. at the surface and due north at a vertical depth of 1,350 feet. The dip is easterly, steepening from 58° at the surface to 70° below the 975-foot level. As a consequence, the vein zone approaches the intermediate type granodiorite with depth and passes into it at the 1,350-foot horizon.

The veins in the Main zone are composed of white quartz. They contain very little tourmaline or, for most of the zone, sulphides. These latter include some chalcopyrite. Gold is irregularly distributed through the quartz, locally in spectacular concentration. In such high-grade ore, the gold is seen along fractures in the quartz.

(c) *Strike about 20° E. of N.; dip W.*

The *C* vein, first producer on the property, is of this type. Now largely worked out, it has yielded some 40,000 ounces of gold. The vein is in the quartz-albite type of granodiorite east of the Main vein zone. Since the latter dips eastward and the *C* vein at 35° to 40° to the west, the two approach one another with depth and they intersect at about the 450-foot horizon. The *C* vein is the younger. It has been followed for a length of 400 feet and its width ranges from ten inches to ten feet, averaging two to three feet. It becomes narrower toward its intersection with the Main vein zone.

The *C* vein is notable for abundant tourmaline and white quartz, or rather glassy quartz with included tourmaline needles. The walls are strongly albitized and pyritized. Scheelite is quite common. The gold is erratically distributed. Where visible in the quartz it is often wiry or crystalline. In the pyrite, it is in small particles or along fractures.

No. 20 zone, like the *C* vein, is a short distance east of the Main vein zone, but near its northern end. It dips westward at about 50°. This zone has a length of at least 160 feet and a width up to 40 feet. It has been traced for a vertical distance of 600 feet, from the first to the fourth level, where it intersects the Main vein zone. The altered granodiorite and vein material at the intersection form a low-grade orebody with erratic gold content but of considerable indicated tonnage.

A large number of quartz-tourmaline veins having about the same strike and dip as the *C* vein have been found in the mine workings cutting across the Siscoe vein, practically all of them between the 600- and 1,350-foot levels.

(d) *Strike N.W., dip N.E.*

The orebodies in the *K* shear zone are of this type. Their age relationship to the other vein systems is not definitely known, but it is believed they are about contemporaneous with the Siscoe and Main-zone veins. This zone, 30 to 200 feet wide but averaging 70 feet, contains, besides the sheared and altered aplite and porphyry mentioned earlier, numerous orebodies, which occur singly or in parallel and conform with the northwest strike and north-

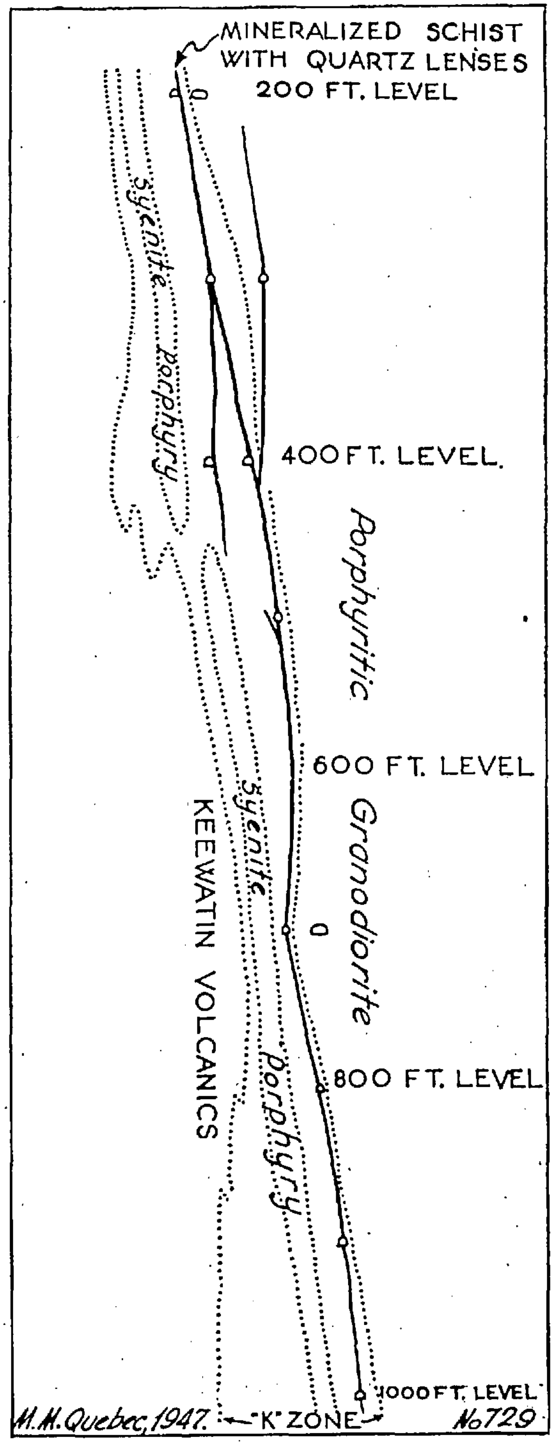


FIGURE 39.—*Siscoe mine, vertical section through "K" zone.* Que. Dept. Mines, G. R. 17, 1947, Fig. 5).

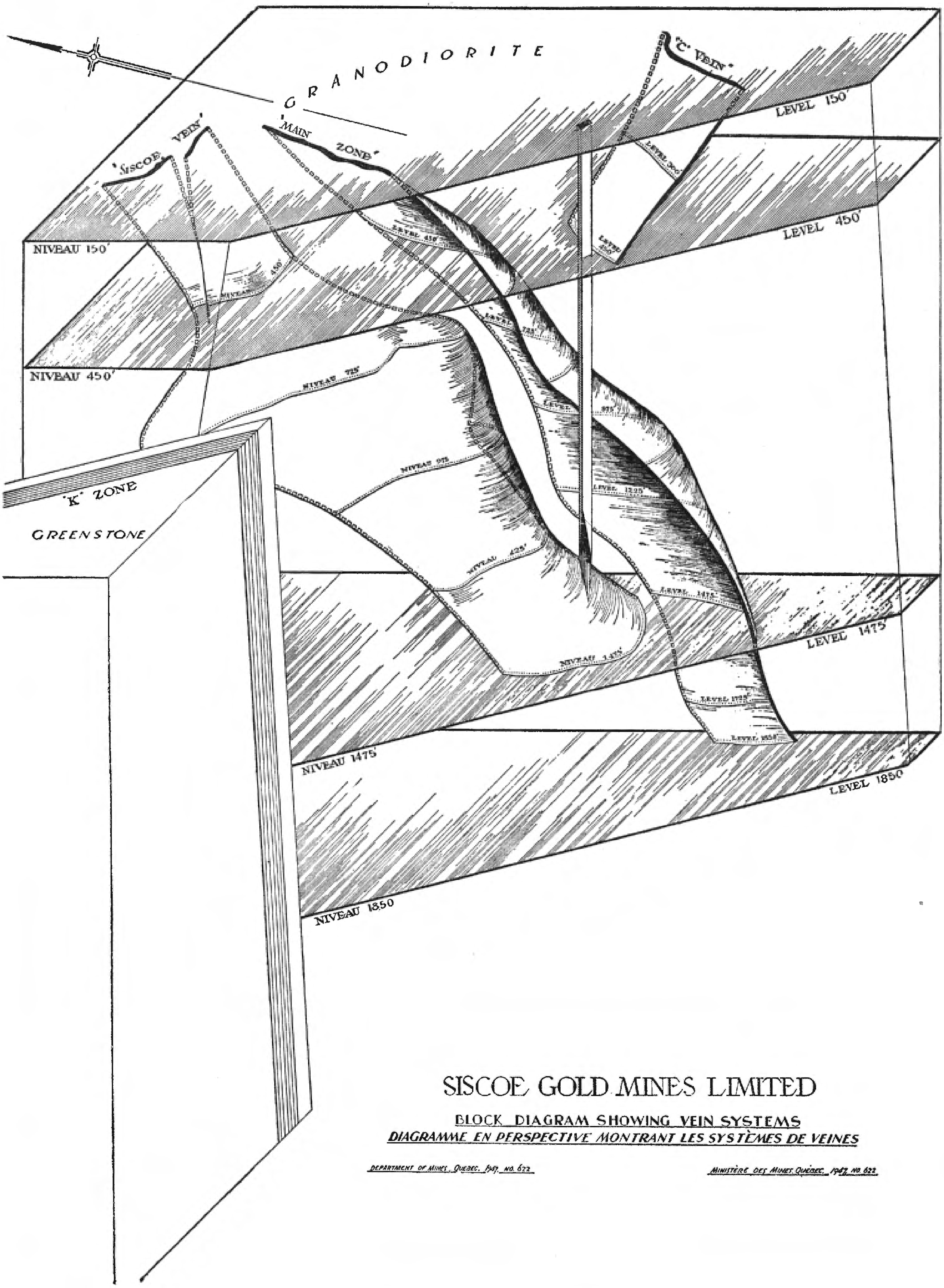


FIGURE 40.—*Siscoe Mine, block diagram showing vein systems.*

east dip of the zone. These orebodies have been found along the zone for a considerable length and to a depth of at least 1,850 feet. Their individual lengths are from 25 to 350 feet and they are from 3 to 10 feet wide. One lens is known to have a vertical continuity of 500 feet. Some bodies consist of granular white quartz, fractured and banded with chlorite and containing gold and two to three per cent sulphides. Others are highly carbonatized talc-chlorite schist or talc-actinolite schist containing two to five per cent sulphides, subordinate quartz in the form of irregular stringers and films, and, in places, fine visible gold. A third type consist of green talc which, with or without minor amounts of chlorite, forms vein-like, sharp-walled masses containing minutely disseminated gold; no quartz or sulphides are associated with the gold (Auger, 1940, 1947; Cooke *et al.*, pp. 247-253; Hawley, pp. 39-53; Backman, pp. 467-475; Moss, A. E., thesis; Gillanders, E. B., Geologist, Siscoe Gold Mines, Ltd., personal communications, 1939).

Sullivan Consolidated Mines, Limited

The property of Sullivan Consolidated Mines is in the northeast quarter of Dubuisson township, on the mainland immediately south of Siscoe ground. Gold-bearing veins were discovered on the property by J. J. Sullivan in 1911 — the first recorded occurrence of gold in the eastern part of the Rouyn-Bell River area. In the years that followed, a limited amount of stripping and trenching was carried out, and in 1928 Sullivan Gold Mines, Limited, was incorporated to develop the property. Exploration by diamond drilling, and underground from two shafts, was continued for a year or two, following which operations were suspended until 1932. In that year, the Company was reorganized as Sullivan Consolidated Mines, Limited. Further diamond drilling was carried out with encouraging results, one of the shafts (known as No. 1 shaft) was deepened to 370 feet, and a mill was erected and started production in 1934. Sinking of a new shaft, No. 2, inclined at 45 degrees to the northeast, was commenced in 1935. This shaft is on a point on the east shore of de Montigny lake, about two miles southeast of the Siscoe mine. In 1943, No. 1 and No. 2 shafts had attained depths of, respectively, 1,180 and 1,750 feet, with levels at 100-foot intervals and the workings connected at several horizons. To the end of 1944, the mill had treated 1,045,443 tons of ore with recovery of 292,294 ounces of gold, or 0.280 oz. per ton. In March, 1945, reserves were estimated at 629,550 tons containing 0.2535 oz. gold per ton.

The veins mined are within the narrow west end of the Bourlamaque granodiorite batholith, which here is believed to have a north-south width of about a mile. The granodiorite is considerably altered, but chemically it is quite similar to the quartz-albite type in the Siscoe stock.

Cutting the granodiorite are dykes of various types, to many of which the veins are, structurally, closely related. With very few exceptions, they are quite narrow. The oldest is a granodiorite porphyry or albite porphyry up to twenty-five feet wide which outcrops a short distance northeast of No. 1 shaft.

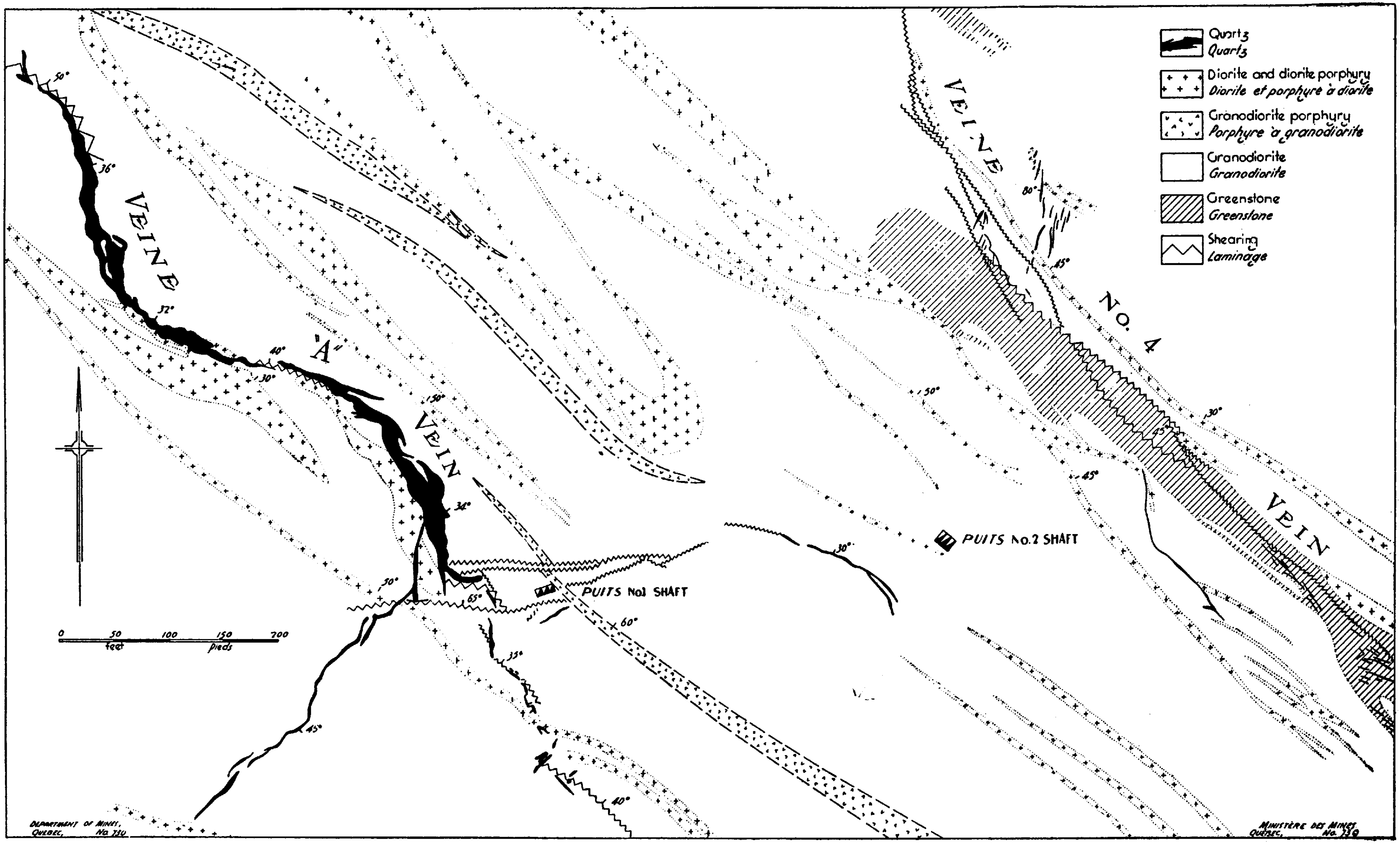
Next in age are fine-grained diorite and diorite porphyry dykes. They are generally narrow and much altered. A number of these dykes in the southwestern section of the mine strike east-west to slightly north of east and dip from vertical to 45 degrees north or south. In the most productive section of the mine, northeastward from No. 1 shaft, similar dykes strike northwest and dip 40 to 45 degrees northeast. These dykes are similar in character, and in their association with the quartz veins, to the diorite dykes that occur in the Sigma mine, four miles to the southeast.

Quartz albite porphyry or aplite dykes are numerous below the 580-foot level and appear as high as the 250-foot level in the southwest section of the mine.

In the vicinity of No. 2 shaft, the granodiorite encloses bands of schistose greenstone which have a northwesterly trend and dip 55° to 60° northeast. They are traversed by dyke-like tongues of massive granodiorite with similar strike and dip. The principal ore shoots occur in or near shear zones in the greenstone bands.

What is known as No. 4 shear zone lies for the most part within a band some 200 feet northeast of No. 2 shaft. It has a width up to five or more feet, with strike a few degrees more northerly than the schistosity of the greenstone and dip averaging 45° northeast. Strong mud seams indicate that there has been late movement of the rocks along the zone. The No. 4 vein is in the greenstone along or adjacent to this shear zone, and about parallels it in strike and dip. Some 600 feet to the southwest is another important shear zone, designated the *A* shear zone, with similar trend and dip. The *A* vein occurs in this zone, closely associated with an altered diorite dyke but passing into the adjacent granodiorite. Production has come mainly from the No. 4 vein zone and *A* vein which, on various mine levels, have been developed and mined over lengths of as much as 1,400 feet. Stoping widths have been generally greater along the No. 4 zone than along the *A* vein. A number of other gold-bearing veins have been encountered in the ground between the two principal veins. Many of these have a more westerly strike and flatter dip, and apparently are not closely associated with diorite dykes. There are also veins striking north, or northeasterly, with dip 45° or steeper eastward.

Wall-rock alteration is usually pronounced and consists chiefly of albite, carbonate, and pyrite. Carbonate is present also in some of the veins. Tourmaline is a usual but not abundant constituent of the veins, commonly occurring as thin seams cutting the quartz. Sulphide mineralization is chiefly pyrite, with or without minor amounts of chalcopyrite, sphalerite, and galena. Tellurides of gold have been reported, but practically the whole of the gold occurs in the free state along fractures in the quartz. There appears to be no relationship between the gold content of the veins and the amount of tourmaline or sulphide mineralization (Hawley, pp. 56-63; Bell, 1936, pp. 32-42; H. D. McKenzie and Maurice Scott, Geologists for Sullivan Consolidated Mines, personal communications).



SULLIVAN CONSOLIDATED MINE - Geology of Part of 150-foot Level. —Fig 41— MINE SULLIVAN CONSOLIDATED-Géologie d'une partie de l'étage de 150 pieds.

Shawkey Gold Mining Company, Limited

The Shawkey property is at the south shore of de Montigny lake, where a gold-bearing vein was discovered in 1911. Various interests carried out exploration work on the property, including diamond drilling and lateral work from a shaft 325 feet deep, but it was not until 1934 that intensive development was commenced by the Shawkey Gold Mining Company, incorporated in that year. The shaft, which is on the shore of the lake just west of its main inlet, was deepened to 725 feet, and a mill was erected and started production in 1936. Several gold-bearing veins were discovered in the course of the exploration, but the whole of the production came from the discovery vein. By 1938, this had been mined out and operations were then suspended. Total production amounted to 25,414 ounces of gold from 137,978 tons of ore treated, a recovery of 0.184 oz. gold per ton. Following reorganization of the Company in 1945 as Shawkey Gold Mines, Limited, the mine was re-opened.

The property is underlain by basaltic lavas, or greenstones, which in places are strongly sheared, with southeasterly strike and dip steep to the southwest. These are intruded by dykes of syenite porphyry, most of which have similar strike. The dykes are fresh, relatively massive rocks and are obviously later then much, at least, of the shearing.

The main vein zone consists of a central quartz vein from six inches to two feet wide paralleled by other quartz stringers over a total width of one to four feet. Both the zone and the quartz veins within it show a pronounced tendency to pinch and swell. The wall-rock has been altered by the development of albite, carbonate, and pyrite. Pyrrhotite and chalcopyrite are sparingly present in the veins. Gold is evidently later than the sulphides. In places, it is present in spectacular amount in the quartz and along slip planes at the vein walls (Cooke *et al.*, pp. 242-245; Bell, 1936, pp. 42-49, 1937, p. 50; Leaman, pp. 544-545).

Provincial Mine School

(Formerly property of *Gale Gold Mines, Limited*)

This property of 207 acres is immediately south of de Montigny lake, on the east side of the narrows between that lake and Lemoine lake, to the south. In early surface exploration by various interests, a number of narrow gold-bearing veins were discovered, and between 1935 and 1937 a shaft was sunk by Gale Gold Mines, Limited, and lateral work and diamond drilling was carried out on two levels at 125 and 250 feet. Some narrow quartz veins were encountered and in some places they contained visible gold, but the work did not reveal any continuous ore zone. In 1938, the property was purchased by the Provincial Government and since that time it has been operated as a Mine School. The shaft is on lot 43, range VIII of Dubuisson township, about a mile southeast of the Shawkey shaft.

The property is underlain by Keewatin-type volcanics, chiefly andesitic flows with some tuffs and breccias in the southeast claim. The flow rocks are of two types — fine grained pillow and amygdaloidal lavas, and massive, moderately coarse andesite. They strike a few degrees south of

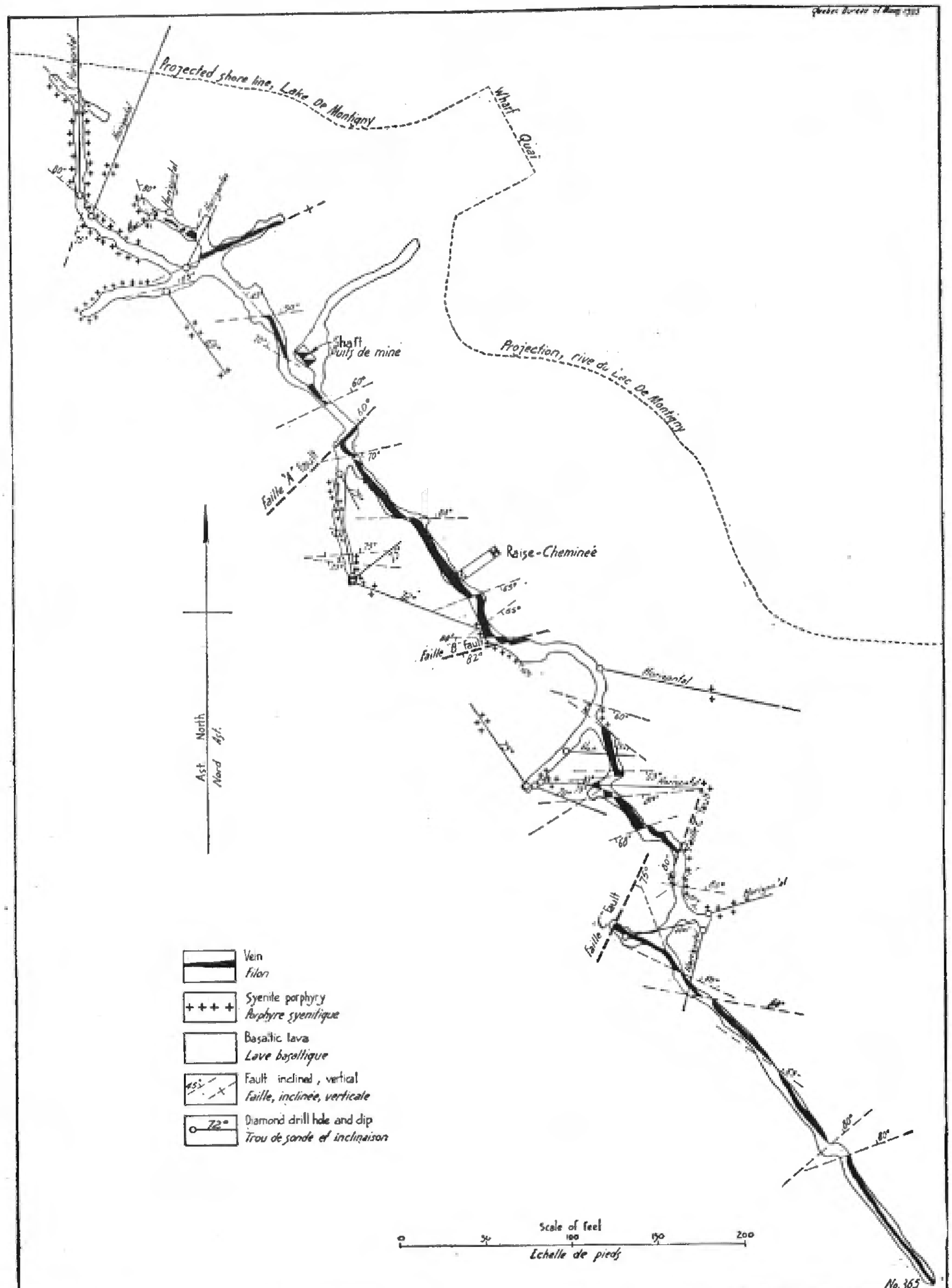


FIGURE 42.—*Shawkey mine.* (Que. Bur. Mines, 1935, Part *B*, Fig. 1. p. 47).

east and have steep dip. In the vicinity of the shaft they are cut by three dykes of syenite porphyry, two of them 20 to 30 feet wide and the third and most northerly having a width up to 100 feet. West of the shaft, the dykes have about the same strike and dip as the volcanics, but in the vicinity of the shaft their strike swings to a more southerly direction, across the flows.

The gold-bearing veins occur along fractures or narrow shear zones in the volcanics, and many of them are in close proximity to one or other of the porphyry dykes. Some have northeasterly strike, but more generally they nearly parallel the strike of the volcanics and the dykes. Two of the vein zones, No. 1 and No. 2, actually follow the dyke-greenstone contact along the north and south sides, respectively, of the most southerly of the three dykes. The evidence indicates that the fractures in which the veins occur are post-porphyry in age and that the gold and other mineralization is genetically related to the porphyry intrusions.

The veins so far found are, individually, narrow, many of them mere stringers which lack appreciable length. Along the principal fractures or shears, the vein filling rarely exceeds a width of two feet or a length of 200 feet. The quartz of the veins is glassy, white, or bluish-grey. Variable amounts of actinolite, epidote, and chlorite are present, in part at least in fractures in the quartz, and there is a little tourmaline in some of the veins. Sulphides include pyrite, pyrrhotite, chalcopyrite, and, more rarely, sphalerite. Gold may be seen here and there in many of the veins and stringers; but assays of material containing no visible gold have returned low or negligible results. The gold occupies fractures in the quartz (Cooke, pp. 97-98, Cooke *et al.*, pp. 269-270; Hawley, pp. 77-78; Bell, 1936, pp. 49-52, 1937, p. 50).

Shawmaque Gold Mines, Limited and Amity Gold Mines, Limited

Some surface exploration has been done on claims held by these Companies a mile and three-quarters south, and two miles south-southeast, respectively, of the Provincial Mine School property. The claims are underlain by Keewatin-type volcanics which, immediately to the south, are in contact with Temiscamian-type sediments. Some gold-bearing veins and stringers have been found on both properties and, although apparently of no commercial importance, they are of interest as indicating the persistence of gold mineralization to the south margin of the volcanics.

On Shawmaque ground, across lots 40 and 41, range VI, a series of narrow, lenticular veins and stringers has been traced for 3,000 feet. These veins are in tuffs and intrusive diorite about 1,000 feet north of the Temiscamian-type greywacke. The vein material is quartz and rather abundant tourmaline, with some feldspar, actinolite, chlorite, and sericite. Minor amounts of pyrrhotite, chalcopyrite, and pyrite occur in fractures in the quartz. Erratic gold assays have been reported.

On the Amity claims, a veinlet one to two inches wide, with strike N.45°W. and dip steep to the northeast, has yielded relatively high assays in gold. It is 100 feet south of lot-post 46-47, range-line VI-VII. It borders a feldspar porphyry dyke which occupies a fault in a pillowed greenstone flow. The vein is of sugary quartz, well mineralized with chalcopyrite (Bell, 1936, pp. 52-54, 1937, p. 51; Ross *et al.*, p. 14).

Greene Stabell Mines, Limited
(Now *Jacola Mines, Limited*)

This property is at the east boundary of Dubuisson township, between de Montigny and Blouin lakes. The town of Val d'Or is at the south end of the latter lake. Mining has been carried on from two shafts, the more westerly of which is a little less than a mile and a half southeast of the Sullivan No. 1 shaft. The deposit mined from this shaft was discovered by J. F. Stabell in 1914, and is known as the Stabell vein; it contained copper as well as gold. In 1922, the property was purchased by W. F. Greene and associates, and Stabell Gold Mines, Limited, was incorporated to carry on development. This included trenching, diamond drilling, and the sinking of a shaft (No. 1) to a depth of 620 feet, with lateral work on levels at 285 feet and 600 feet. Underground operations were suspended in 1924, but exploration was carried on intermittently in the succeeding years and in 1928 the Company was reorganized as Greene Stabell Mines, Limited. After a further period of idleness, preparations were made in 1933 to bring the mine to production. A mill with a capacity of 60 tons per day was erected and the first gold brick was poured in December of that year.

By 1936, the principal ore shoots of the Stabell vein had been almost completely mined out. In 1935, however, diamond drilling along the south shore of the small Stabell lake had intersected gold-bearing quartz veins in granodiorite, and here, about 2,800 feet northeast of No. 1 shaft, a new shaft, No. 2, was sunk which, in 1937, had attained a depth of 1,000 feet. Some ore from these veins was put through the mill, but milling operations ceased in March, 1937, and all operations at the property were suspended two years later. In 1937, the Company was reorganized as Jacola Mines, Limited.

Total production from 1933 until the closing of the mill in 1937 was 397,703 lb. copper, 15,159 oz gold, and 4,223 oz. silver, from 71,504 tons of ore treated.

The northern part of the property is occupied by granodiorite of the Bourlamaque batholith which here, at its western end, has the form of a relatively narrow band with east-west trend. Southward from this are volcanic rocks of Keewatin type which strike due east or a few degrees north of east, dip 70° south, and face south. The succession southward from the contact is: dark schistose, serpentinized lavas, 900 feet; several thin flows of diverse composition and an agglomerate band, 210 feet; an andesite (greenstone) flow, for the most part coarse and massive, 370 feet; followed by pillow lavas, volcanic breccias, and serpentinized lavas. The Stabell vein lies within a fault in the andesite flow. Intruding these volcanic rocks are a number of granodiorite porphyry and more basic dykes, which strike northwest and dip steeply northeast. One has been noted with a width of twenty-five feet, but in general they are much narrower than this. The basic dykes are believed to be younger than the others. Similar porphyry dykes cut the

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granodiorite of the main batholith, to which, presumably, they are genetically related. The veins, with their gold and sulphide mineralization, are later than the granodiorite dykes.

Surface and underground exploration revealed several systems of faults on the property. The oldest of these is the Mine, or Stabell, fault which, at the surface, passes a short distance southwest of No. 1 shaft with trend N.60°W. and dip 70° northeast. Striæ indicate that the movement on this fault was horizontal, with relative displacement of the north side about 135 feet to the southeast. Cutting this fault obliquely is a dyke of granodiorite porphyry. At the surface, this dyke lies chiefly to the north of the fault, but below the 100-foot level it occupies the fault for a length of some 150 feet. The Stabell vein is confined to the fault and for the most part follows one or both walls of the dyke.

About 1,000 feet northwest of the shaft, the Mine fault is offset 300 feet to the east by a northeasterly trending fault, known as the West fault, and 150 feet still farther northwest it is similarly offset for 100 feet by the Legault fault, which parallels the West fault. In their eastward continuation, the trend of both of these faults changes to only 15° or so north of east, or it may be that they merge with older faults having this trend. In any case, in their northeasterly trending sections, these faults are clearly later than the Main fault, and it is believed they are later also than the granodiorite porphyry dykes.

About 300 feet southeast of No. 1 shaft, the Mine fault meets the younger Blouin Lake fault, beyond which it continues with an offset of 160 feet to the southwest. This is the most persistent fault in the area. With trend N.30°E. and dip very steep to vertical, it has been traced for several miles from south of No. 1 shaft, across Stabell lake — at whose south shore it passes from the volcanics into the Bourlamaque granodiorite at a point 800 feet west of No. 2 shaft — and beyond that along Blouin lake. It is a zone some 200 feet wide of sheared and contorted rock, marked at the surface along part of its course by a drift-filled depression and, farther northeastward, by the long and narrow Blouin lake. Movement along the fault has been, in part at least, subsequent to the gold and sulphide mineralization.

The Stabell vein was quite rich in sulphides. The ore milled contained about 2 per cent by weight chalcopyrite and copper recovery was approximately ten pounds per ton. The oldest vein constituent is white quartz, with possibly a little pyrite. This was considerably fractured before introduction of a second generation of quartz together with minor amounts of carbonate, sericite, and the metallic minerals. The order of deposition of the latter was apparently pyrite, magnetite, pyrrhotite, chalcopyrite, tellurides, and gold. The gold is usually associated closely with the chalcopyrite, in very fine particles, but tellurides and gold were also found in the quartz. Where the wall-rock was the granodiorite dyke, this rock was largely altered to epidote; where it was andesite, this was traversed by paper-thin fractures containing pyrrhotite or epidote and quartz. The vein material was found in greatest amount along sections where the dyke was continuous. Of several ore shoots west of the Blouin Lake fault, the best had a length of 270 feet at the surface, 150 feet on the 450-foot level, and bottomed at 490 feet. In the upper levels, the width of the ore averaged about six feet, and in the lower levels about three feet. Ore was found both on the hanging-wall and footwall side of the dyke, and in places lenses on the two sides overlapped. In the main ore shoot, the ore occurred mostly on the hanging-wall side in the southeastern section and on the footwall side in the northwestern section.

In the No. 2 shaft area, on the south shore of Stabell lake, several gold-bearing veins or ore shoots have been found occupying fractures in the Bourlamaque granodiorite. One of these, on the 400-foot level, was developed for a length of 110 feet, but subsequent mining revealed that it lacked vertical extent. This vein strikes N.50°E. and dips at 25° to the southeast. Another ore shoot was encountered on the 500-foot level. Although it did not extend far above that level, it was found to be continuous in a winze sunk to the 600-foot horizon. As indicating that fractures in the granodiorite persist to considerable depth, however, is the fact that a high-grade, though narrow, vein was cut on the 1,000-foot level. This was followed for 380 feet along its strike, and the average assay over a length of 240 feet and width of 20½ inches was reported as 0.3 oz. gold per ton. Besides fine gold and tellurides, these quartz veins and ore shoots contain abundant sphalerite, with which much of the gold recovered was closely associated. They contain little or no pyrrhotite, and much less chalcopyrite than the Stabell vein. The granodiorite wall-rock shows pronounced silicification (Cooke *et al.*, pp. 256-261; Hawley, pp. 63-70; Taschereau, 1936, p. 64; Bell, 1936, pp. 23-32, 1937, p. 53).

Other Gold Occurrences in the Vicinity and to the South of De Montigny Lake

The results obtained in mining operations at the Siscoe, Sullivan Consolidated, and Shawkey mines greatly stimulated exploration efforts in this district. Some significant structural features and ore occurrences have been disclosed by this work.

Dorval-Siscoe Gold Mines, Limited, carried out exploration northwest of Siscoe island by drilling from the lake ice and by 3,700 feet of underground work on the 300-foot level from a 343-foot shaft on island No. 6, slightly less than two miles northwest of Siscoe island. Up to the end of 1939 this work had traced for a mile or more a strong, talcose shear zone at the contact of granodiorite and greenstone. It is believed to be the continuation of the Siscoe *K* zone.

A strong vein has been exposed for a length of 780 feet in a drift on the 300-foot level, and it has been cut in two diamond drill holes at points beyond the eastern end of the drift. It has a very uniform strike of N.40°W., but the dip varies from place to place, being 50° to the south at the eastern end of the drift and almost vertical at the western end. At several places, the vein is wider than drift width. Assays as high as 0.53 oz. gold per ton have been reported (Bell, 1937, p. 54; Ross *et al.*, p. 12; Auger, 1940, p. 11).

Along the mainland shore to the northeast of Siscoe island there are intermittent outcrops of schistose greenstone, serpentine, and altered granitic rocks. Visible gold has been reported in a granitic dyke mineralized with pyrite and carbonate and cut by stringers of white quartz seamed with tourmaline, carbonate, and pyrite. The mineralized zone has an east-west strike and a width of about 100 feet.

To the east of this occurrence, and southward under the waters of the bay, much exploration has been carried on by *Siscoe Extension Gold, Limited,* and by related interests in the hope of encountering the eastward continuation of the Siscoe *K* zone. To the end of 1938, this work included much diamond drilling and the sinking on the lake shore of a 750-foot-shaft, with considerable lateral work on the 350- and 725-foot levels. On the 350-foot level, a gold-bearing zone which had been intersected in two drill holes was encountered in a drift southeastward from the shaft. It consists of schists mineralized with pyrite, chalcopyrite, pyrrhotite, magnetite, and a little arsenopyrite. Three ore shoots, with lengths of 65 to 85 feet, within this zone are reported to have yielded assays ranging from 0.21 to 0.353 oz. gold per ton across widths of two to three feet. On the 725-foot level, erratic gold assays were obtained from quartz lenses in a strong shear zone east of the shaft and also from quartz stringers and veins along the margin of, and within, a wide granitic dyke (James and Mawdsley, p. 71; Hawley, pp. 53-56; Bell, 1937, p. 56; Ross *et al.*, p. 12; Auger, 1940, p. 9).

During the winter of 1936-37, several diamond-drill holes were put down from the ice on the property of *West Siscoe Gold Mines, Limited,* which lies within de Montigny lake, immediately west of Siscoe island and of the holdings of Siscoe Gold Mines. The drilling intersected a number of gold-bearing veins, with indications of a mineralized zone about 1,000 feet long. To explore this zone, a cross-cut was driven from the west end of the Siscoe workings, on the 450-foot level, and about 200 feet of drifting had been completed on West Siscoe ground when operations were suspended in 1939. Gold assays of material encountered in the drifts were lower than those obtained from drill intersections (Bell, 1937, p. 52; Auger 1940, p. 9).

A number of years ago, some narrow gold-bearing quartz veins were discovered on Parker island, a small islet in de Montigny lake about a mile and a half west-northwest of the Shawkey mine. The veins are in greenstone, which is cut by southwest striking dykes of fine-grained feldspar porphyry. The island forms part of the property of *Kiena Gold Mines, Limited,* who, in 1936, carried out a diamond drilling programme and sank a shaft which, in 1937, had a depth of 455 feet, with a total of 2,200 feet of lateral work completed on the 430-foot level and on a sub-level at 390 feet.

The No. 1 vein, on which the shaft was sunk, was traced on the surface for a length of 150 feet. It consists of a series of stringers and lenses of white quartz arranged *en échelon* in an east-west trending shear zone, 3 to 7 feet wide. The wider lenses contain pyrite, pyrrhotite, chalcopyrite, galena, sphalerite, and erratically distributed gold. Pyrite and pyrrhotite occur also in the wall-rock.

On the 390-foot sub-level, a gold-bearing lens in actinolite rock some 400 feet southwest of the shaft has been explored for a length of 100 feet and a width of 30 feet. Assays are reported to average 0.285 oz. gold per ton over a width of ten feet. The drilling indicated that there are other similar lenses in this actinolite rock, which extends, with variable thickness, over a considerable area.

The northern part of the property, which is covered by the waters of de Montigny lake, was explored by diamond drilling from the ice and from a cross-cut northward from the shaft workings. D. R. Derry, geologist for Ventures, Limited, states that the rocks encountered were basic lava flows and tuffs intruded by (1) diorite and hornblendite dykes or lenses, (2) granodiorite dykes, light grey in colour and fairly acid in composition, and (3) diorite and feldspar porphyry dykes. The work carried out up to 1940 had outlined an orebody with general northerly dip within a zone 400 feet long from east to west and 100 feet wide. It is estimated that the grade of ore in blocks suitable for wide, regular stopes would probably be near 0.14 oz. gold per ton. Other less definite zones of mineralization have been indicated but require further exploration in order to be blocked out (Cooke *et al.*, p. 245; Hawley, pp. 74-76; Bell, 1937, p. 48; Ross *et al.*, p. 12; Auger, 1940, p. 10; D. R. Derry, personal communication, 1940).

About 1,000 feet north of the IX-X range-line of Dubuisson township, a third of a mile west of the shore of de Montigny lake — on ground now controlled by *West Shore Malartic Gold Mines, Limited* — trenching and stripping over a length of 750 feet has disclosed a steeply dipping shear zone in a hornblende-rich intrusive. It is up to 15 feet wide and strikes N.70°E. At intervals along the zone are narrow lenses of white, sugary quartz with some carbonate, which are rather sparsely mineralized with pyrrhotite, chalcopyrite, and pyrite. Gold is present, and some fair assays have been reported from the mineralized vein material. The rock marginal to the quartz lenses is in places silicified and largely replaced by biotite (Bell, 1936, p. 56).

A considerable amount of surface and underground exploration has been carried out at Moccasin island, which is in de Montigny lake, about half a mile south-southeast of Parker island. A mineralized shear zone in Keewatin lavas was investigated by diamond drilling in 1934-35 by Teck Hughes interests, and between 1935 and 1937 *Wisik Gold Mines, Limited*, sank a shaft to a depth of 385 feet and completed a total of 2,100 feet of lateral work on the 200- and 300-foot levels before suspension of operations late in 1937. The shear zone strikes southeastward toward, and in structure closely resembles, the main vein zone on the adjoining Shawkey property. The underground development is reported to have disclosed an ore shoot 58 feet long on the 200-foot level, with an average gold content of 0.30 oz. per ton over a drift width of 4.5 feet, and another, or possibly the same, ore shoot on the 300-foot level, 43 feet in length, assaying 0.454 oz. gold per ton over an average width of 8.7 feet. On the latter level, also, a drift northwestward from the shaft exposed a length of 365 feet of ore carrying 0.10 oz. gold per ton over an average width of 5.75 feet, and a drift to the southeast cut 28 feet of ore assaying 0.298 oz. gold per ton over an average width of 8.5 feet (Bell, 1936, p. 55; 1937, p. 50).

Various interests have investigated a gold bearing-quartz vein cutting biotite-chlorite schist on a property a short distance south of de Montigny lake, extending westward from the centre-line of Dubuisson township in ranges VII and VIII. Work has included diamond drilling in 1922, the sinking of a shaft to a depth of 100 feet in 1925 by *Unison Gold Mines, Limited*, and the commencement of a second shaft 500 feet farther south by *Crossroads Gold Mines, Limited*, in 1935. The rock in which the vein occurs is biotite-chlorite schist of doubtful origin but possibly representing a post-Keewatin intrusive rock related to the Bourlamaque granodiorite. In surface outcrop, the vein is arcuate, striking N.45°W. at its eastern end, then N.20°W., and finally due north at its western end. It has been exposed for a length of 200 feet with average width of ten feet, and diamond drilling indicates that it maintains this width to a depth of 400 to 500 feet. The vein consists of bluish-grey quartz, much fractured, and cut by narrow stringers of tourmaline. It is sparingly mineralized with pyrite, chalcopyrite, and pyrrhotite, and is reported to contain visible gold in places (Cooke *et al.*, pp. 246-247; Hawley, pp. 72-73; Bell, 1936, p. 34).

Formaque Gold Mines, Limited

(Successors to *Payore Gold Mines, Limited*)

This property extends southward from the north boundary of Bourlamaque township, on either side of the north-south centre-line. It lies well within the Bourlamaque granodiorite batholith. Gold-bearing veins occurring in shear zones in the granodiorite in the south part of the property, immediately south of Herbin lake, have been investigated by surface work and diamond drilling, the latter carried out chiefly by *La Reine Mines, Limited*, in 1929 and by *Payore Gold Mines, Limited*, in 1934 and subsequent years. In 1936, the latter Company sank a shaft to a depth of 375 feet, with lateral work on three levels, and in 1938 a 35-ton mill was erected. Between June and the end of that year it treated 4,812 tons of ore with recovery of 466 ounces of gold, or 0.095 oz. per ton. Operations were then suspended. In 1944, the property was acquired by *Formaque Gold Mines, Limited*, who completed some 4,000 feet of diamond drilling.

The main vein system, on which the shaft was sunk, is in the western part of the property and consists, on the surface, of two easterly trending lenses of quartz, one to four feet wide and some fifty feet long, separated by a barren section twenty-five feet long. Coarse pyrite is practically the only sulphide mineral in the veins. Spectacular visible gold was reported in one of the lenses. Gold occurs also in the granodiorite wall-rock, which is altered and impregnated with pyrite (Hawley, pp. 84-87; Bell, 1935, pp. 55-57, 1937, pp. 63-64).

Northern Margin of Bourlamaque Batholith

The contact between the Bourlamaque granodiorite and Keewatin-type volcanics to the north is everywhere concealed beneath clay and other unconsolidated deposits, but as the result of trenching, diamond drilling, and geophysical surveys it is known that its general trend from the south end of Blouin lake is first northeasterly and then east-northeasterly across Senneville township, passing two to three and a half miles north of the Bourlamaque-Senneville boundary. In some places, the exploration work has revealed gold mineralization along or adjacent to the contact.

On lots 19 to 23, about 3,000 feet north of range-line III-IV of Senneville township, trenching has exposed a zone of silicification and fracturing, about a foot and a half wide, in feldspar porphyry which, probably, is a dyke related to the main body of granodiorite. Pyrite and marcasite are abundant along this zone and grab samples are reported to have yielded assays as high as 0.123 oz. gold per ton. On lot 37, range III, drilling through more than 300 feet of overburden intersected the granodiorite-volcanic contact and indicated that the rocks along the contact are sheared over a width of fifty feet. The drilling encountered two quartz-tourmaline zones associated with basic dykes. Chalcopyrite and pyrrhotite occur along these zones, but assays of the material indicated that its gold content is below commercial grade. A small gold-bearing vein was cut in a drill hole on lot 39, range III (Ross *et al.*, p. 16).

LAMAQUE GOLD MINES, LIMITED

This property is in the northwest quarter of Bourlamaque township, extending eastward from the west boundary to near the north-south centre-line. For most of this length it embraces, and extends a short distance to north and south of, range VII. Gold was discovered here in 1923, and in the following year two prospect shafts were put down to explore these occurrences. In 1932, Teck-Hughes Gold Mines, Limited, took an option on the claims, then known as the Read-Authier property, and, following completion of an extensive diamond drilling programme, Lamaque Gold Mines, Limited, was incorporated in 1933 to develop the property and bring it to production.

Sinking of three shafts was commenced in 1933 and of two others in 1934 and 1936. The relative positions and depths of these shafts are as follows: No. 3, 700 feet deep; No. 4, 600 feet east of No. 3, 318 feet deep; No. 5, 1,300 feet south of No. 3, 310 feet deep; No. 6, inclined 60° south, 350 feet north of No. 3, 1,200 feet deep; No. 7, 430 feet N.25°E. of No. 3, 3,600 feet deep, a vertical, four-compartment shaft.

Production commenced in 1935. The first unit of the mill had a capacity of 500 tons per day, and a second 500-ton unit was added in 1937. To the end of 1944, a total of 3,090,461 tons of ore had been treated with recovery of 944,285 ounces of gold, or 0.305 oz. per ton. 'Positive ore' reserves at that time were reported to be 2,530,212 tons, averaging 0.2145 oz. gold per ton.

The mine is situated within an area underlain generally by Keewatin-type volcanic rocks, a mile and a half south of the south margin of the Bourlamaque granodiorite batholith and two and a quarter miles north of the contact between the volcanics and a wide belt of Temiscamian-type sediments to the south. Actually, in the vicinity of the ore deposits, the rocks are predominantly intrusives, and the volcanics these have intruded are chiefly fragmentals, which here form an east-west trending band 3,000 to 4,000 feet wide. The fragmentals are of various types, most prominent of which is a coarse agglomerate or breccia consisting chiefly of rounded or angular fragments, for the most part of various fine-grained acidic rock types, enclosed in a fine, dark green matrix. Many of the fragments are amygdaloidal and all of them apparently represent surface flow rocks.

They range from a fraction of an inch to several feet in diameter. These fragmental rocks are quite massive; only locally do they show any evidence of shearing. Some of the agglomerate beds grade into fine tuffs, and tuffs are in places interbedded with the coarser fragmentals. Unlike the latter, they are often schistose. Both the bedding, where discernable, and the schistosity have about the same easterly strike and steep to vertical dip. Near its northern margin, this belt of fragmental volcanics includes minor beds of basaltic lava.

The oldest, and also the largest, body of intrusive rock in the vicinity of the mine is a boss of fine grained diorite porphyry. It has extremely irregular outline, and, from its borders, equally irregular dykes extend into the surrounding fragmentals. In general, the rock of the boss shows gradation from a dark green, relatively basic facies at the margin to a pale grey, more acidic facies at the centre. Some of the fragments in the surrounding agglomerate or breccia closely resemble certain facies of the intrusive. Inclusions of agglomerate are common in the diorite boss.

Later than, and in places intruding, the diorite porphyry boss are dykes of three ages, progressively more acidic. The oldest of these are dykes of diorite porphyry of two types, known locally as *C* and *D*. They are relatively small and are often flat and lenticular in shape. The most important of these diorite porphyry dykes is thirty feet wide, strikes northeast, and dips 35 degrees southeast; its projected outcrop is close to No. 3 shaft. No. 1 vein, the largest and strongest on the property, follows this dyke more or less closely throughout its length. Next in age are dykes of fine-grained porphyry (type *A*). They occur as a series of more or less parallel, branching dykes which have a sinuous east-west strike and dip at 70 degrees or so to the south. They have widths of 150 feet and upward and, at the surface, lie chiefly to the north and northeast of No. 3 shaft. The youngest dykes are of coarse granodiorite porphyry (type *B*), containing large phenocrysts of albite. A narrow, but persistent, dyke of this type occurs just south of the dykes of type *A*, which it parallels in strike.

More or less in the centre of this area of intrusives are two still later pipe-like stocks. At the surface, No. 3 shaft is about 100 feet outside the northwest margin of the larger of these stocks, which is irregularly oval in horizontal section, with the major axis trending S.70°E. The dip is about 70 degrees northward. On the 200-foot level, the dimensions of this body are 540 feet by 350 feet. Below this, the major diameter gradually increases to some 850 feet on the 700-foot level and to 1,000 feet on the 1,800-foot level, with little change in the minor diameter.

This stock is composed of three successively intruded rock types, more or less concentrically arranged: first, and oldest, a marginal zone of dark, medium-grained, hornblende-biotite diorite; next, a relatively narrow, discontinuous zone of coarse quartz diorite porphyry; and last, forming the core of the stock and rather more than 50 per cent of its volume, a fine-grained, pale grey to pinkish, albite-biotite granodiorite. The rock of the marginal and central zones is generally very fresh, but the granodiorite is more or less altered and nearly half of the quartz it now contains is believed to be secondary. The contacts between the three types are usually quite

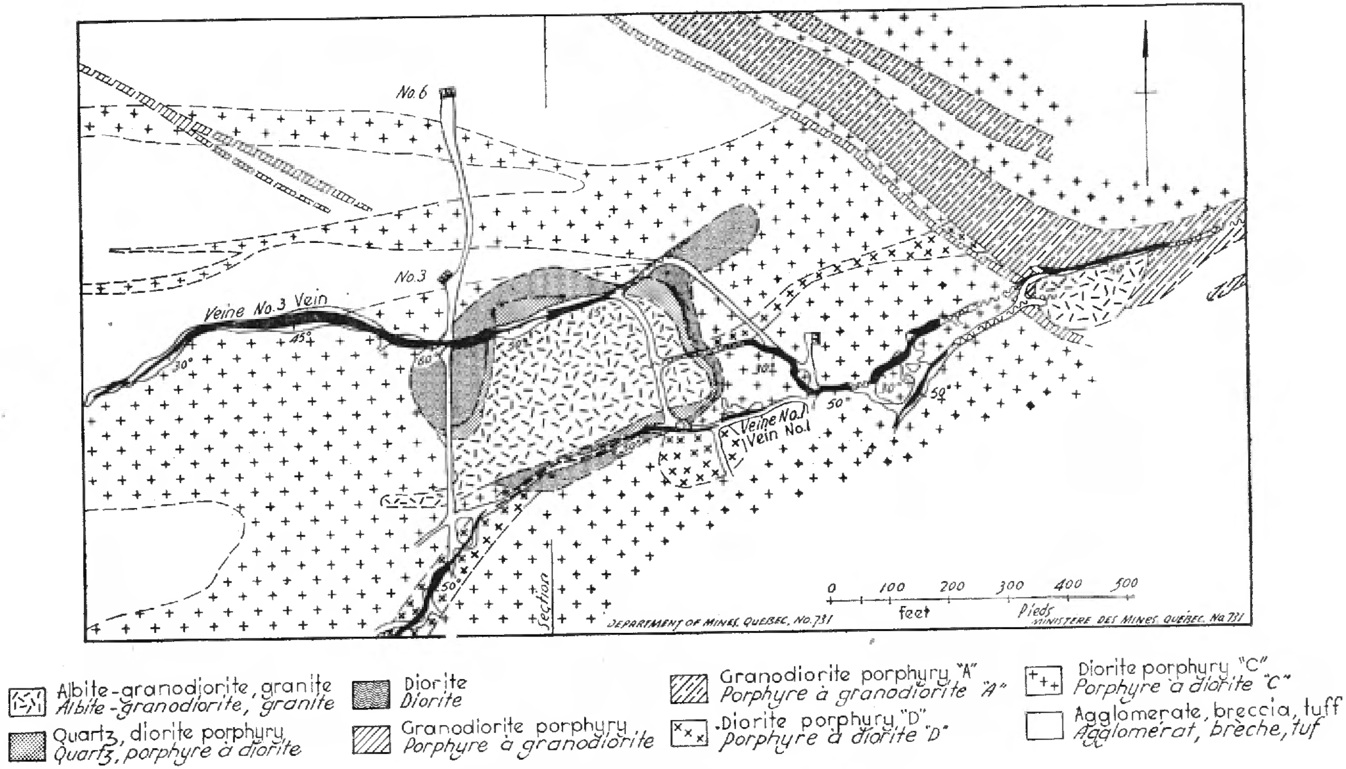


FIGURE 44.—*Lamaque mine, 200-foot level.*

sharp, but narrow, transition zones are present locally. The older types are cut in places by granodiorite dykes that radiate outward from the central core.

The second stock, which lies some 500 feet east of that just described, is rudely circular in outline and some 200 feet in diameter. Like the main stock, it dips N.20°E. at 70 degrees. Some diorite, similar to that forming the marginal zone of the larger stock, occurs locally on its northern (hanging-wall) side, but in this body the great bulk of the rock is albite granite.

Slip planes and minor faults are common in these stocks. Generally, they strike within 20 degrees of east-west and dip south at angles of 45 degrees to vertical. They frequently intersect one another, or one or other of the major faults referred to below, and the movement on them, in most cases, has not been more than a few feet.

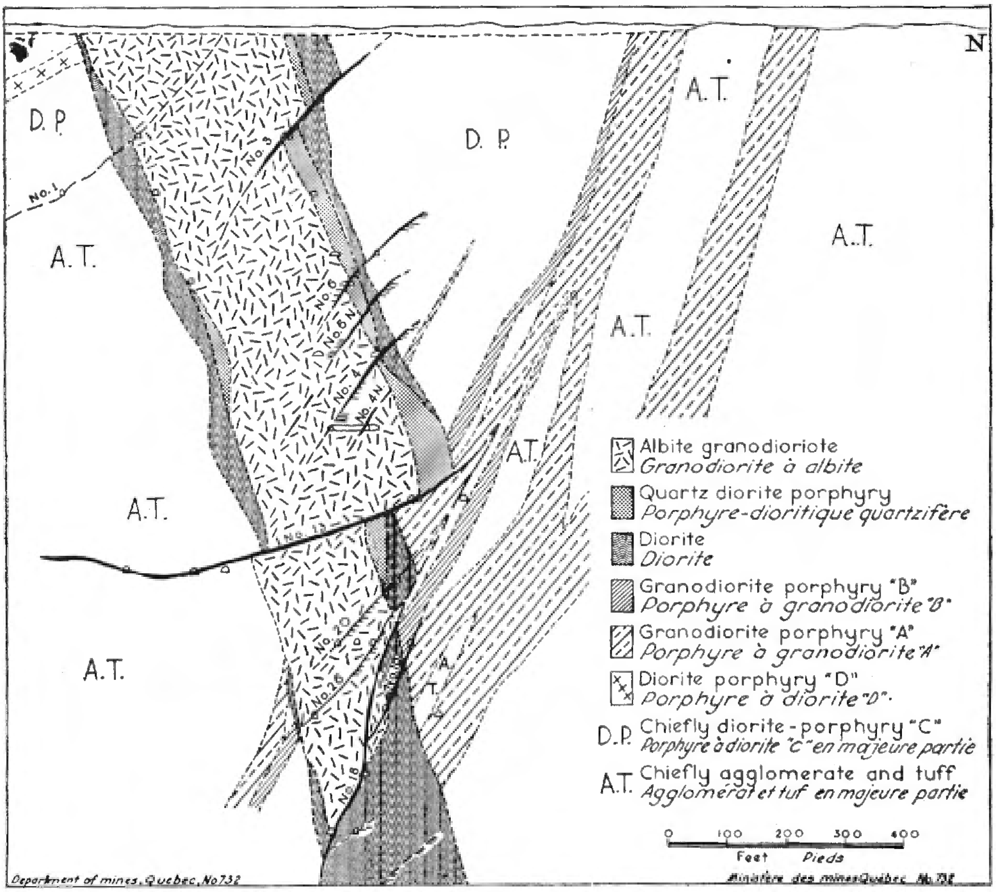


FIGURE 45.—*Lamaque mine, vertical section.*

Structural Characteristics of the Orebodies

The principal veins of the Lamaque mine are closely related to the larger of the two pipe-like stocks. With the exception of No. 1 and No. 13 veins, which are very persistent and cut through the stock, the productive veins are found dipping southerly into the north or hanging-wall side of the stock at irregular vertical intervals. The veins are oval, warped, flattened bodies, with general strike ranging from S.70°E. — the trend of the major axis of the stock — to slightly north of east, and their dips are from 35 to 75 degrees in a southerly direction. The result is that, although the individual orebodies dip southward, the ore zone as a whole dips steeply northward with the hanging-wall of the stock.

These orebodies are in major thrust faults or in fractures subsidiary to them. The faults have warped surfaces. Usually, they dip more steeply in the eastern part of the stock than farther westward, where they flatten before finally dying out. Within the stock, also, their dip usually steepens slightly with depth, but in the fragmental rocks west of the stock they tend to flatten. Some of the older, southerly dipping dykes are paralleled by faults.

The fault zones range in width from one foot to more than twenty feet. Their walls usually show strong fracture or flow cleavage, dipping more steeply than the zone itself. Discontinuous slip planes are common on the hanging-wall of the veins, and in many places there is brecciation of the footwall.

In general, the amount of movement along these fault zones has been no more than a few tens of feet, with a possible upper limit of 150 feet. Some examples are: No. 3 vein, 100 feet; No. 6 vein, 50 feet; No. 13 vein, 125 feet; No. 18, 150± feet. When movement took place, the hanging, or upper, block moved upward and slightly westward. Along any fault zone, the greatest relative displacement has apparently been in the middle section. Toward both ends, it decreased. In the upper parts of the faults, this has resulted in the development of flat tension cracks on the footwall side, lengthening this side to compensate for the movement of the hanging-wall. These vein-filled tension fractures, which are lenticular in section and from a few inches to several feet thick, have greatly increased the mineable width of these sections of the veins. In No. 6 vein, continuous, closely spaced fractures of this type resulted in the formation of a section of ore 100 feet wide and 40 feet in height, paralleling the vein for a distance of 300 feet.

In a few instances, tension cracks in the hanging-wall have continued down the dip toward the lower end of the faults. However, tension cracks of this type are not common; the faults and included veins as a rule fade out into widely spaced slip planes, showing little movement but marked wall-rock alteration. It may be that the steep slips and minor faults that are common in the core of the stock provided the compensation, or, as H. S. Wilson, mine geologist, suggests, the thrust faults may have originated prior to the final consolidation of the central core of granodiorite.

Wilson considers it doubtful that the faults actually fade out at depth. It is now known that all major faults pass through the stock, although in some cases there seems to have been less movement along them on the footwall or south side of the stock than on the hanging-wall side. The recognition of the magnitude of the movement on these faults has been made more difficult by the difference in the expression of the faults in different types of rock. For instance, in the greenstones on the hanging-wall side of the stock, a fault along which there has been 100 feet of movement may be expressed by upwards of ten feet of strong shearing, but, in the granodiorite of the stock, the same fault may be marked merely by a number of small, inconspicuous slip planes and little or no shearing. On emerging on the footwall side of the stock, it may be expressed by shearing, but if so this will be in minor amount as compared with that on the hanging-wall side of the stock. For the most part, only a few faults, for instance No. 1 and No. 13, contain vein material on the footwall side of the stock and, for this reason, faults on the footwall side have not been thoroughly explored.

Down to the 1,200-foot level, numerous veins have been encountered, of which eight have been important ore producers. Consisting of massive quartz and tourmaline, they range in width from one foot to more than twenty feet, and in places, notably in the footwall, where irregular masses of vein material project out along tension cracks, fracture cleavages, and breccia openings, the width of the veins is, on the average, doubled. In mineable length they possibly average 700 feet. There is no particular tendency for the gold to occur in sheets within these bodies, and for the most part the whole vein is ore. The flatter veins are markedly regular. In those with steep dip, the vein material occurs as more or less discontinuous lens-like sections, and associated subsidiary vein-filled fractures are common.

Mineralogical Nature of the Ore

The stronger veins show a rude banding, due to dark, discontinuous zones of unreplaced, pre-vein material on slip surfaces. The bulk of the vein material consists of white to glassy quartz and black tourmaline in varying proportions and lesser amounts of carbonate (ankerite and calcite) and scheelite. Both the quartz and the tourmaline are of more than one age, and even a single vein may consist in some parts of almost pure quartz and in others of almost pure tourmaline. Pyrite, often coarse – crystals up to several inches in diameter — forms two and a half to three per cent by weight of the ore, and chalcopyrite is present in very minor amount. Much of the gold is coarse and occurs in late fractures. An appreciable amount of the gold is combined in tellurides, those identified including petzite $(Ag,Au)_2Te$, calaverite, $AuTe_2$, and krennerite, $(Au,Ag)Te_2$. The gold is associated with the quartz and tourmaline. Its amount is dependent on the extent of the late fracturing, and scarcely if at all on the nature or width of the vein filling.

The mineral composition of the subsidiary tension cracks is similar to that of the main veins, except that tourmaline is less abundant. A rude crustification and small crystal-lined cavities indicate that these were once open fractures. They are generally high-grade ore, much of the gold being coarse and distributed along the margins of the vein material.

Minerals that have been introduced later than the main vein-forming minerals include selenite (gypsum) and sericite, near hanging-wall slip planes, and fluorite, pink calcite, and quartz in the form of veinlets.

Wall-rock alteration is apparently closely linked with the introduction of the quartz and tourmaline of the veins. It extends for a few inches to several feet outward from the vein walls, and in the case of the main veins it is more prominent on the footwall than on the hanging-wall side. Irrespective of the nature of the original wall-rock, alteration results in a conspicuous bleaching due to the development of albite, carbonate, and quartz, generally with more or less finely crystalline pyrite, and tourmaline needles. Except where the pyrite is abundant and definitely introduced, or where the wall-rock is traversed by fine quartz stringers, the wall-rock contains very little or no gold. Where wall-rock alteration is extreme, the bright green chrome mica, fuchsite, is usually present in addition to the other minerals mentioned. Its presence invariably indicates a high gold content.

Despite the fact that the emplacement of at least most of the gold is related to fractures in the main vein-forming minerals, post-vein faulting is generally negligible. In some instances, however, movement may have occurred on the conspicuous slip planes present on the hanging-wall of the veins (Hawley, pp. 79-84; Bell, 1935, pp. 34-47; Wilson, pp. 511-516, and personal communication, 1939).

Sigma Mines (Quebec), Limited

The Sigma property adjoins Lamaque on the north, and, in a general way, the geology and gold deposits of the two are similar. The Sigma main shaft (No. 2) is 2,900 feet N.40°E. of the Lamaque No. 3 shaft.

What is known as the South, or Main, ore zone was discovered by Read-Authier interests in 1933. Under an option arrangement, the zone was explored by intensive surface trenching and diamond drilling by Dome Mines, Limited, who, in 1934, formed a subsidiary Company, Sigma Mines, Limited (since 1938, Sigma Mines, Quebec, Limited) to develop the deposits and bring the mine to production. An inclined shaft was put down to a depth of 264 feet and a large amount of drifting and cross-cutting was carried out on levels at 100 feet and 225 feet. In 1935, sinking of the present vertical operating shaft, No. 2, was commenced and by 1939 it had attained a depth of 2,125 feet, with mining, development, or other lateral work on sixteen levels, the lowest at 1,975 feet. A mill with capacity of 300 tons per day was erected, and production commenced in the spring of 1937. Since that time, the capacity of the mill has been increased to 1,000 tons per day. To the end of 1944, total ore treated amounted to 2,314,092 tons, from which 471,081 ounces of gold was recovered, or 0.203 oz. per ton. Ore reserves at the end of 1944 were estimated at 927,500 tons averaging 0.208 oz. gold per ton.

The gold-bearing veins occur within a band, about 1,000 feet wide, of light coloured, in places amygdaloidal, trachytic lavas, with which are associated some lens-like beds of volcanic breccia. The beds strike east-west or a few degrees north of east, and dip, usually to the north, at a high angle. These lavas are followed on the south by a band, 3,000 to 4,000 feet wide, of volcanic fragmental rocks (chiefly) which are the continuation of the band of similar rocks on the Lamaque property. On the north side, also, the trachytic lavas are in contact with similar fragmental rocks, which form a poorly exposed band 1,000 feet or more wide. In the vicinity of the ore shoots, the lavas are literally riddled by dykes of fine grained diorite porphyry, believed to be of the same age as the body of that rock on Lamaque ground, which form possibly more than 50 per cent of the country rock. These dykes are cut by later diorite porphyry dykes which average ten feet in width, strike N.80°E., and have a vertical attitude or dip steeply to the south. The gold-bearing veins parallel these dykes. Still later are some narrow dykes of lamprophyre and basalt, which commonly strike north-south. They are apparently later than the veins, one of which is cut by a basaltic dyke, three feet wide.

The pipe-like boss of diorite and granodiorite that occurs on the Lamaque property, and to which it is believed the ore shoots there are closely related, has not been encountered in the workings of the Sigma mine. Should this body maintain its dip of about 70° in a direction N.20°E., its northern margin would enter Sigma ground at a depth of about 5,000 feet, and at still greater depth it would pass below the Sigma veins.

There are seven or more gold-bearing veins in the shaft area within a zone 700 feet wide. Structurally and mineralogically, they closely resemble the Lamaque veins. They are quartz and tourmaline filled fractures mineralized chiefly with pyrite and a little chalcopyrite. All of them strike about ten degrees east of north. Two dip northward at 45 degrees, but all the others dip southward at about 80 degrees. They range in width from a few inches to twenty, and rarely as much as fifty, feet, and have been developed for lengths of more than 1,200 feet, with indicated vertical extent in some cases as much as 1,000 feet (Bell, 1935, pp. 27-35, 1937, pp. 61-62; J. G. McCrea, Manager, and W. J. Bichan, Geologist, Sigma Mines, Ltd., personal communications, 1939).

Blouin Lake Gold Mines, Limited

This property is in Bourlamaque township, extending eastward in range IX from the western boundary. The claims lie immediately southeast of Blouin lake, at whose southern end is the town of Val d'Or. Adjoining on the west is the property of Jacola Mines, Limited.

The east-west trending contact between the granodiorite of the Bourlamaque batholith and Keewatin-type volcanics to the south crosses the claims. Diamond drilling along the contact failed to reveal any noticeable shearing but it encountered a number of quartz stringers in the volcanics, some of them gold-bearing and containing chalcopyrite. These were all very narrow and their gold content was low (Bell, 1935, pp. 22-23; Ross *et al.*, p. 17).

Harricana Amalgamated Gold Mines, Incorporated

The claims of this Company lie on either side of the Dubuisson-Bourlamaque township line, immediately south of the Jacola and Blouin

Lake properties. In 1936-37, the Company sank a 325-foot shaft and did some lateral work on three levels to explore a gold-bearing quartz vein that had been discovered in the course of surface work and diamond drilling by former holders of the claims. The main vein occurs in coarse Keewatin-type greenstone on the footwall side of a dyke of granodiorite porphyry. It has been traced along its southwesterly to westerly strike for a length of 200 feet and has an average width of three and a half feet. The quartz is mineralized with pyrite and chalcopyrite and is reported to carry 0.263 oz. gold per ton. In addition, several short quartz lenses and stringers containing chalcopyrite have been found in the greenstones on both sides of the dyke (Bell, 1935, pp. 23-26, 1937, p. 58).

Numaque Mining Company

The Numaque claims adjoin Sigma ground on the northeast. Rock exposures are sparse, but the claims are underlain by Keewatin-type volcanics and, in the extreme north, possibly by granodiorite of the Bourlamaque batholith. Surface exploration in 1934-35 by the Nu Sigma Gold Syndicate, former holders of the claims, exposed a narrow gold-bearing quartz vein following fractures in a granodiorite dyke, which occurs in low ground between two outcrops of andesitic lava. The vein has been traced for a length of 150 feet, striking N.30°W., with average width of the order of a foot and a half. It consists of sugary quartz, heavily mineralized, chiefly with chalcopyrite, and in places it contains visible gold. Some 1,200 feet westward from this vein, diamond drilling encountered lenticular gold-bearing quartz veins in a strong shear zone in andesite (Bell, 1935, pp. 50-51, 1937, p. 62).

Bidlamaque Gold Mines, Limited

The Bidlamaque claims adjoin Numaque ground on the east. They cover the southeasterly trending contact between the granodiorite of the Bourlamaque batholith and Keewatin-type lavas to the southwest and south. Surface exploration in 1934 revealed the presence of some steeply-deeping quartz-tourmaline veins in fractures in the granodiorite not far from the margin of the mass. They are sparingly mineralized with sulphides. Diamond drilling during 1936 indicated a strong east-west shear zone in the volcanic rocks. This was encountered in holes spaced over a distance of three-quarters of a mile, to the Bidlamaque-Numaque boundary line. Systematic probing over a length of 200 to 300 feet intersected gold-bearing material, but apparently this is in the form of discontinuous lenses. As a consequence, it is difficult to appraise the possible economic importance of the occurrence (Bell, 1935, p. 57, 1937, p. 62; Taschereau, 1937, p. 73).

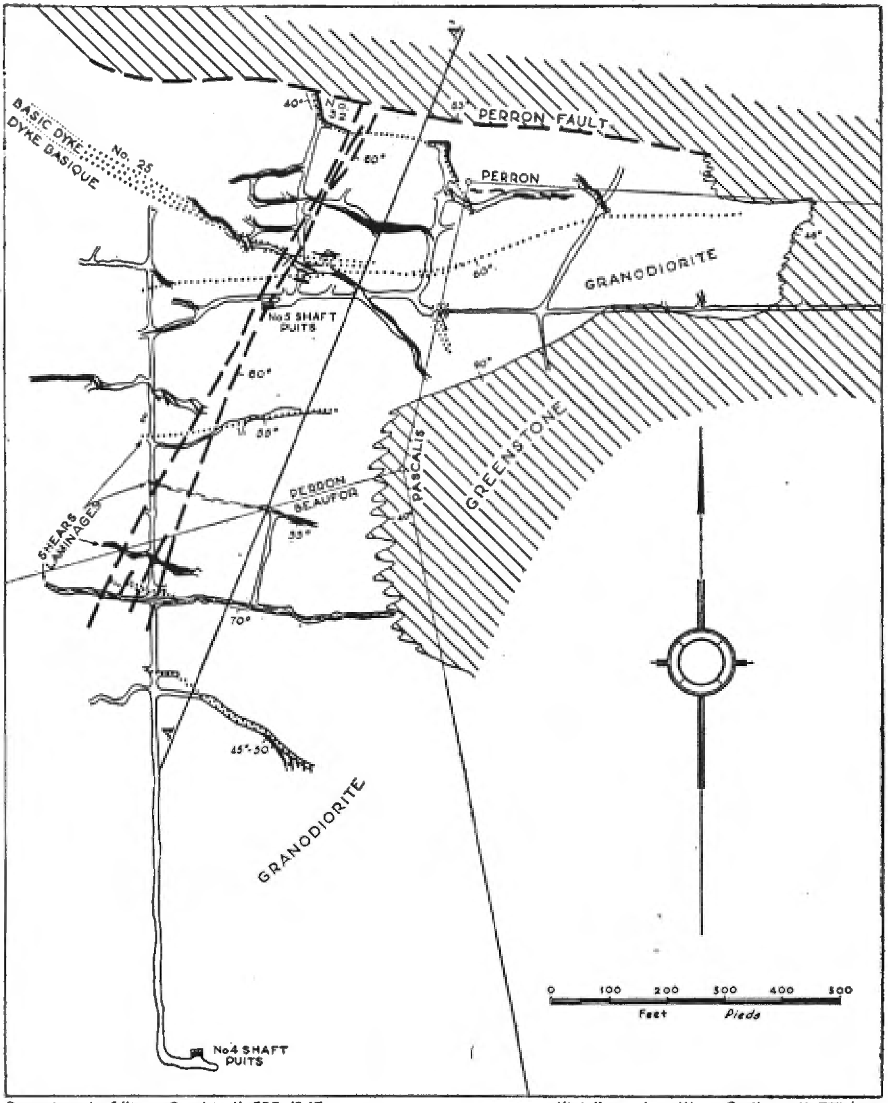
Standard Gold Mines, Limited

This Company controls a group of claims extending eastward from those of Bidlamaque Gold Mines. As on the latter property, the granodiorite-greenstone contact crosses the claims, with southeasterly strike. Stripping and test pits have exposed fractured granodiorite containing short quartz-tourmaline lenses, within some of which are pockets of granular pyrite.

Low gold assays are reported from this material. During 1936, these occurrences were further investigated by diamond drilling (Hawley, p. 87; Bell, 1935, p. 60, 1937, p. 63).

PERRON GOLD MINES, LIMITED

Perron Gold Mines, Limited, was incorporated in 1934 to develop a group of claims held until that time by Mathews Gold Mines, Limited.



Department of Mines Quebec No.733 1947. Ministère des Mines Québec, No.733,1947.

FIGURE 46.—*Perron and Beaufor mines, diagram of 625-foot level. Includes part of Pascalis ground.*

The property is in Pascalis township, about one mile north of the southwest corner, and extends westward for a short distance into Senneville township. In 1933, the former owners had sunk a shaft to a depth of 200 feet, and had also produced a small amount of gold from surface workings. This shaft was deepened to 325 feet, and in 1935 a new shaft, No. 4, was sunk, by arrangement, on Beaufor ground, which adjoins Perron on the south. It has a depth of 705 feet. In 1938, sinking of another shaft, No. 5, was commenced. By 1941, this had attained a depth of 2,250 feet, with levels established at 100-foot intervals. Meanwhile, a mill had been erected, and production has been continuous since 1935. To the end of 1944, 1,084,250 tons of ore was treated with recovery of 316,747 ounces of gold, or 0.292 oz. per ton. Ore reserves at the end of 1944 were estimated at 230,499 tons averaging 0.188 oz. gold per ton.

The Bourlamaque granodiorite batholith, which occupies much of the south part of Senneville township and the north part of Bourlamaque, projects for a short distance into the southwest corner of Pascalis and the northwest part of Louvicourt. Its contact with the Keewatin-type volcanics to the east has an irregular trend northward and west of north, and for at least part of its course is marked by a fault and shear zone — the Perron fault. The granodiorite is cut by dykes of aplite, and in places apparently grades into aplite. It is intersected also by later andesite and diorite dykes, rarely as much as five feet wide, which are commonly schistose and somewhat contorted. The fractures or shear zones occupied by these dykes follow no particular pattern, some striking east-west, others southwest or northwest. Most of the important gold-bearing veins are closely associated with, and are parallel to, these dykes.

The strongest fault in the district is the Perron fault, at the granodiorite-greenstone contact, marked by a zone of shearing some thirty feet wide with general trend N.80°W. Its dip is northward, at 83° from the surface to a depth of about 625 feet and below that at 75°. There has been considerable and recurrent movement on this fault, but no vein material has been introduced.

Some of the gold-bearing veins and lenses occur along shear zones with east-west trend and dipping 55° to 60° south, where they are associated with andesite dykes of like strike and dip. A strong and important shear zone of this type, fifty feet wide, or more, passes 500 feet south of No. 4 shaft. The gold-bearing veins and associated andesite dykes just south of the Perron fault occur in shear zones striking N.45°-60°W. — or more rarely only a few degrees west of north — and dipping southward at 35° to 40°. Still other veins — which are believed to be older than the main veins — lie along joint planes in the granodiorite, with average strike N.65°E. and dip 60° northwest. These veins consist of bluish quartz mineralized with chalcopyrite, pyrite, and pyrrhotite, and their gold content is usually very low. However, a vein with this attitude on the Beaufor property contains much visible gold.

The largest individual orebodies lie south of and against the Perron fault in shear zones in the granodiorite which strike northwest and dip southwest at 35° to 40°. These vein zones are found in the granodiorite to

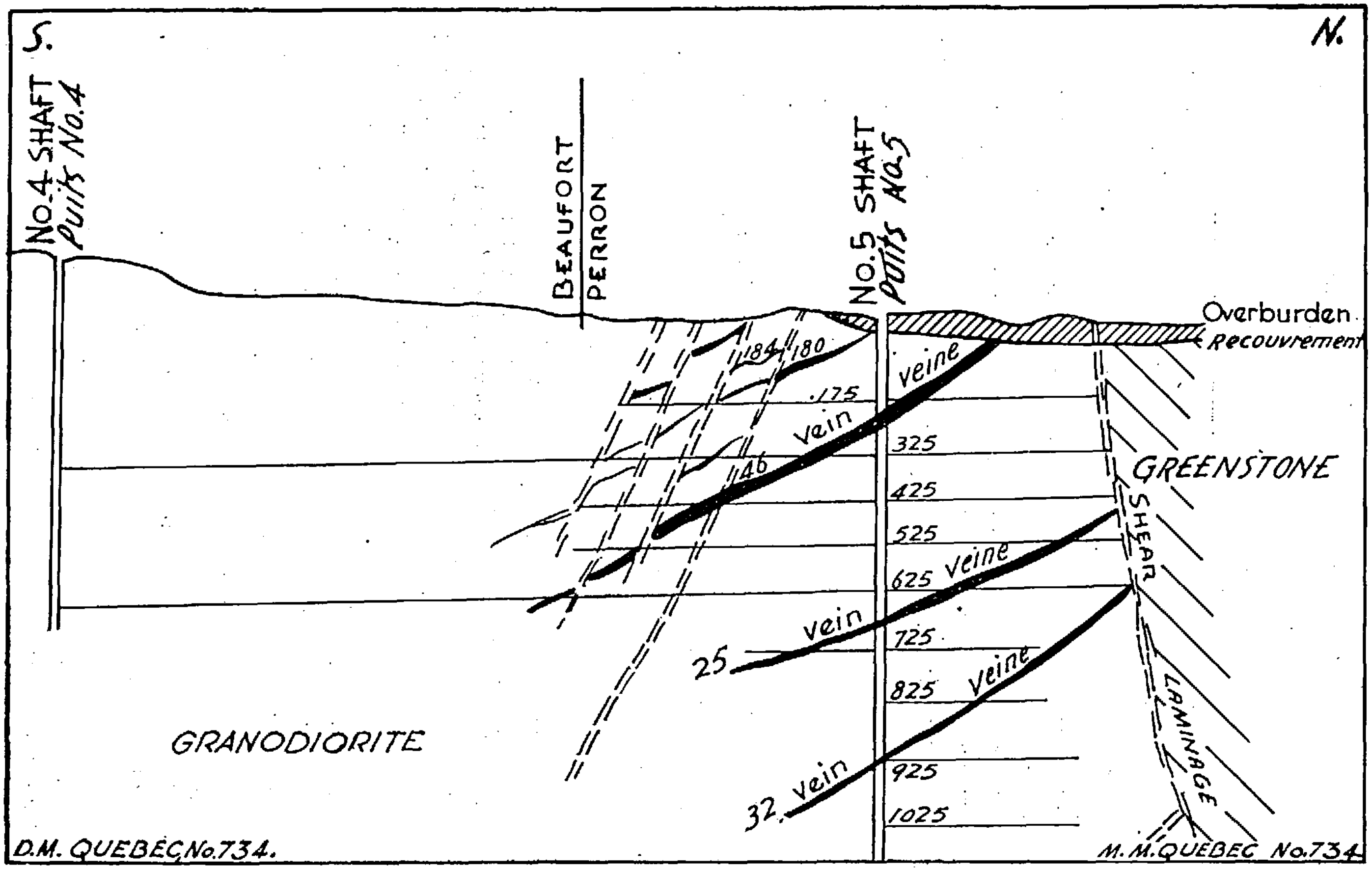


Fig.47

FIGURE 47.—*Perron and Beaufor mines, diagrammatic vertical cross-section A-A.*

a distance of 700 feet from the fault and to a depth of at least 1,025 feet. No. 32 vein is 100 feet long on the 625-foot level, and 704 feet long on the 1,025-foot level, with an average width of fifteen feet and grade of 0.3 oz. gold per ton.

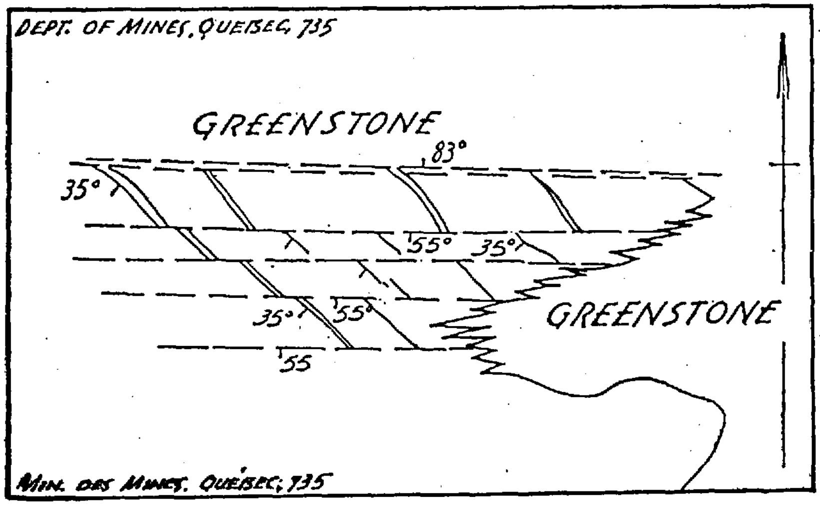


FIGURE 48.—*Perron mine, diagram of fracture pattern, 175-foot level.*

No important gold-bearing veins have been found in the greenstones to the east of the batholith nor, within the latter, far from the granodiorite-greenstone contact.

White quartz forms the bulk of the vein material. Tourmaline may be present and in some veins it is in massive aggregates. Sulphide mineralization is chiefly pyrite, both coarse and fine grained, with some associated chalcopyrite. The sulphides occur as massive aggregates and also filling fractures in the quartz, and the coarse pyrite is often fractured and veined by later quartz. Pyrite occurs also in the wall-rock, with carbonate and sericite. Some of the veins contain appreciable amounts of scheelite, and, during 1942-43, small shipments of scheelite concentrates were made to the Provincial Mine School at Val d'Or and to the Department of Mines, Ottawa. A large percentage of the gold occurs as minute flakes or films along fractures in the pyrite and quartz, but some of the gold in the quartz is coarse and associated with a telluride, believed to be tetradymite. L. P. Warriner, the mine geologist, has noted that in some of the veins pale and dark yellow gold occur together (Bell and Bell, 1932, pp. 114-115, 1935, pp. 357-358; Bell, 1933, pp. 40-43; L. P. Warriner, Mine Geologist, personal communication, 1939).

BEAUFOR GOLD MINES, LIMITED

The Beaufor property is at the southwest corner of Pascalis township and the northwest corner of Louvicourt. Adjoining properties are Cournor on the west, Perron on the north, and Pascalis on the east.

Beaufor Gold Mines, Limited, was incorporated in 1931 and in 1936 was reorganized as the Beaufor Mining Corporation, Limited. In 1939, the latter Company was amalgamated with the Cournor Mining Company, Limited.

The Beaufor orebodies are similar in type and mode of occurrence to those on the adjoining Perron property, described above. They were developed and mined from an inclined shaft sunk in 1932-34 to a depth of 450 feet, with lateral workings on three levels, and from the Perron No. 4 shaft which, by arrangement, had been put down on Beaufor ground. Production commenced in 1939, the ore being transported to the Cournor mill for treatment, and from then until 1942, when operations were suspended, some two-thirds of the gold produced in the Cournor mill (see p. 273) was from Beaufor ore (Bell and Bell, 1932, pp. 110-114; Bell, 1933 pp. 32-40).

Pascalis Gold Mines, Limited

Pascalis Gold Mines, Limited, incorporated in 1931, holds a large group of claims bounded on the north and west by, respectively, Perron and Beaufor (Cournor) ground and extending to north and south of the Pascalis-Louvicourt township line.

In recent years, work has been confined to the northwestern section of the property, into which the eastern margin of the Bourlamaque granodiorite batholith projects. Following extensive trenching and close to 40,000 feet of diamond drilling, a shaft was sunk here in 1940 to a depth of 1,565 feet, and from it levels were opened at 467, 667, 867, 1,067, 1,292, and 1,542 feet. Except for a granodiorite section between 120 and 490 feet, the shaft is in greenstone. Cross-cuts have been driven northwest from the shaft to the greenstone-granodiorite contact and, from this, westward through the granodiorite to the boundary of the property. The contact dips eastward, so that the width of granodiorite on Pascalis ground increases with depth. Most of the development has been on the four lower levels. Encouraging results were obtained in this exploration and plans to bring the mine into production were under consideration when wartime restrictions necessitated the suspension of operations at the end of April, 1942.

Earlier work had explored some gold-bearing quartz-tourmaline veins in Keewatin-type lavas on what were formerly known as the Cockshutt-McLeod claims. These are in the southern part of the property, about two and three-quarters of a mile east, and half a mile south, of the northwest corner of Louvicourt township. The occurrences were investigated by trenching and diamond drilling in 1931-32 by Noranda Mines, Limited. One vein zone, in fragmental volcanics, has been traced for a length of 500 feet, striking S.80°E. The vein walls are highly carbonatized and contain a considerable amount of pyrite, which is present, but less abundant, in the veins themselves. Visible gold is reported. Sampling over a length of 140 feet and a width of a foot and a half yielded assays averaging 0.30 oz. gold per ton. There is a similar, but apparently smaller, vein zone 1,200 feet to the south, in lavas of intermediate composition (Bell and Bell, 1932, pp. 116-117; Bell, 1933, pp. 44-47; Ann. Rept., Q.B.M., 1931, 1940, 1942).

COURNOR MINING COMPANY, LIMITED

The Cournor property is at the northwest corner of Louvicourt township, from which it extends eastward for about two and three-quarter miles, bounded on the north first by Beaufor (now Cournor) and then by Pascalis ground. It includes what were formerly known as the Bussières claims and, east of these, the claims of the Hoskings Mining Company. The western half of the property is occupied by granodiorite of the Bourlamaque batholith and the eastern half by Keewatin-type volcanics, the contact between these having a general north-south trend.

Gold-bearing veins on the old Bussières claims were investigated by surface work and diamond drilling in 1931 by the Treadwell Yukon Company. From 1932 until 1935, development and mining were carried on by the Bussières Mining Company, who sank a shaft to a depth of 677 feet, with lateral workings on four levels. The shaft is in granodiorite, about 500 feet west of its contact with the greenstones. A small mill was erected, and production started late in 1932. To March, 1935, when operations

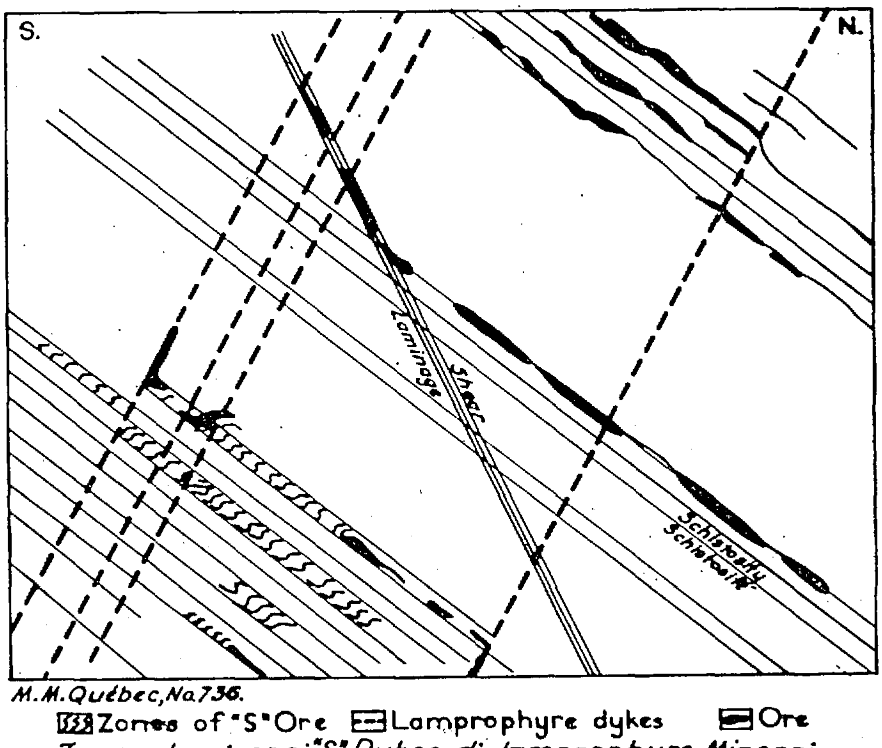


FIGURE 49.—*Cournor mine, diagram showing idealized cross-section of flat-dipping regular veins and zones of 'S' ore.*

were suspended, 100,949 tons of ore was treated with recovery of 15,711 ounces of gold, or 0.15 oz. per ton. In 1937, the property was acquired by the Cournor Mining Company, incorporated in that year, and operations were resumed, the shaft being deepened to 805 feet and a new level opened at 775 feet. In addition to mining of the orebodies in the vicinity of the shaft, a cross-cut was driven northward for some 2,500 feet on the 500-foot level to investigate gold-bearing veins in the vicinity of the granodiorite-greenstone contact that had been intersected in earlier diamond drilling. In 1939, Cournor acquired the Beaufor property, ore from which was thereafter treated in the Cournor mill. Owing to wartime difficulties, all operations were suspended in June, 1942. During this second period of operation, the mill produced 60,671 ounces of gold from 305,732 tons of ore treated, an average of 0.198 oz. per ton. About two-thirds of this gold was credited to ore from the Beaufor property.

The orebodies occur in the granodiorite. Underground work and diamond drilling have shown that the granodiorite-greenstone contact is 500 to 600 feet east of the shaft and that it has a general trend almost due north. No mineralization of economic interest has been found in the greenstone. Intruding both the granodiorite and the greenstone are aplitic dykes, believed to be genetically related to the main intrusive mass, and the granodiorite is also cut by later, sheared dykes which have been variously described as andesite, diorite, and lamprophyre. These are usually only a few feet wide, and some are lens-like. They strike N.70°-80°E. and dip southward at about 60°. For some distance westward from the contact, the granodiorite is much jointed and in places is traversed by poorly developed shear zones, striking N.65°E. and dipping northward at 45°. Close to the contact, this structure is more pronounced and the granodiorite is fairly schistose and strongly sheared.

Although the granodiorite-greenstone contact has a general northerly trend, in detail it is irregular, with granodiorite jutting into embayments in the greenstone. One such embayment has its head about 800 feet northeast of the shaft. It has a north-south length of some 1,500 feet and a depth of 500 feet. The ore zones in the shaft area are in the granodiorite near the south end of this embayment. There are two of these zones, designated the North and South ore zones, about 300 feet apart and each 100 to 250 feet wide. They strike N.60°-70°E., and the North zone has a known length of about 1,000 feet; the South zone is probably longer. The shaft is between them, some 600 feet and 300 feet, respectively, west of their eastern ends.

The orebodies in these two zones are chiefly lenses striking a few degrees north of east and dipping north at 20° to 30°. They have lengths of 50 to 300 feet along the strike and of 30 to 175 feet down the dip, and their thickness ranges from a few feet to 30 feet; one has a thickness of 80 feet. The lenses are irregularly superimposed one above another and form a relatively small proportion of the ore zone as a whole. In the two zones, more than forty of these bodies have been mined.

With these lens-like bodies are some regular veins. These occur in shear zones.

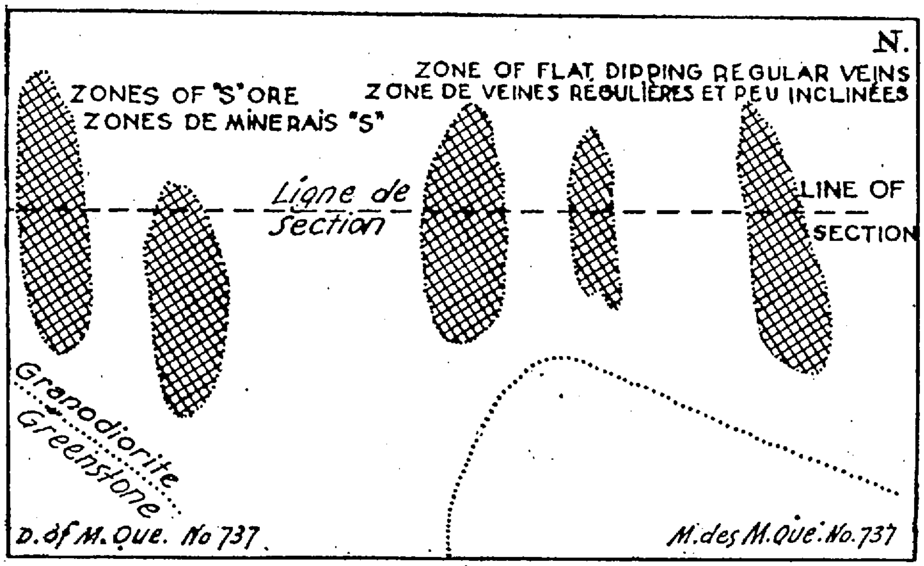


FIGURE 50.—*Cournor mine, diagram illustrating relationship of orebodies to irregularities in greenstone-granodiorite contact.*

The orebodies encountered in drifts from the north cross-cut, at points 1,500 and 2,500 feet north of the shaft, are similar in character and attitude to those mined in the shaft area.

The vein quartz in these bodies is white and vitreous and may not be all of the same age. With it may be associated a considerable amount of black tourmaline, apparently earlier than the quartz, some of it occurring as massive bands, upwards of an inch thick, parallel to the vein walls. Along these, and often along the quartz veins, the wall-rock is highly altered to carbonate, albite, and pyrite, and it is estimated that such wall-rock has contributed some 10 per cent of the gold output. The sulphide mineralization consists almost entirely of pyrite, some of which is very coarse, with cubes as much as one foot in diameter, and the highest gold assays have been obtained from such material. Elsewhere, the pyrite is in friable aggregates. For the most part, the gold is associated with the pyrite, as a film coating faces of the crystals or along fractures traversing them. However, visible gold occurs also in fractures in the quartz. A minor amount of chalcopyrite is associated with the pyrite; where much is present, the gold content of the ore is related to late fracturing which particularly affected the pyrite and vein quartz (Bell and Bell, 1932, pp. 98-104, 1935, pp. 357-358; Bell, 1933, pp. 19-28; F. C. Buckland, Mine Manager, personal communication, 1940).

OTHER GOLD OCCURRENCES IN VICINITY OF EAST MARGIN OF BOURLAMAQUE BATHOLITH

The contact between the eastern margin of the Bourlamaque batholith and the Keewatin-type volcanics to the east trends northward for about three miles in the northwest quarter of Louvicourt township and then crosses the southwest corner of Pascalis and continues into Senneville with trend west of north. The volcanics for several miles eastward from the batholith are intruded by a number of bodies of granodiorite, quartz diorite, and diorite which, probably, are genetically related to the main mass. Intensive prospecting and exploration along and eastward from the contact has resulted in the discovery of several gold-bearing occurrences of interest.

Senore Gold Mines, Limited, has done some surface work and diamond drilling on lot 2, range III, Pascalis township, and, about half a mile to the west, on lot 62, range III, Senneville, where gold-bearing veins were found in the Bourlamaque granodiorite near the east margin of the batholith. In Senneville township, the well defined shear zone in which the veins occur has been traced for a length of 600 feet, striking northwest and dipping 55 degrees southwest. In both occurrences, the mineralization is similar to that in the Perron orebodies, which are about one mile to the south. Gold assays of interest are reported (Ross *et al.*, p. 21).

Beaucourt Gold Mines, Limited, owns a group of claims extending eastward from the west boundary of Louvicourt township in ranges VII and VIII. The northern part of the property is underlain by granodiorite and the southern part by Keewatin-type volcanics, chiefly rhyolite breccia, the contact between the two trending east-west. During 1931-32, gold-bearing veins in the granodiorite were explored by LeRoy Gold Mines, Limited, who carried out extensive surface work and sank a shaft to a depth of 270 feet, with lateral work on two levels. Later work by Beaucourt Gold Mines included a considerable amount of diamond drilling.

The principal vein, known as the LeRoy vein, is some 200 feet north of the contact. It has been traced on the surface for a length of more than 600 feet, with the central section, for about 225 feet, striking east-west and the eastern and western portions about 30 degrees north of east. The dip is 60 degrees south. With maintenance of this dip, the vein would meet the contact at a depth of approximately 300 feet. At the west end of the vein, the granodiorite is intruded by a body of presumably related aplite and, at the surface, the vein splits into unimportant stringers where it enters this rock. On the 125-foot level, however, it continues completely across the body of aplite, which here has a width of 140 feet, but, in the granodiorite beyond, it is represented only by a fracture containing very little vein material.

Actually, the LeRoy vein is a zone of lenses and stringers of quartz averaging about three feet in width but with a range from twelve feet to a few narrow stringers. It and the wall-rock usually contain carbonate and some sericite. Sulphide mineralization consists of pyrite. The distribution of the gold is erratic, with visible gold by no means uncommon in both quartz and pyrite. A 60-foot length of the vein on the 125-foot level is reported to have averaged 0.368 oz. gold per ton across a width of 3⅓ feet.

Several other veins and mineralized shear zones, some in the granodiorite, others in the volcanics, have been investigated but, to date, none of these has proved of commercial interest (Bell and Bell, 1932, pp. 91-95; Bell, 1933, pp. 6-12; Denis, 1938, p. 3).

Louvicourt Mines, Limited.—This property adjoins Beaucourt on the east. The mineralization of chief interest occurs in granodiorite immediately north of its contact with Keewatin-type volcanics, chiefly rhyolite and rhyolite breccia. This is at the point where the trend of the margin of the Bourlamaque batholith changes abruptly from east to north. The rock here is foliated and in places strongly sheared. Along one of these shear zones, trending northeast, is a series of quartz lenses, rather closely spaced across a width up to thirty-five feet. Intermittent trenching has indicated that the zone has a length of at least 650 feet. Sulphide mineralization is widespread but erratic along the zone. It is chiefly pyrite, but some chalcopyrite is commonly present. Assays show that the gold content of the veins or lenses varies considerably from place to place. A sample of well mineralized quartz taken by L. V. Bell and assayed in the laboratory of the Quebec Department of Mines returned 0.21 oz. gold per ton, and a sample of the pyrite assayed 0.52 oz. per ton (Bell and Bell, 1931, pp. 95-97; Bell, 1933, pp. 12-15, 1937, p. 65).

Fleming Mines, Limited.—This Company holds a large group of claims extending eastward from the west boundary of Louvicourt township at and north of the centre line. The claims are underlain by Keewatin-type volcanics, chiefly rhyolitic lavas. These are intruded by a body of diorite, 9,000 feet long (east-west) and 1,000 feet wide. The lavas are now in large part represented by sericite schists, which strike N.80°E. and dip steeply to the north. Immediately north of the diorite, a strong zone of shearing in the volcanics is mineralized with pyrite and varying amounts of chalcopyrite. The zone has been explored by trenching and diamond drilling, but the results did not appear to justify underground development. A composite sample, made up of picked material, taken along a trench by L. V. Bell yielded an assay of 5.5 per cent copper and 0.80 oz. silver per ton.

Near the township boundary, a short distance south of the diorite body, five diamond-drill holes spaced over a distance of 1,100 feet intersected a zone of mineralization carrying 1 to 3 per cent copper across widths of ten to thirty feet (Bell, 1933, pp. 53-54; Denis, 1938, p. 3).

Louvre Gold Mines, Limited.—This property, formerly the Wyeth-Jowsey property, extends eastward from the north-south centre-line of Louvicourt township in ranges VI and VII. Intruding the volcanic rocks which underlie most of this part of the township is a mass of granodiorite about four miles long (east-west) and one mile wide. In 1931, gold-bearing veins were discovered in an east-west trending shear zone in the granodiorite near the west end of this mass, and between that year and 1939 they were investigated by various interests by surface trenching, a geophysical survey, and upwards of 25,000 feet of diamond drilling. The mineralized zone has been exposed along its strike for a length of 100 feet and has a maximum width of fifty feet, narrowing toward the east. Similar mineralization has been intersected in a drill hole 900 feet to the west along the projected strike of the zone. Where exposed, the zone contains veins of white, vitreous quartz, some carbonate, and rather abundant tourmaline, and is erratically mineralized with pyrite, often in massive, friable aggregates. Gold is associated with both the quartz and pyrite, but assays indicate that it is very unevenly distributed (Bell and Bell, 1932, pp. 97-98; Bell, 1933, pp. 15-19, 1937, p. 67; Denis, 1939, pp. 2-3).

Val d'Oro Mines, Limited.—During the years 1936 to 1940, this Company investigated a number of gold occurrences on their property, which extends eastward from the west boundary of Louvicourt township, immediately south of the centre-line and of the Fleming property. The underlying rocks are Keewatin-type volcanics, chiefly andesitic flows with some interbedded agglomerates and tuffs, intruded in places by stocks and dykes of diorite and porphyritic syenite. Sulphide mineralization, consisting of pyrrhotite, pyrite, and more rarely chalcopyrite, occurs along shear zones in the volcanics, striking N.70°E. Of the four principal zones investigated, two have been traced intermittently in trenches for lengths, respectively, of 2,500 feet and 1,800 feet. Gold assays ranging from negligible to 0.45 oz. per ton have been reported. One of the zones (No. 3) follows the north side of an 8-foot-wide dyke of quartz diorite porphyry, and, although material within the shear zone contains little gold, assays as high as 0.32 oz. per ton are reported from the mineralized dyke (Hawley, pp. 93-94; Ross *et al.*, pp. 23-24; Denis, 1939, p. 3; Ross and Asbury, p. 42).

Metcalfe Claims.—In 1932, some gold-bearing veins were discovered on claims held by G. E. Metcalfe and associates to the east of the Val d'Oro property. They occur in well defined fractures in quartz diorite, a small body of which intrudes the volcanic rocks by which the claims are chiefly underlain. One vein, about a foot wide, has been traced for a length of forty-five feet. It consists of white quartz, some carbonate, and bands of tourmaline parallel to the vein walls. Where best exposed in a shallow pit, the quartz is heavily mineralized with pyrite at a point where the main vein and a cross-fracture meet. In this pit, also, the vein is accompanied by flat dipping quartz lenses spaced at vertical intervals of about four feet. The lowest of these lenses, at the bottom of the pit, is well mineralized with pyrite, tetradymite (bismuth telluride), and minor amounts of chalcopyrite and pyrrhotite. Visible gold occurs in fractures in the quartz, usually in close association with the telluride (Bell, 1933, pp. 52-53).

Vicour Gold Mines, Limited.—The property of this Company extends eastward from the centre-line of Louvicourt township on either side of the east-west centre-line. On the north side it is bounded in part by the claims of Louvre Gold Mines.

Intruding the volcanics on the Vicour property is a body of sodic granite, or quartz diorite, with outcrop dimensions about one mile (east-west) by half a mile. A number of quartz veins and lenses have been found along fractures in the intrusive rock and have been investigated by extensive trenching and from a shaft sunk in 1935 to a depth of 150 feet. Later development included a magnetometer survey of the property, a considerable amount of diamond drilling, and lateral work underground on three levels, the shaft having been deepened in 1941 to 470 feet. All operations were suspended in 1942.

The veins consist of vitreous, white or slightly bluish, quartz, mineralized in places with pyrite and pyrrhotite. Rarely, arsenopyrite occurs in the wall-rock. Visible gold is not uncommon, but assays of vein material from the surface and mine workings, and from drill cores, indicate that the distribution of the gold is very erratic. A well mineralized sample taken from one of the veins by L. V. Bell assayed 0.34 oz. gold per ton.

In many places, the volcanic rocks on the property are highly carbonatized, mineralized with pyrite, and sheared, and contain gold-bearing quartz veins and stringers (Bell and Bell, 1932, pp. 119-120; Bell, 1933, pp. 48-52; Taschereau, 1936, p. 73).

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COURVILLE-PASCALIS-TIBLEMONT DISTRICT

General Note

Crossing these townships in a southeasterly direction and occupying the southern part of Courville, the northeast half of Pascalis, and about two-thirds of the width of Tiblemont, is a granitic mass, known as the Pascalis-Tiblemont batholith, which has intruded the Keewatin-type volcanics, chiefly 'greenstones', that otherwise occupy these and adjacent townships. It has a length of twenty-three miles and a north-south width of five to ten miles, except near its western end where it is much narrower and projects for a short distance into Fiedmont township. There are no producing mines in these townships, but gold and other metallic mineralization has been found at a number of localities, both in the volcanics and in the intrusive rocks, and a considerable amount of exploration has been carried out at some of these occurrences.

The batholith is a composite mass in which Bell and Bell (p. 29) have distinguished several facies, as follows, beginning with the earliest: (1) highly altered and sheared diorite or quartz diorite; (2) massive diorite; (3) soda granite; (4) lamprophyre dykes; and (5) feldspar porphyry and aplite dykes. Diorite is estimated to form about 7 per cent of the mass, chiefly in its central and southeastern part, in Tiblemont township.

The soda granite, which makes up some 90 per cent of the mass, is of two types, a highly siliceous facies in which the quartz commonly appears as opalescent 'eyes' and which is especially common in the northeast part of the batholith, and a rock containing less quartz, which is typical of the northwest part. Analyses of the highly siliceous rock indicate a potash-soda ratio of 1 to 3 or 4 (Bell and Bell, p. 27). This is in marked contrast to the Preissac-La Corne batholith, whose eastern end, in Fiedmont township, is close to the western end of the Pascalis-Tiblemont mass and in which the potash-soda ratio is about 1.5 to 1.0.

The lamprophyre dykes, which generally are highly altered, range in width from a few feet to upwards of 100 feet. They occupy fractures which have any of three trends—northwest, northeast, or (more rarely) north-south, and the same is true of the later feldspar porphyry and aplite dykes. The latter are most numerous in Tiblemont township.

The youngest intrusive rocks in the area are dykes of quartz diabase ('later gabbro'). Generally, they strike east of north, and some are traceable for several miles.

The strike of the volcanics, and also the trend of their schistosity, parallels, in general, the margin of the batholith, from which it may be concluded that the latter was intruded after the lavas were folded. Along contacts, the schistosity dips steeply away from the intrusive, which is thus considered to be a batholith and not a laccolith or sill (Bell and Bell, p. 35).

As already indicated, there are three main directions of fracturing and faulting in the district—northwest, northeast, and north-south. The major joint planes also have these trends, or, more rarely, east-west. In many places where gold or other metallic mineralization has been found, the fracturing of the rocks is irregular as if due to differential movement under stress along contacts between rocks of different degrees of competence.

In the several occurrences of metallic mineralization that have been investigated, gold is the only metal present in amount of possible economic interest. Generally, it occurs in quartz veins, with or without sulphides. The bismuth telluride, tetradymite, has been reported in some of these veins in northwest Tiblemont. Massive sulphide mineralization, with low gold tenor, has been found in some places. In most such occurrences, the sulphide is pyrite, but in some there are minor amounts of chalcopyrite or sphalerite.

FIEDMONT TOWNSHIP

Swanson Claims

The only occurrence of metallic mineralization in Fiedmont township on which any appreciable amount of exploration work has been carried out is on the Swanson claims, on lots 56 and 57, range V, a short distance west of the margin of the Pascalis-Tiblemont batholith. A pit, twenty feet wide, has exposed a flat-lying lens, two feet wide, of massive sphalerite, with minor pyrite, in Keewatin-type mica schists and phyllites which are themselves well mineralized with these sulphides. Several barren quartz stringers, averaging six inches wide, are exposed in the centre of the pit. A grab sample of the massive sulphides, taken by S. H. Ross, gave a high assay in gold and contained 45.8 per cent zinc. Trenching in the vicinity of the pit has exposed a number of shear zones, striking N.10°E., along which the greenstones are mineralized with disseminated pyrite, and some of these zones have been explored at depth by diamond drilling. Assay of a grab sample taken by Ross from one of the trenches showed only a 'trace' of gold (Ross *et al.*, 1940, p. 30).

COURVILLE TOWNSHIP

Granitic rocks of the Pascalis-Tiblemont batholith occupy the southern part of Courville township, with the northern two-thirds or more underlain by Keewatin-type volcanics. Drift cover is extensive and only locally are outcrops at all numerous.

Quartz veins or lenses mineralized with pyrite, and some with minor amounts of chalcopyrite, have been found in several places, but assays indicate that their gold content is, in general, negligible. These veins are chiefly in the volcanics, particularly in the vicinity of dykes, small granitic bosses, or the main batholith, but some are within the intrusive rocks. Locations of some of the principal occurrences on which there has been a limited amount of surface exploration are, from north to south: lot 43, range X; lot 16 and lots 50 and 51, range IX; at the north-south centre line, ranges VI and VII; lots 36 and 37, and lot 50, range V; and lot 38, range IV (Bell and Bell, pp. 65-69; Ross *et al.*, 1938, p. 21; Ross and Asbury, p. 41).

PASCALIS TOWNSHIP

The northeast half of Pascalis township is underlain by granitic rocks of the Pascalis-Tiblemont batholith, the contact between which and the Keewatin-type rocks to the west and south has a fairly straight trend from the northwest to the southeast corner of the township. The Bourlamaque batholith projects for a short distance into the township at its southwest corner and the ground in this vicinity forms part of the Perron, Cournor (Beaufort), and Pascalis properties, described on pages 267-274. Exploration elsewhere in the township has so far failed to reveal gold or other mineralization of importance. Following are brief descriptions of occurrences which have been investigated by a limited amount of surface work.

Block A, Northwest Corner of Pascalis Township (Byck Claims).—Traversing an outcrop of massive soda-granite is a quartz vein, averaging eight inches in width, which has been traced for a length of 115 feet. The quartz is accompanied by some carbonate, sericite, and chlorite, but carries no metallic minerals (Bell and Bell, p. 57).

Two Miles East of Landing Lake, S.W. Quarter of Township.—In altered, schistose volcanics close to the margin of the Pascalis-Tiblemont batholith, a mineralized quartz vein or series of lenses striking N.50°W., parallel to the bounding schists, has been traced for a length of sixty feet. Toward the northwest, two lenses, 24 and 16 inches wide, lie within a zone four and a half feet wide. The quartz is white and cherty, and is well mineralized with pyrite, with which a very minor amount of sphalerite is in places associated. Assays of grab samples indicate only a 'trace' of gold.

East Boundary of Township, just North of Centre Line.—At a point about 1,000 feet northwest of the southern extremity of a prominent point on the west shore of Tiblemont lake, the soda granite of the batholith is cut by a series of quartz veins which average about two inches in width. Some surface work has been done here, but apparently the veins carry no gold or other mineralization (Bell and Bell, p. 56).

Southeast Corner of Township (Carroll-Meen Pascalis Syndicate).—Extensive trenching and shallow blasting was carried out in 1932 to investigate a large sulphide body in light-coloured masses and dykes of rhyolite or rhyolite porphyry which intrude the volcanic rocks about one mile south of the Pascalis-Tiblemont batholith. The locality is just south of the portage from Bell river to the southeast bay of Tiblemont lake and the sulphide mineralization extends eastward from Pascalis into the adjoining townships of Tiblemont and Vauquelin.

The sulphides occur chiefly in a mass of rhyolite which has a probable width, north-south, of 250 feet and has been traced for a length of 760 feet. The rhyolite has been intensely altered and replaced by carbonate, sericite, quartz, and pyrite, and some sections of the mass over widths from 15 to 50 feet consist entirely of massive pyrite and quartz with, usually, pyrrhotite and, in places, chalcopyrite. There are also a few quartz lenses, the largest observed being 3½ feet wide with exposed length of 25 feet. Sampling has indicated that the gold content of the massive sulphides is low. Two samples taken across 8-foot sections are reported to have assayed 0.20 oz. gold per ton (A. M. Bell, 1933, pp. 86-87).

Some work has been done on occurrences of gold-bearing mineralization to the southeast of Landing lake (Leo Springer claims) and on the McIvor and Sinclair claims in the southeast quarter of the township a short distance west of the large bay in Tiblemont lake (L. V. Bell, 1933, pp. 57-58); and on lots 42 and 43, range IX of Pascalis township (Bell and Bell, p. 57).

TIBLEMONT TOWNSHIP

Broadly, the southwest two-thirds of Tiblemont township is occupied by granitic rocks of the Pascalis-Tiblemont batholith, with Keewatin-type volcanics beyond these to the north and east, The contact between the granite and volcanics extends south of east from near the northwest corner across nearly three-quarters of the width of the township and there turns abruptly south and continues with irregular contour to a short distance beyond the south boundary. The relatively narrow, northerly trending Tiblemont lake lies within the granitic rocks at or adjacent to the west boundary of the township from near its south to, and slightly beyond, its north limit.

Gold mineralization has been found within and near the granitic rocks of the batholith in several localities and particularly in the northwest corner of the township, on Tiblemont island and adjacent to the lake shore. Further south, some surface work has been done on occurrences east of Fish lake, which lies within the batholith somewhat south of the centre of the township, and on others, still farther east, near Pine lake, at the granite-volcanic contact.

Smith-Tiblemont Mines, Limited

The property of this Company is adjacent to the east shore of Tiblemont lake, at the extreme north of the township. It is underlain by Keewatin-type greenstones which are intruded by a small stock of soda-granite, evidently an outlier of the main batholith, whose northern margin is about one mile to the south. Lamprophyre dykes, in turn, cut the granite. Most of them strike S.70°E., which is about parallel to the folding of the volcanics and to the contact of these with the main batholith; others have a more southerly strike, ranging from south 40° to 60° east.

In 1933, gold-bearing quartz veins were found here, lying within shear zones in the granite stock. One of these zones was exposed by trenching for a length of 175 feet. It has a width of three feet and centrally within it is a quartz vein from two to six inches wide. Free gold occurs in the quartz but not, apparently, in the adjacent sheared granite. Two nearby trenches exposed quartz veins, twelve inches wide, flanked on either side by twelve to eighteen inches of sulphides. A grab sample taken from one of these by Bell assayed 1.2 oz. gold per ton. Gold-bearing quartz stringers and sulphides are found also in the wall-rock of some of the lamprophyre dykes.

In addition to surface work, some diamond drilling was carried out on the property by the Consolidated Mining and Smelting Company of Canada, and in 1936 the Smith Tiblemont company sank a shaft to a depth of 170 feet and did some lateral work on the 150-foot level. A cross-cut north from the shaft intersected several steeply dipping east-west shear zones. Drifting along one of these for a length of 270 feet is reported to have disclosed mineralized vein matter which, for a length of 75 feet and a width of 2½ feet, carried an average of 0.23 oz. gold per ton (Bell and Bell, pp. 51-53; Bell, L. V., 1937, p. 78).

Tiblemont Consolidated Mines, Limited

This Company was incorporated in 1938, succeeding the Tiblemont Island Mining Company, Limited. The property includes the whole of Tiblemont island, near the north end of the lake of that name. The northern two-fifths of the island, which is two miles long in a north-northeast direction, is underlain by Keewatin-type volcanics, the remainder by granitic rocks of the Pascalis-Tiblemont batholith. These latter are chiefly soda granite, but dioritic facies are present and within the mass are patches of sheared chloritic rock which may be inclusions of altered volcanics. Near the east side of the island, the granite is cut by a north-northeasterly striking dyke of quartz diorite. All the mineralized bodies of interest lie within the granite to the east of this dyke.

Gold mineralization was first discovered on the island in the winter of 1932-33, and exploration and development has continued almost without interruption since that time. Besides extensive surface work, this has included a very considerable footage of diamond drilling, the driving of an adit 1,180 feet long, and the sinking of a shaft, completed in 1935, to a depth of 515 feet with lateral work on four levels but chiefly at the 500-foot horizon. The shaft reaches the adit at the 100-foot level. A 50-ton mill was erected and it operated for a time testing the grade of bulk samples.

The principal gold-bearing veins are in the granite about half a mile south of its contact with the volcanics and immediately south of a large, schistose, chloritic inclusion. They strike N.75°-90°W. and dip 60° to 80° north. A few minor stringers strike north-south, and some are almost flat-lying. Individual veins are lenticular, with maximum width ranging from six to twelve inches.

Fine and coarse gold may be seen in the veins in many places and particularly at and near vein intersections. Pyrite, chalcopyrite, and rarely tetradymite (telluride of bismuth), are also present in the quartz. These sulphides, and also very minor amounts of molybdenite, occur in the granite wall-rock. It is reported that some gold is associated with the sulphides in the quartz but apparently not with those in the wall-rock (Bell and Bell, pp. 49-50; L. V. Bell, 1937, p. 76).

Wahu Mines, Limited

This property is at about the centre of the north half of Tiblemont township, one mile east of Tiblemont lake. Gold-bearing veins were discovered here in 1932, at which time the group of claims was known as the Wood-Etcheverry property, and in that and the following year the occurrences were investigated by Hollinger Consolidated Gold Mines, who did a considerable amount of rock trenching and shallow diamond-drilling as well as sampling. In 1934, Murwood Gold Mines, Limited, was organized to develop the property. A shaft was sunk to a depth of 117 feet and some lateral work was done on the 100-foot level. The results, however, were less encouraging than those obtained in the surface trenching. About a year later, the property was acquired by Lakman Gold Mines, Limited, who in turn leased it to Wahu Mines, Limited. In 1936, the latter Company installed a 35-ton mill in which they treated some of the gold-bearing material that had been blasted out by the Hollinger company. Operations were suspended at the end of that year.

The gold-bearing veins form a stockwork in granite of the Pascalis-Tiblemont batholith about 1,700 feet from its northern margin. Immediately to the south of the veins is a mass of Keewatin-type volcanics whose contact with the granite has an east-west trend. Drilling indicates that this is a relatively thin roof-pendant overlying the granite, and presumably it was at one time continuous northward to the main body of volcanics.

The fractures occupied by the quartz veins have various trends, with the most prominent striking N.45°E. and N.60°E. Some fractures with trend N.75°W. are not filled with quartz, and these offset some of the quartz veins. The veining has been exposed over a length of 300 feet in a series of eleven cross-trenches. The five most westerly trenches have exposed an irregular, northeast trending, zone of quartz veins for a length of 120 feet and a width of 60 feet, in which quartz makes up about 40 per cent of the material as a whole. This is known as the 'main' zone. Drilling indicated that, at a depth of sixty feet, quartz is in much lesser amount, suggesting that the stockwork is relatively flat-dipping and that it passes beneath the greenstone roof-pendant to the south. What is known as the 'base line' zone joins the main zone at its west end. It has been exposed at intervals for a length of 180 feet, striking N.60°E., and consists of a quartz vein, two to five feet wide. It has a vertical dip and was intersected in diamond-drill holes at a depth of 75 feet. Numerous other quartz veins and stringers were exposed elsewhere in the trenching but they are widely spaced and nowhere make up as much as 10 per cent of the rock exposed.

The gold is confined to the quartz and is in places accompanied by pyrite, pyrrhotite, and chalcopyrite. Channel sampling of the 'base line' zone by the Hollinger company indicated that the quartz carries an average of 0.195 oz. gold per ton. Owing, however, to the coarse nature of the gold and to the irregular distribution of the quartz, reliable sampling is difficult (Bell and Bell, pp. 44-48; L. V. Bell, 1937, p. 78).

South Tiblemont Mining Company, Limited

The property of this Company is in the south part of Tiblemont township, about half a mile east of the south end of Fish lake. It is underlain by granitic rocks of the Pascalis-Tiblemont batholith. In 1933, gold-bearing quartz veins were discovered within sheared zones in the granite. These were explored in a series of trenches and later by diamond drilling and from a shaft 240 feet deep with levels at 125 and 225 feet. Operations were suspended in 1935.

The trenching exposed two northeasterly trending zones of quartz veins. No. 1 zone, which was traced for a length of 175 feet, consists of a series of parallel quartz stringers and veins up to fifteen inches wide, spaced across a width of ten to fifteen feet of the sheared granite. No. 2 zone, commencing seventy feet east of the northern end of No. 1, is a quartz vein, three to fifteen inches wide, with accompanying stringers; it was traced for a length of 240 feet. Besides gold, the quartz contains minor amounts of pyrite, sphalerite, and tetradymite (Bell and Bell, pp. 58-60; Taschereau, p. 120).

On the *Martyn-Sweet claims*, about a mile north of the South Tiblemont property, quartz veins in the granite contain both gold and galena (Bell and Bell, p. 60). East of here, on the *Chaput claims*, the granite is traversed by a number of quartz veins and stringers, the most important of which is a vein eighteen to twenty-four inches wide which has been exposed for a length of 350 feet, striking N.25°E. Although small specks of gold were seen in this vein, the results of extensive sampling at 10-foot intervals were disappointing (Ross and Asbury, pp. 44-45).

Blairdon Gold Mines, Limited

The property of this Company, formerly known as the Blair-Martyn property, is immediately south of Pine lake, in the southeast quarter of Tiblemont township. This lake, little more than half a mile long, lies at the eastern margin of the Pascalis-Tiblemont batholith. The contact between the latter and the volcanics to the east passes just within the northeast and southeast corners of the property, which otherwise is underlain by granitic rocks.

Gold-bearing quartz veins occur within fracture zones in the granite at a point about 2,100 feet south of the lake. Hayes Cadillac Mines, under an option held jointly with Capital-Rouyn Gold Mines, investigated the occurrences by extensive test pitting and bulk sampling and by a small amount of lateral work from a shaft 100 feet deep. This work was suspended in the fall of 1938. Later, the property was acquired by Blairdon Gold Mines, who carried out some 3,000 feet of diamond drilling in 1944.

There are two main veins, or vein zones, on the property. No. 1 zone consists of two nearly adjacent, parallel quartz veins which strike N.25°E. and dip 80° southeast. It has been traced for upwards of 200 feet, over which the combined vein width increases, going northward, from nine inches to fourteen inches. At its northern end it joins No. 2 vein, which strikes N.60°E. and dips northwest. This has a length of 85 feet and average width of sixteen inches, but the fracture zone in which it occurs has been traced for more than 1,000 feet and contains intermittent lenses and veinlets of quartz.

The gold occurs in the quartz in the free state and is accompanied in places by very minor amounts of pyrite, chalcopyrite, and galena. Bulk sampling of material from thirteen test pits is reported to have indicated that No. 1 vein averaged 0.45 oz. gold per ton across a width of 15 inches for a length of 255 feet, and No. 2 vein 0.48 oz. across 15½ inches for a length of 55 feet, with one bulk sample from the latter vein returning 1.68

oz. per ton. In the shaft, and in the workings at the 100-foot level, however, the veins were found to be relatively narrow and their gold content much lower than at the surface. A number of other veins have been found on the property, some of them richly sprinkled with free gold, but they are all of very limited extent (Taschereau and Herring, p. 93; Ross and Asbury, pp. 43-44; Lafontaine, p. 118).

MECCA GOLD MINES, LIMITED

At some time prior to 1933, Mecca Gold Mines investigated some occurrences of sulphide and gold mineralization on a group of claims in the southwest quarter of Tiblemont township. The claims, at that time held by Paul Croteau, are underlain by soda granite of the Pascalis-Tiblemont batholith through which are distributed large, irregular masses of an older, altered diorite. Trenching has exposed rusty-weathering sulphide replacement zones in the diorite at several places, but such assays as have been reported indicate that these carry little or no gold. Quartz veins averaging six inches in width also occur in fractures in the granite, and in one of these visible gold has been reported (Bell and Bell, p. 61).

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SOUTHEAST END OF THE ROUYN-BELL RIVER AREA

General Note

One hundred and thirty miles from the Quebec-Ontario boundary, the Rouyn-Bell River belt of volcanic and sedimentary rocks terminates near the east boundary of Juric and Haig townships. Here, on its north side, it is flanked by granite, which extends far to the northeast. Along a fairly straight line southwestward from near the northeast corner of Haig township to about the east-west centre-line of Fréville, it terminates against gneiss of Grenville type which stretches far to the east and southeast. The relative positions of the townships mentioned, and of others adjacent to them, are as follows:

Tiblemont	Tavernier	Juric
Vauquelin	Pershing	Haig
Villebon	Denain	
Fréville		

Keewatin-type volcanic rocks form the northern part of the belt and they predominate across its entire width. The relatively wide band of Temiscamian-type sediments which, farther west, flanks the volcanics on the south, appears here only as a very narrow zone between these and the gneiss, but in Pershing and Villebon townships tongues from this zone extend westward into the volcanics. The volcanic rocks are chiefly 'greenstones' of intermediate composition. The sediments are for the most part greywacke, but they include beds of conglomerate, arkose, and some slate.

The rocks of the belt are intruded by two granitic masses. The larger of these occupies much of the southwestern part of Pershing township and the east-central part of Vauquelin. It has a length, east-west, of about thirteen miles and averages five miles in width. This Vauquelin-Pershing batholith is flanked on the south by volcanics and on the north and east by sediments. Like the Pascalis-Tiblemont mass, adjacent on the northwest, it is a composite body due to successive intrusions of material grading from diorite, or even gabbro, to granodiorite and soda granite. Acidic dykes, some of them porphyritic, cut the mass and the adjacent rocks. The connected Guéguen and Vauquelin lakes lie at the western end of the mass, and Pershing (Matchi Manitou) lake at the eastern end.

The other granitic body, elliptical in outcrop, with north-south length of seven miles and width three and a half miles, is in the western part of Villebon and Fréville townships and is flanked by volcanic rocks. The township line passes centrally across the body.

'Later gabbro' dykes occur in various parts of the district but are not numerous. They all contain a little quartz and some have a distinctly diabasic texture.

The regional strike of the volcanics and sediments is S.80°E., and dips are steep to vertical. The regional schistosity has a similar strike and dip. The volcanics south of the Vauquelin-Pershing batholith, and the sediments still farther south, all face southward, indicating that this batholith is in an anticlinal structure.

There are no producing mines in these townships, but numerous occurrences of gold mineralization are known and have been investigated, particularly in Vauquelin and Pershing townships, within and adjacent to the granitic batholith. There is reason to believe that the regional structural features that have localized commercial orebodies within the belt farther west find some expression here, though modified by local structures and controlled by the termination of the volcanic and sedimentary rocks against the great eastern area of granites and gneisses, in which no gold has yet been found.

TAVERNIER TOWNSHIP

The northern margin of the Rouyn-Bell River belt passes within the northeast corner of Tavernier township, which is occupied by granite. Elsewhere, the township is underlain by Keewatin-type volcanic rocks of the belt, intruded in places by diorite and porphyry dykes.

Clark and McHoull Claims

Gold-bearing quartz veins and lenses were found on these claims in 1933 at a point about three miles south and two and a half miles east of the northwest corner of the township. They occur in and along the walls of a porphyry dyke, five to ten feet wide, which cuts sheared greenstones. The largest lens exposed is one foot wide and forty feet long. Some of the veins and lenses contain visible gold. A zone of iron sulphides follows a branch of the dyke eastward from the quartz veins (Bell and Bell, 1934, p. 71).

Lacoma Gold Mines, Limited

On this property, which is at the southeast corner of the township, a zone of gold and sulphide mineralization in sheared, carbonatized, and silicified greenstone has been investigated by extensive trenching, some 3,000 feet of diamond drilling, and from a shaft 263 feet deep with a small amount of lateral work on levels at 125 and 250 feet. Most of this work was done during 1933 and 1934, but some drilling and underground work was carried out in 1940 by the Inspiration Mining and Development Company, who held an option on the property. The shaft is about three-quarters of a mile northwest of the southeast corner of the township.

The trenching exposed a zone, 1,000 or more feet long with maximum width of 150 feet, along which the greenstone contains masses of silicified carbonate rock carrying veins and lenses of gold-bearing quartz and pyrite. The schistosity of the greenstone strikes east-west, but in places at least the carbonatized zone has a trend some 20° north of west. About 500 feet to the north, the greenstones are intruded by a dyke or elongated mass of diorite, 800 feet wide. There are similar, but narrower, carbonatized and mineralized zones 150 feet to the north, and 300 feet to the south, of the main zone.

The quartz is usually white in colour, and some of the veins and lenses contain tourmaline. They are very irregularly distributed along the zone, and generally, where they are plentiful, the intervening rock is heavily mineralized with pyrite. Visible gold has been reported in the quartz.

Assays indicate that, while gold is distributed over considerable widths of the zone, it is very erratic in its occurrence, both across and along the strike. Channel sampling in trenches and assays of drill cores, as reported by the Company, indicate a gold content, over widths ranging up to twenty feet or so, of 0.05 oz. to 0.40 oz. per ton (A. M. Bell, pp. 79-83).

Eastward, along the projected strike of this zone, similar mineralization has been uncovered in the northwest corner of the adjoining Haig township (A. M. Bell, p. 84).

JURIE TOWNSHIP

The contact between the volcanic rocks of the Rouyn-Bell River belt and the granite that flanks them on the north crosses the northern part of the township with easterly trend nearly to the east boundary, where it swings sharply southward into Haig township. This marks the extreme east end of the belt. Throughout the township, drift and muskeg deposits are extensive.

Some surface work has been done on claims about four miles from the southwest corner of the township where, on the east side of a rocky hill, carbonatized and pyritized volcanics, striking N.35°W., are traversed by quartz veins, two of which are 20 inches and 6 inches wide. A grab sample taken by A. M. Bell from the wider of these veins gave a negative assay for gold (A. M. Bell, p. 78, p. 86).

VAUQUELIN TOWNSHIP

The western half of the Vauquelin-Pershing batholith occupies much of the central and eastern part of the township. On the north it is flanked by a narrow zone of Temiscamian-type sediments, which extends completely across the township. A narrow width of similar rocks appears at the south boundary. At the north, granitic rocks of the Pascalis-Tiblemont batholith extend for a short distance into the township. Elsewhere, the rocks are all Keewatin-type volcanics, intruded in places by bosses and dykes of porphyry and diorite.

Gold mineralization has been found at numerous localities in the township and in rocks of all the types represented, but particularly in and near bosses of porphyry and the granitic rocks of the batholith.

Wisewill Gold Mines, Limited

This property is near the northwest corner of Vauquelin township, west of Bell river. A narrow east-west band of Temiscamian-type sediments passes centrally across the claims, flanked on the north and south by volcanics. These rocks are intruded by a boss of hornblendite and also by feldspar porphyry.

Quartz veins lying within an intensely carbonatized shear zone in the porphyry, striking N.25°W., contain pyrite and nests of galena and chalcopyrite. Farther north, trenching has exposed mineralized shear zones in a body of hornblendite that intrudes the sediments (Tolman, p. 22).

BRUELL GOLD MINES, LIMITED

This property, formerly known as the Spencer and Burton claims, is near the north boundary of the township, extending eastward from Bell river. It is underlain by volcanic rocks, chiefly andesitic, which are intruded by a body of quartz-albite porphyry estimated, from scattered outcrops, to have a length, east-west, of 4,500 feet and a width of 1,000 feet. Paralleling it are a number of dykes of similar porphyry and also later diorite dykes.

The gold mineralization occurs in the volcanics, and is of two types: (1) lens-like veins of quartz, which usually contain tourmaline and a little pyrite; and (2) carbonatized and silicified shear zones.

The most important of the lens-like veins occurs in the greenstones to the west of the porphyry body and has been exposed intermittently along its east-west strike for a length of several hundred feet. For part of its length it is followed closely by a narrow porphyry dyke. Native gold, some of it quite coarse, is reported to have been found in the quartz at a number of points. In addition to trenching, a shaft 45 feet deep was sunk on the vein and it was explored also by diamond drilling.

The main shear-zone type of mineralization occurs in a swamp area and has been explored chiefly by diamond drilling and also in a shaft 85 feet deep, which is 1,500 feet east of the 45-foot shaft. This zone has been intersected in drill holes variously spaced along its strike over a distance of 3,000 feet. It appears to have a width of many tens of feet, across which the rock is heavily carbonatized, more or less silicified, and contains pyrite and quartz-tourmaline lenses (Tolman, pp. 16-18).

QUEBEC EUREKA MINES, LIMITED

In 1938, this Company put down two diamond drill holes on a claim immediately north of the Bruell property to intersect a fracture zone in massive andesite which contains lenses of quartz accompanied by tourmaline, chlorite, and very minor pyrite. The fracture strikes N.80°W. (Tolman, p. 22).

AURORA MINES, LIMITED

In 1938, this Company acquired the claims formerly held by the Avocalon Mining Syndicate, which extend eastward from Bell river and lie immediately south of the Bruell property. The claims are traversed centrally by an east-west trending belt, about 2,500 feet wide, of Temiscamian-type sediments, to north and south of which are volcanics. The boss of quartz-albite porphyry referred to in describing the Bruell property projects into one of the most northerly claims.

Work on the property has been concentrated chiefly in the area immediately south of the porphyry boss. In addition to trenching and a geophysical survey, the ground has been explored by diamond-drilling and from a shaft, 120 feet deep, with about 900 feet of lateral work on the 100-foot level. The shaft is half a mile east of the 85-foot shaft on the Bruell property. It is in an area of andesitic lavas cut by east-west dykes and irregular masses of porphyry which, doubtless, are genetically related to the porphyry boss, whose southern margin is only 500 feet or so north of the shaft. As on the Bruell property, the mineralization occurs in quartz-tourmaline veins which contain minor pyrite. Visible gold has been reported at a number of points, both on the surface and underground.

North of the shaft some 125 feet, and again at 250 feet, test-pitting has exposed carbonatized greenstone sheared over a maximum width of twelve feet and traversed by stringers of quartz containing a little pyrite. In both occurrences, the shearing follows the south side of a porphyry dyke. Narrow bands of similarly mineralized rock are exposed 100 feet, and 340 feet, east of the shaft (Tolman, pp. 18-20).

Consolidated Mining and Smelting Company of Canada, Limited

In 1938, the Consolidated Mining and Smelting Company of Canada carried out systematic prospecting and trenching on Portage island, at the head of the southwest bay of Guéguen lake, in the southwest quarter of Vauquelin township. The island is underlain by volcanic rocks except for small areas at the north and on the east side, which are occupied by granitic rocks of the Vauquelin-Pershing batholith (Tolman, p. 22).

Russian Kid Group

This is a large group of claims extending southward from the west bay of Guéguen lake. They are chiefly in range IV of Vauquelin township and from half a mile to one mile west of its centre line. The contact between the granitic rocks of the Vauquelin-Pershing batholith and the Keewatin-type volcanics of the belt crosses the claim group with general southeasterly trend, so that the southwest part of the group is underlain by volcanic rocks and the north and northeastern part by intrusive rocks of the batholith, which are here largely an early, dioritic facies. Intruding both are granitic dykes. The claims were first staked in 1924 and surface work and diamond drilling in subsequent years has revealed a number of occurrences of gold, copper, and zinc mineralization and also one of native silver, which hitherto has been encountered very rarely in the Province.

Two parallel zones of mineralization in the intrusive rock have been exposed a short distance south of range-line IV-V and about two-thirds of a mile west of the centre line of Vauquelin township. They are 200 feet apart, striking N.50°W. The intrusive rock here is diorite with much injected granitic material, and along both zones it contains numerous milky quartz veins over widths up to fifteen feet. The veins contain some pyrite, but where present this mineral is chiefly disseminated through the country rock. The gold is reported to occur with the pyrite rather than with the quartz.

About 2,000 feet northwest of this occurrence, a zone of shearing two feet wide in highly altered basic rock has been exposed for a length of about 140 feet. It is mineralized with sphalerite, chalcopyrite, and a little pyrite which usually are present as small, discontinuous veins in shears and fractures but in places appear as massive sulphides up to three inches wide. The heaviest mineralization is at the west end of the exposure, where it passes under swamp.

Farther south, in the south part of range IV, five or six pronounced northwesterly trending shear zones in the greenstones have been uncovered. In one of these, 2,300 feet north of range-line III-IV and one mile west of the centre-line of the township, trenching has exposed a vein, about two inches wide, of sphalerite accompanied by a little pyrite, chalcopyrite, and native silver. Native silver is found also along adjoining fractures in the greenstone. The length of the vein is only fifteen feet. Although the rock around it has been stripped clean, there is no indication of further extension of the vein.

About 400 feet north of this silver-bearing vein, a considerable amount of stripping and test-pitting has been done along east-west shear zones in the greenstone which contain quartz and carbonate and are mineralized with a little pyrite and chalcopyrite. Samples from these occurrences are reported to have returned high assays in gold. Three samples taken by Tolman gave assays of 0.022, 0.305, and 0.020 oz. gold per ton (Tolman, pp. 20-21).

NUBELL GOLD MINES, LIMITED

The claims of this Company are at the southwest end of Simon lake from which they extend westward across the Vauquelin-Louvicourt boundary in the north part of range III and the south part of range IV. The northern claims are underlain by Keewatin-type volcanics, chiefly andesite and rhyolite, the southern ones by diorite breccia. The contact between these has an east-west trend, which is also the regional strike of the volcanics. Cutting these rocks are feldspar porphyry and quartz porphyry dykes, up to thirty feet wide.

Gold-bearing veins and lenses have been found at several points on the claims in shear zones in the volcanics and also in porphyry dykes. These have been investigated by a considerable amount of surface work and some diamond drilling. Low gold assays over substantial widths are reported from some of the occurrences (Ross *et al.*, 1938, p. 24; Tolman, p. 22).

MANIWAKI MINES, LIMITED

This property is in range III of Vauquelin township, one mile south of the southwest bay of Guéguen lake, and extends westward from the centre-line of the township for two and a half miles. It was first staked by the McDonough Mining Syndicate in 1936 and in the following year was taken over by Maniwaki Mines, who carried out surface exploration and diamond drilling until late in 1938. The property was later acquired by Playsafe Mines, Limited, since 1945 held by Simon Lake Mines.

The claims are underlain by volcanic rocks, which have a general east-west strike. Gold mineralization occurs in a band of coarse tuff which contains sparsely distributed, relatively large fragments of andesite or diorite. This has been completely stripped of overburden for a length of 300 feet and over a width of 30 to 75 feet. The stripping has exposed a conspicuous fracture within the tuffs, striking S.83°W. with dip 55° south, extending continuously for some 200 feet, and, paralleling this on the south at a distance of about 30 feet, a lens-like body of syenite porphyry up to

15 feet wide. The fracture is mineralized over a maximum width of two feet with quartz, plentiful tourmaline, sparsely distributed pyrite, and a little chalcopyrite, sphalerite, and ankerite. Adjacent to its hanging-wall side are intersecting fractures containing narrow lenses of quartz with variable amounts of tourmaline, and there are also later, narrow, cross-fractures containing stringers of quartz with no tourmaline.

Relatively coarse visible gold was found in some of the narrow cross-fractures, and material from the wider cross-fractures and from the main fracture also returned assays for gold. The best results were obtained from bulk sampling at depths between eight and ten feet in a pit at the east end of the stripping. Bulk sampling of material from two other pits, farther to the west, and from a number of places along the fracture, is reported to have given erratic results. In the pits, there appears to be a decrease in quartz with depth, and shallow diamond drilling in thirty holes failed to reveal gold mineralization of interest (Tolman, pp. 11-14).

LeBlancq Group

This group of claims, known also as the Blue Grass option, lies immediately south of the Maniwaki property and is adjoined on the east by that of Quemartic Mines. A band of Temiscamian-type sediments, about 1,500 feet wide, extends eastward across the southern part of the property, flanked to north and south by volcanic rocks. Gold mineralization in shear zones in the sediments has been investigated by extensive trenching, test pitting, and some diamond drilling, much of which was carried out by the Consolidated Mining and Smelting Company of Canada prior to 1938. In that year, some further work was done by Raymond Tiblemont Gold Mines, who held an option on the property.

The sedimentary rocks are chiefly greywacke, largely altered to mica and hornblende schists, with occasional beds of conglomerate and slate. Gradation of grain indicates that the tops of the beds face south, but their dip, which is steep, is generally to the north. The original gold discovery was in a shear zone, five to six feet wide, in schistose greywacke, in which the shearing strikes N.85°W. and dips 75° north, about paralleling the bedding planes of the sediments. Where exposed in a pit near the east end of the trenched area, the rock is carbonatized, sericitized, and mineralized with fine to coarse arsenopyrite and pyrite. Free gold was found in the material in the pit, and samples taken here and in nearby trenches gave assays for gold. Five diamond-drill holes were put down along the zone, spaced over a distance of 750 feet, but gold assays of interest were obtained in only one of the cores.

Native gold was found also in a similarly mineralized shear zone, 30 feet wide, in greywacke exposed in a trench 800 feet northwest of the pit, but three diamond-drill holes put down to test this zone at depth failed to disclose appreciable gold mineralization (Tolman, pp. 14-15).

Quemartic Mines, Limited

This property adjoins the LeBlancq group on the east, extending in that direction to the centre-line of Vauquelin township. Between 1936 and

1938, a considerable amount of stripping, trenching, and test-pitting was carried out, and two diamond-drill holes were put down, to explore two gold-bearing shear zones.

The northern part of the property is underlain by Keewatin-type 'diorite breccia', a band of which extends, with easterly trend, across the township. Cutting the breccia are numerous granitic dykes and some conspicuous quartz veins, but where the latter have been examined they contain no gold or other mineralization. This breccia band is followed on the south by volcanic flow rocks for a width of about 3,000 feet, and these in turn by Temiscamian-type sediments.

The shear zones investigated are in the volcanics near their contact with the sediments to the south. They are slightly north of the centre of range II and about three-quarters of a mile west of the centre-line of the township. The more northerly zone has been exposed for a length of 150 feet, with both ends passing beneath heavy overburden. It is one to two feet wide and is sparsely mineralized with milky to vitreous quartz and a very minor amount of pyrite; native gold has been reported. The other zone, 400 feet to the south, has been exposed for only twenty-five feet, where it shows a width of six feet of a sheeted, rather than schistose, rock containing veinlets of bluish and milky quartz, with very little pyrite, pyrrhotite, and arsenopyrite. Fairly coarse gold has been reported, particularly along subsidiary, northeast trending, fractures. Two diamond-drill holes were put down 440 feet and 660 feet westward along the strike of the zone, but although they intersected rock containing quartz and sparse sulphides, assays for gold were not encouraging (Tolman, pp. 15-16).

McKinnon Claims

These claims are south of the LeBlancq group, about a mile east of Villebon lake. Southward, the claim-group extends into the adjoining Villebon township. The property is underlain by Temiscamian-type sediments, now represented chiefly by mica and hornblende schists, which strike N. 70°W. and dip 70° to 80° north. In 1939, and prior to that year, quartz veins, sparingly mineralized with pyrite, which fill fractures in silicified hornblende schists, were investigated by trenching and some diamond drilling. Two chip samples taken in a trench by S. H. Ross, over widths of two and three feet, gave assays of a 'trace' and 0.06 oz. gold per ton. A similar, but wider, zone of quartz stringers and lenses has been exposed 200 feet farther west, and to the south, in Villebon township, a rock trench has been opened on a quartz lens, containing some pyrite, which cuts sheared conglomerate (Ross *et al.*, 1940, pp. 43-44).

Storey Claims

During 1932, some surface work was done on claims covering the 'narrows' near the north end of Guéguen lake. Here, the southern tip of the Pascalis-Tiblemont batholith extends for a short distance into Vauquelin township. It is flanked on the south by a narrow width of schistose volcanics, and these, in turn, are followed by a narrow, easterly trending band of Temiscamian-type sediments which crosses the lake at the narrows. Within the volcanics, just east of the narrows, and paralleling their schistosity, is a band of altered rock, referred to as 'granodiorite', which possibly is silicified and albitized greenstone. Along its northern margin, this band is well mineralized with sulphides and traversed by quartz and calcite stringers. Pyrite is the principal sulphide, but with it are some chalcopyrite and arsenopyrite. Assays up to 0.30 oz. gold per ton are reported from grab samples, but the mineralized section as a whole would contain much less gold than this (A. M. Bell, pp. 89-90).

PERSHING TOWNSHIP

West Shore of Pershing (Matchi-Manitou) Lake

Some old workings on the west shore of Pershing lake at a point about one mile north of the south boundary of the township have exposed sulphide mineralization in a band of sheared iron formation which is interbedded with greenstones and intruded by porphyry dykes. The sulphides are pyrrhotite, pyrite, chalcopyrite, and sphalerite. They appear to extend irregularly over a width of one hundred feet or more, and in the more northerly of two pits sphalerite is fairly abundant. Nowhere, however, is the sulphide concentration sufficient to make copper or zinc ore, and assays of grab samples indicate that gold and silver are absent. Similar sulphide mineralization occurs in iron formation about a quarter of a mile farther south. The volcanic rocks with which these occurrences are associated are only a short distance south of the southern margin of the Vauquelin-Pershing batholith, which forms the western shore of, and underlies, the northern part of Pershing lake (Bell and Bell, 1932, p. 122).

Northern Part of Pershing Township

At five points spaced over a distance of five and a half miles across the northern part of the township, a considerable amount of surface exploration, and at one place some diamond drilling, has been done to investigate occurrences of gold mineralization. All of these are in volcanic rocks and are from three-quarters of a mile to a mile and a half north of the Vauquelin-Pershing batholith. They are as follows:

Heffren Group.—A mile and a quarter east of the north end of Vauquelin lake, which is at the west boundary of Pershing township, several quartz veins and numerous quartz stringers have been found along shear zones in the greenstones. Assays have indicated the presence of gold in some of these, but in small amount only (Ross and Asbury, p. 45).

Anderson Claims.—These are a mile and a quarter east of the Heffren claims. Spectacular visible gold was found here in a quartz vein, or series of connected lenses, from two to ten feet wide, dipping steeply to the north and striking N.75°W. The country rock is a complex of andesitic flows and dioritic intrusives within which, south of the vein, a carbonatized zone 100 feet wide contains quartz stringers and coarse pyrite. The quartz vein is much fractured and heavily rust-stained, but it does not appear to contain any metallic mineralization apart from occasional specks of native gold. Sampling in 1938 by the Consolidated Mining and Smelting

Company of Canada from ten cross-trenches over a length of 155 feet returned some interesting gold assays across widths up to eight feet. In 1939, the Company put down eighteen diamond-drill holes aggregating 5,767 feet, to explore the occurrence at depth (Ross and Asbury, p. 45; Taschereau and Herring, p. 94).

Gladstone-Bussières Claims.—These claims are about one mile east of the northeast corner of Garden Island lake and two and a half miles southeast of the Anderson claims. Several quartz-tourmaline lenses, some apparently barren, others well mineralized with pyrite, occur here in sheared volcanic rocks along or close to their contact with a wide body of what appears to be intrusive porphyry. Adjacent to the mineralized veins, the wall-rock is carbonatized and also contains tourmaline and pyrite. Four chip samples taken by W. N. Asbury from two test pits indicated that the wall-rock, as well as the vein matter, is gold bearing, the assays ranging from 0.02 to 0.10 oz. gold per ton (Ross and Asbury, p. 45).

Holland Claims.—In 1931, McIntyre Porcupine Mines, Limited, did some surface work on these claims, which are about a quarter of a mile due east of Garden Island lake. Trenching has exposed a series of parallel zones of shearing, with strike N.75°W. and dip 60° north, along which the volcanic country rock is silicified and carbonatized and, especially near some porphyry dykes, mineralized with pyrite, chalcopyrite, and pyrrhotite. The shears also contain quartz veins up to four and a half feet wide. Assays show that both the mineralized schist and the massive pyrite carry gold (Bell and Bell, 1932, pp. 120-121).

Duffy-Denis Claims.—Mineralized shear zones similar to those on the Holland claims, occurring a mile and a half south of east of them and approximately on their projected line of strike, were explored in 1931 by Brett-Trethewey Mines, Limited. Three parallel zones were investigated. The central zone was traced over a length of 600 feet and a width of 50 feet, and another, 200 feet to the north, for a still greater length. Very little work was done on the third zone. Free gold was found in one quartz stringer at the most easterly exposure of the central zone, and pannings of coarse gold were reported from the adjacent schist. In the north zone, a bluish quartz-tourmaline vein four and a half feet wide is mineralized with fine pyrite, but where exposed is not known to carry gold (Bell and Bell, 1932, p. 121).

Southeastern Corner of Pershing Township

Peacock Claims.—These claims lie on either side of the Pershing-Haig township line, between three and four miles north of the south boundary of these townships. The claims in Pershing are underlain by Temiscamian-type sedimentary rocks. Not far to the north, these are in contact with Keewatin-type volcanics, and near the southeast corner of the township they meet the Grenville-type gneisses which mark the eastern termination of the Rouyn-Bell River belt and whose contact with the sediments trends northeastward across Haig township (Norman and Dawson; Norman and Tiphane).

In Pershing township, about a quarter of a mile from its eastern boundary, a mineralized fault-zone in the sedimentary rocks has been trenched systematically by the Consolidated Mining and Smelting Company of Canada over a length of seven hundred feet. This work was carried out in 1930, and in 1932 further extensive trenching was done by W. Peacock. The rocks are chiefly greywacke, but they include bands of staurolite schist, chert, and cherty iron-formation, and they are cut by narrow pegmatite dykes. The best mineralization is exposed in the southern four hundred feet of trenching, where it has widths of six to twenty feet. A one-foot band exposed in trenches for a length of twenty feet is quite heavily mineralized with fine pyrite and is cut by quartz stringers. Assay results obtained in this work are not available (A. M. Bell, pp. 85-86).

HAIG TOWNSHIP

The southeast half of Haig township is underlain by Grenville-type gneisses. In the northwest half, the rocks are Keewatin-type volcanics, except at the southwest corner where these are followed by Temiscamian-type sediments, and at the northeast corner, which is occupied by a small projection of the granite which borders the Rouyn-Bell River belt on the north. Prospecting has been confined almost entirely to the volcanic rocks and up to the present very little mineralization of commercial interest has been found.

Near the northwest corner, some surface work has been done along a zone which is the southeastward continuation of that investigated on the property of Lacoma Gold Mines, in the adjoining Tavernier township (see p. 289).

About three miles from the northwest corner, on the *Peacock claims*, a zone of sulphide replacement in pillow lavas has been explored by stripping, trenching, and test-pitting. It has been traced for a length of nearly three-quarters of a mile, in a direction S.70°E. Intermittently along the zone, the lavas over a maximum width of 300 feet are silicified, heavily rust-stained, and replaced to a greater or less extent by sulphides which, in some places, are quite massive. The sulphides present are pyrite, marcasite, and a little chalcopyrite. Veins of rather barren-looking quartz are common. Paralleling the zone on its northern side is a dyke or sill of diorite, 400 feet wide, to which, it is thought, the mineralization may be related. A sample taken by A. M. Bell across twelve feet of heavy sulphides gave a negative assay for gold (A. M. Bell, p. 84).

VILLEBON AND DENAIN TOWNSHIPS

A narrow strip along the west side of Villebon township is occupied by Temiscamian-type sediments, the eastern end of the band of these rocks that extends far to the west. East of these sediments, the rocks of the township are Keewatin-type volcanics which, on the north and east, are again flanked by relatively narrow widths of the sediments. The latter continue eastward to occupy the northwestern part of Denain township. These sediments mark the termination of the Rouyn-Bell River belt, whose contact with the Grenville-type gneisses extends, with southwesterly trend, from near the northeast corner of Villebon. In the south part of Villebon township, the volcanics are intruded by a small granitic batholith which extends northward into Fréville. Gold mineralization of interest has been found at two localities in the volcanics just north of this batholith.

Ceres-Chaput Claims.—On the east side of Dog lake, in range V, of Villebon township about 500 feet west of lot-line 33-34, a shear zone in altered lavas and diorite contains lenses of quartz sparingly mineralized with sulphides. It strikes north-south and has been trenched at intervals over a length of 365 feet. In places, the lenses contain visible gold, and some encouraging assays have been reported (Ross *et al.*, 1938, p. 27).

Fortin Claims.—These claims comprise a part or the whole of lots 31 to 33, ranges III and IV of Villebon, and are half a mile or so southwest of the Ceres-Chaput claims. A bluish quartz vein in amphibolite, which may be highly altered volcanic rock or a basic facies of the granodiorite, has been stripped along its southwestward strike for a length of 380 feet. It has an average width of two and a half feet. The vein contains pyrite, pyrrhotite, sphalerite, galena, and chalcopyrite. Visible gold was seen at one point, but assays for gold are reported to have given low results (Lowther, Map. No. 345; Ross *et al.*, 1938, p. 27).

Other Occurrences of Sulphide Mineralization.—Sulphide mineralization is known to occur in several other localities in Villebon township and also in Fréville, which adjoins on the south. Lowther encountered three such bodies in the course of mapping the area. In all of them, the mineralization is chiefly pyrrhotite, with a minor amont of pyrite, and it occurs in intrusive rocks or in volcanic rocks in the vicinity of granitic intrusions. One of these occurrences is in an acidic intrusive east of the southwest arm of Villebon lake, in range VII of Villebon township. The rocks in the vicinity are intensely sheared and metasomatized, and contain tourmaline and much carbonate. Another zone occurs in Keewatin-type rock, described as 'amphibolite', near the north end of lot-line 52-53, range III, of the township. This is immediately west of Shamus river, just off the north end of a long, narrow granitic body which parallels the river. A third occurrence is in Fréville township, about a mile east of Victoria lake. This also is in 'amphibolite', near its contact with the south end of the Villebon-Fréville granodiorite mass (Lowther, p. 52).

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(Southeast end of Rouyn-Bell River area)

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SOUTHWEST MARGIN OF THE ROUYN-BELL RIVER AREA

General Note

In discussing, in earlier pages, the gold mineralization at the west end of the Rouyn-Bell River belt of volcanic and sedimentary rocks, descriptions have been given of deposits occurring only as far south as the row of townships:

Dasserat-Beauchastel-Rouyn-Joannès-Bousquet-Cadillac

which follow one another in that order eastward from the Quebec-Ontario boundary. This, as it happens, has so far proved the most productive section of the belt. Actually, however, the rocks of the belt extend for ten or more miles farther southward across the next succeeding row of townships, which are:

Dufay-Montbeillard-Bellecombe-Vaudray-Montanier-Suriman

In these latter townships, the rocks of the belt are Temiscamian-type sediments, except in the eastern half of Dufay, where there is an outlier of the Keewatin-type volcanics which, northward, greatly predominate across the entire width of the belt. In Dufay, also, Middle Huronian (Cobalt series) conglomerate, extensively developed farther west, in Ontario, appears as a narrow band along the west boundary of the township. Along a very irregular line with general easterly trend, near the south boundary of these townships, the Temiscamian-type sediments are in contact with granitic rocks. These occupy the whole of the country southward for some sixty miles, to the Ville Marie-Guillet (Mud) Lake belt of mineralization, described in the immediately following section of this volume (pp. 304-320).

The Temiscamian-type sediments are chiefly greywacke, in many places altered to biotite schist. Cutting them, in addition to granitic rocks, are a number of 'later gabbro' dykes, some of which are traceable for miles. The rocks are faulted in places, but no large zones of dislocation have been recognized. The absence of major faults and shear zones may be responsible, in large part at least, for the observed lack of important gold or other metallic mineralization in this southwestern section of the belt. Some mineralization has been found, however, and a considerable amount of surface work has been done on four of these occurrences, in Dufay and Montbeillard townships. Although gold is not the principal metal present in any of these, they are referred to here as a matter of convenience.

DUFAY TOWNSHIP

Carlson Mines, Limited

The claims of this Company, formerly the Carlson Copper Syndicate, are from two to three miles east of the west boundary of the township, close to its north boundary and immediately north of Germain lake. They are underlain by biotite-rich schistose greywacke, intruded by dykes and irregular masses of granite and syenite, and cutting both the sediments and the intrusive rocks is a dyke, more than 100 feet wide, of 'later gabbro' striking northeast. A north-south fault passes across this dyke, displacing its western section 900 feet to the south. On the west side of the fault, a quartz vein which parallels the dyke not far from its northern side has been traced by trenching and test-pitting southwestward for 2,500 feet from the fault. With width ranging from three to thirteen feet, it closely follows the contact between the schistose greywacke and a small body of granite, and in places it lies within the latter. The vein is sheared and brecciated and contains chalcopyrite, both disseminated and as masses up to six inches in diameter. Several narrower quartz veins carrying chalcopyrite have been exposed in trenches and pits adjacent to the main vein.

Work on these claims has been carried on intermittently since 1929 and has included a large amount of trenching and test-pitting and some diamond drilling. Two of several holes put down in 1929 are reported to have intersected 3.4 feet and 7.6 feet, respectively, of material containing 16 per cent and 2.34 per cent copper, and, in 1939, the present Company reported that a diamond-drill hole which intersected the vein at a depth of 410 feet showed a true vein width of 7.3 feet averaging 0.25 oz. gold per ton. Two samples taken from a trench by S. H. Ross returned assays of 6.56 and 2.15 per cent copper, with negligible gold (Taschereau, pp. 92-94; Ross *et al.*, pp. 19-20).

West Boundary of Township, Near Centre-Line

Near the west boundary of Dufay township, about half a mile south of the east-west centre-line, several white quartz veins cutting conglomerate of the Cobalt series are mineralized with pyrite and a little chalcopyrite. They occur in two sets of fractures, striking north-south and northeast, and have widths from five to six feet. Although somewhat lens-like, they are continuous along their strike for several hundred feet. Assays indicate that the copper content is much below commercial grade and that gold is negligible (A. R. Byers, personal communication, 1942.)

MONTBEILLARD TOWNSHIP

Lot 36, Ranges IX and X

The claims on these lots are underlain by mica schists, representing original greywacke, which strike N.60°E. and have gentle dip. Cutting the schists is a lens-like mass of quartz, striking a few degrees west of north and dipping steeply east, which has a length of 1,400 feet and is up to 125 feet wide. Within this mass, a fracture zone, averaging three and a half feet in width and having a length of 640 feet, is mineralized with sphalerite and galena, the two sulphides making up about 50 per cent of the material of the zone, with the ratio of sphalerite to galena about 8 to 1. Both sulphides are coarsely crystalline, with some galena crystals three-quarters of an inch in diameter. They occur both massive and as disseminations, and with them is associated a minor amount of chalcopyrite. Paralleling this quartz mass are a number of quartz veins, two to three inches wide.

This occurrence has been investigated by a considerable amount of trenching and test-pitting, and in 1938 it was estimated that some 350 tons of broken ore was piled adjacent to the workings. Assay of a channel sample taken by S. H. Ross near the north end of the zone across a width of 3 feet 8 inches gave: 40.35 per cent zinc, 1.69 per cent lead, and 0.02 oz. gold and 1.00 oz. silver per ton (Ross and Asbury, pp. 14-15).

Lots 19 to 22, Range IV

These lots, in the southwestern quarter of the township, are underlain by intrusive biotite gneiss, just south of its contact with the Temiscamian-type sediments which occupy the whole of the township north of here. The foliation of the gneiss strikes N.25°W., with dip 37° northeast.

Cutting the gneiss are a number of pegmatite dykes which contain molybdenite. The principal occurrences that have been investigated are within and adjacent to an isolated outcrop of the gneiss in lot 20. A dyke, four to five feet wide, on the north side of the outcrop has been exposed along its east-west strike for a length of twenty feet. It is coarsely crystalline in the central part, but the marginal zones are fine grained and irregularly banded and contain flakes of molybdenite, from one-sixteenth of an inch to half an inch in diameter, which form about one per cent of the rock. In addition to quartz and feldspar, the dyke contains some garnet and pyrite.

The richest dyke so far discovered is on the south side of the outcrop. It is four to eight inches wide and has been exposed in trenches and test-pits for a length of thirty feet and to a depth of twelve feet. In this dyke, the molybdenite is in flakes up to one inch in diameter and in places it forms from one-quarter to one-third of the material of the dyke. Five other dykes containing molybdenite are exposed in a trench nearby, and still others, one as much as 200 feet wide, occur farther to the north-west. These have a northeasterly strike.

These deposits were under investigation in 1939 by the *Cheabella Mine Company, Registered,* who shipped a bulk sample of 3,807 pounds of the ore to the ore dressing laboratories of the Department of Mines and Resources, Ottawa. This ore contained 1.94 per cent molybdenite. It proved quite amenable to flotation, yielding a concentrate containing 94.30 per cent molybdenite with a recovery of 93.7 per cent of the molybdenite content of the sample (Ross *et al.*, pp. 37-38; Dufresne, p. 18).

References

(Southwest margin of Rouyn-Bell River area)

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VILLE MARIE-GUILLET (MUD) LAKE BELT

General Note

The Ville Marie-Guillet (Mud) Lake belt of volcanic rocks extends eastward from Ville Marie, on the east shore of lake Témiscamingue, to beyond Soufflot lake, at the east boundary of Guillet township, a distance of nearly fifty miles. It is roughly parallel to, and approximately sixty miles south of, the very much longer Rouyn-Bell River belt. The townships it crosses, from west to east, are Duhamel, Laverlochère, Gaboury, Blondeau, and Guillet.

Sandstone and conglomerate of Ordovician age outcrop in a few places along the shore of lake Témiscamingue and, very rarely, they are met with some distance inland. The hills that rise from the plain for some six miles from the lake shore consists of flat-lying beds of Lorrain (Huronian) quartzite, and the underlying Gowganda formation, consisting chiefly of conglomerate with interbedded greywacke and arkose, forms many of the hills for eight miles still farther inland, east of the town of Ville Marie. Apart from these Ordovician and Huronian sediments, and some 'late' dykes of diabase or gabbro, the rocks of the area are all Early Precambrian.

A belt of Keewatin-type volcanic rocks, interrupted at two points by narrow tongues of granite, extends eastward across the area from the vicinity of Ville Marie. The western segment, with a length of twelve miles to A la Loutre river, appears only as occasional outcrops marginal or adjacent to the hills of Huronian sediments. Such outcrops are found along or near the lake shore from Ville Marie southward to the central part of Fabre township, which adjoins Duhamel on the south, indicating that the belt here has a width of at least ten miles. At A la Loutre river, a tongue of granite, one mile wide, intervenes before the belt continues, with a width of about three miles, to Allard lake, in south-central Blondeau township, a distance of seventeen miles, beyond which it follows the south shore of the lake as a narrow band which tapers out near the eastern boundary of the township. An easterly trending tongue of granite, about one mile wide, separates this narrow band from the eastern segment of the belt, which, turning northward, occupies the northern half of Guillet township and much of the southern half of Devlin. Here, along a line that follows closely the eastern boundary of these townships, the volcanic rocks of the belt are in contact with Temiscamian-type sediments, chiefly greywacke, conglomerate, and various types of schist, with possibly some interbedded volcanics. This flanking band of sedimentary rocks is of very irregular width. Commencing near the north-south centre-line of Guillet township, it has an average width of rather more than a mile for a length of five miles northeastward to Soufflot lake. Northward from there, it widens to as much as seven or eight miles. Beyond these sediments, granitic rocks extend far to the east and north.

In the western part of the area, similar Keewatin-type volcanic rocks occupy the southwestern half of Baby township, north of Laverlochère, and are known to extend westward into Guigues, which is almost entirely drift covered. This extensive area of volcanic rocks is separated from the main belt by a westerly projection, about four miles wide, of the granite batholith which flanks the belt on the north throughout its length.

Volcanic flows of andesitic and basaltic composition make up the bulk of the rocks of the belt, but more acidic types, from dacite to rhyolite, are abundant in places, as in the northwestern part of Baby township and as a band along the southern margin of the belt in Guillet township. Interbedded with the lavas are minor amounts of tuff and agglomerate, and thin bands of iron formation.

Southward from the belt, the country is occupied by gneisses and schists of sedimentary origin, with much associated granitic material. These are in contact with the Keewatin-type volcanics throughout the central segment of the belt, but both in the east and west there are intervening masses of granite. They overlie the volcanics conformably and have been variously correlated with the Temiscamian or the Grenville series.

In the east part of Blondeau township, a narrow body of intrusive rock, extending northward for four miles from Allard lake to Gauvin lake, lies between the volcanics and granite to the west. It consists of rock ranging in composition from diorite to peridotite, and numerous small bosses and sills of similar rock appear as intrusions in the volcanic rocks both to the east and the west along the belt. These basic intrusives may be genetically related to the volcanics. They are definitely older than the granite.

The volcanic rocks, and also the granite, are cut by lamprophyre dykes, which have been observed particularly in the vicinity of the Belleterre mine, in Guillet township; and throughout the western part of the belt there are many still later diabase or gabbro dykes, all of which strike within the range N.5°-25°E. Although they have not been observed cutting Huronian rocks, evidence from other areas suggests that they are post-Huronian in age.

In the central segment of the belt, the volcanics, and also the sedimentary gneisses and schists to the south of them, have a general easterly strike with dip steep to the south, and the tops of the flows and beds face south. They thus lie, apparently, on the southern limb of an anticlinal fold that has been cut off on the north by the granite (Henderson, p. 14). At the extreme east end of the belt, however, in Guillet township, the strike swings to northeast, north, and finally west of north where the belt terminates in Devlin township, with tops facing south and east. B. T. Denis (p. 70) interprets the structure here as the south limb of an anticline plunging toward the southeast. Henderson, on the other hand, is of opinion that it is basically the same as in the section of the belt farther west, and that the change in strike of the flows and beds, which is responsible for the apparent plunging anticlinal structure, was a later development, probably caused by the thrusting action of the invading granite. As evidence supporting this view he points to the occurrence of two sets of drag folds, one set plunging at gentle angles, on which determinations of tops of flows and beds check with those based on internal structures of the rocks, such as grain size, the other set plunging at very steep angles, in which there is lack of such agreement. These latter he regards as the results of later stresses that bore no relation to those responsible for the earlier east-west folding.

Two strong northeasterly trending faults, known as the Guillet Lake and Mill Creek faults, have been recognized on the property of Belleterre Quebec Mines, Limited, in Guillet township. They seem definitely to have controlled the transfer from depth of the vein forming material now localized in the closely related vein structures.

Mineral Occurrences

This area is of particular historical interest because here, on the east shore of lake Témiscamingue, in what is now Duhamel township, is one of the earliest recorded metalliferous deposits in North America (excepting Mexico). This is a body of argentiferous galena. It was visited by Sieur de Troyes in 1686 and for nearly one hundred years has been known as the Wright mine (see p. 307).

Modern prospecting in the area dates from about 1905, following the discovery a year or two earlier of the rich silver deposits in the Cobalt district, Ontario, less than ten miles to the northwest. The search for similar ores along the Ville Marie-Guillet Lake belt proved unsuccessful, but quartz veins and zones of sulphide mineralization were discovered at a number of places, particularly in Fabre, Gaboury, and Blondeau townships. Interest in the belt was greatly stimulated in 1933, when gold-bearing veins were discovered in the vicinity of Soufflot lake. In the following year, similar discoveries, which proved to be of more importance, were made ten miles to the west, north of Guillet (Mud) lake, in Guillet township, and here the Belleterre mine was developed and started production in 1936 (see p. 314). At that time, numerous claims were staked in the township all along the belt, and systematic exploration on many of these revealed gold mineralization of interest, but, up to the present, no other producing mine has been developed.

GUIGUES TOWNSHIP

No metallic mineralization of interest has been reported in this township or in Baby township which adjoins on the east.

Silica.—Near the east end of lot 19, range II, Guigues township, an isolated outcrop of basal Ordovician sandstone rises abruptly from the clay flats to a height of forty to fifty feet. It is presumably resting on Precambrian Lorrain quartzite, which is exposed a short distance to the southwest. The sandstone is a loosely consolidated, friable rock in which the angular to sub-angular quartz grains are poorly sorted, ranging in diameter from 5 mm. to 0.5 mm. or less. The upper beds contain much limy material, but in the lower thirty feet or so the rock consists essentially of quartz, analyses averaging 97 per cent SiO_2. The material is quarried by *Flint Sands, Limited,* who produce three products by classification. At present, only the medium grade product is marketed. This is used for sand blasting (Henderson, p. 35).

DUHAMEL TOWNSHIP

Baldface Mine

Many years ago some work, including the sinking of a shaft, said to be forty-five feet deep, was done on a prospect in lot 3, range V, where a number of mineralized quartz lenses with *en échelon* arrangement occur in Keewatin-type agglomerate. Both the lenses and the agglomerate strike S.55°E. and dip vertically. The two largest lenses are 85 feet and 50 feet long with a maximum width of about 15 feet, and there are five smaller ones, each offset 5 to 40 feet from its neighbour. The quartz is heavily mineralized with pyrite and lesser chalcopyrite; the gold content, if any, is not recorded. This prospect, which is four and a half miles southeast of the town of Ville Marie, is known locally as the Baldface mine (Henderson, p. 34).

Wright Mine

One of the earliest recorded occurrences of metallic mineralization on the North American continent (outside of Mexico), a deposit of argentiferous galena, is in blocks *A* and *B*, immediately west of lots 61, 62, and 63, range I of Duhamel township, on the shore of lake Témiscamingue, about seven miles north of the town of Ville Marie. The year of its discovery is not known, but on May 24th, 1686, it was visited by the Sieur de Troyes, a gentleman adventurer of the court of France (Relations des Jésuites) in the course of a journey he made from Montreal to Hudson bay. He carried away some samples of the ore, but apparently the occurrence aroused little interest since there is no further record of it until about the middle of the nineteenth century. On a map of the country published in France in 1744, however, the locality is shown as *Anse a la Mine*. It is of interest to note that it is less than ten miles east of the Cobalt district, Ontario, whose enormously rich deposits of native silver remained undiscovered for more than two hundred years after de Troyes had visited and described this argentiferous galena occurrence on the east shore of lake Témiscamingue.

About 1850, the deposit, apparently long forgotten, was re-discovered by E. V. Wright, who owned timber limits in the area, and since then it has been known as the Wright mine. At various times until 1903, mining operations were carrried on in a small way from a shaft which eventually reached a depth of 330 feet, with workings on five levels, and equipment, including a stamp mill, was installed, but total shipments of ore or concentrates appear to have been small. They included a few tons in the 'seventies', a "considerable quantity" (MacRae) in the period 1890-93, and 527 tons of concentrates containing 70 to 77 per cent galena during the years 1902-3. In 1915, the property was acquired by interests connected with Hollinger Consolidated Gold Mines, who unwatered and sampled the mine workings, and in 1925 the Alpha Mining Syndicate, an affiliate of Hollinger, again unwatered the mine and did some diamond drilling to test the downward extension of the deposit. The results of this work were apparently not encouraging and all exploration equipment was removed from the property in November, 1925 (T. C. Denis, 1926, p. 40).

The ore is a breccia composed of angular fragments of rhyolite and dacite cemented by a matrix of coarsely crystalline calcite and argentiferous galena, sphalerite, and some pyrite and quartz. The brecciated zone, as exposed on the shore of the lake, is about 31 feet by 65 feet. Cooke (p. 24), who examined the mine at the time it was unwatered in 1925, regards this

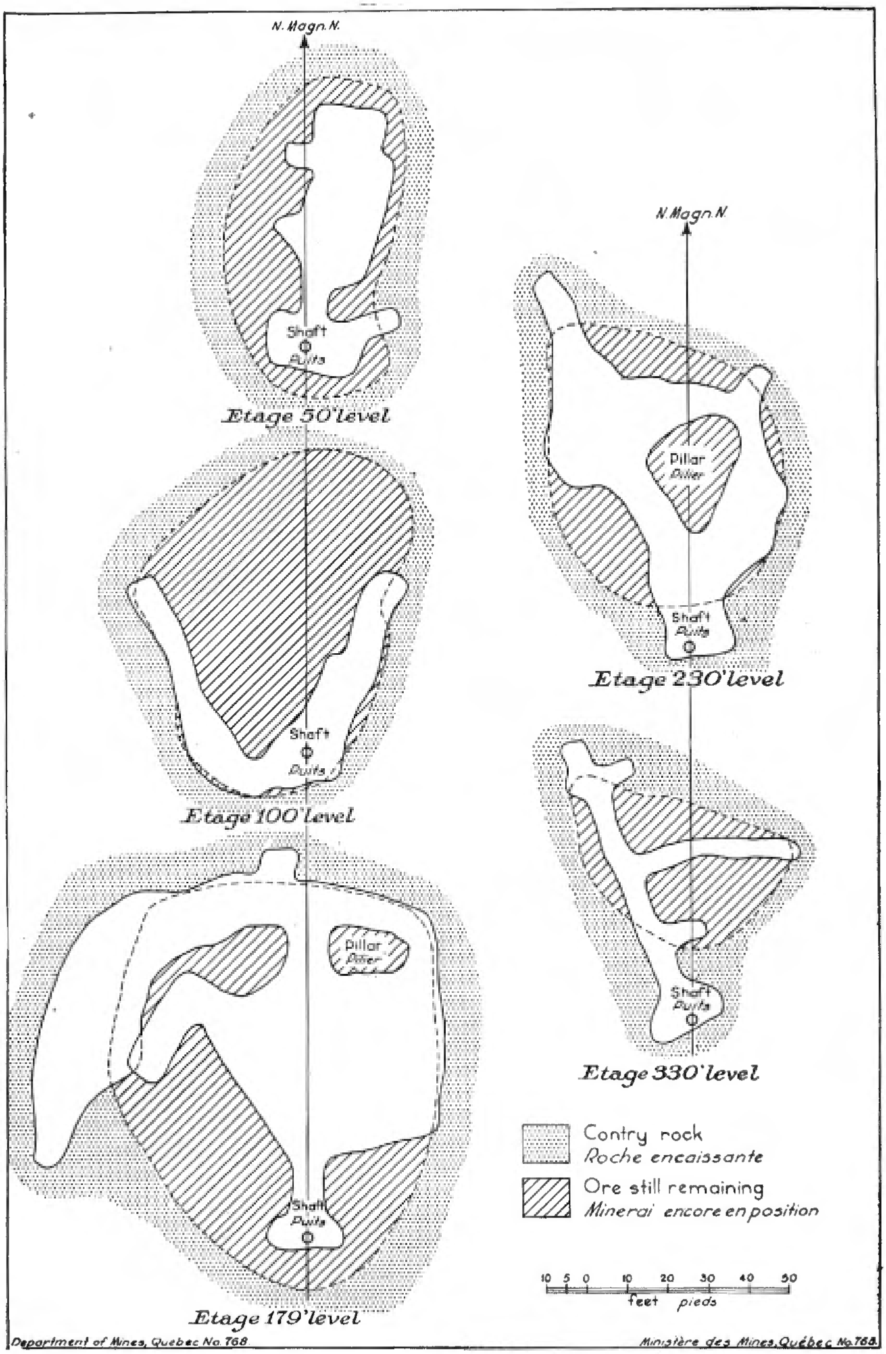

FIGURE 51.—*Wright mine, plan of levels.* (C.G.S., Econ. Geol. Series, No. 8, page 118).

breccia as a basal conglomerate of the Cobalt series, formed almost entirely of material derived from the immediately underlying Keewatin-type volcanics. Henderson (p. 34), on the other hand, considers it is a volcanic agglomerate of Keewatin age. In any case, the rock that formerly overlay the breccia was a normal conglomerate of the Cobalt series, a 40-foot cliff of which rises some 200 feet south of the shaft.

The orebody is an almost vertical pipe, broadly oval in cross-section, beyond which the rock is not brecciated, and no adequate hypothesis has been advanced to account for its origin and limitations. Cooke's examination revealed no evidence of faulting on a large scale. He points out, however, that the ore minerals have not *replaced* the conglomerate. From this he concludes that the introduction of the ore minerals must have been accompanied by a considerable increase in the volume of the rock and that the pressure resulting from this was relieved by progressive brecciation of the overlying rock as the ore-bearing solutions advanced and crystallized. This might account for the pipe-like form of the deposit. Cooke's report includes plans of the workings on each of the five mine levels. These indicate that on the 179-foot level, the orebody had a cross section about 110 feet by 100 feet, and that it tapered somewhat both upward and downward from this horizon, being 80 feet by 40 feet on the 50-foot level and 40 feet by 50 feet on the 330-foot (bottom) level.

From the results of several hundred assays that were made when the mine was sampled in 1915, Cooke computed the following averages for the levels indicated:

Level	Silver (oz. per ton)	Lead (per cent)	Zinc (per cent)
50-foot	1.72	9.62	None
100-foot	0.63	0.20	0.80
179-foot	0.86	3.16	1.63
230-foot	1.10	2.25	0.95
330-foot	0.36	0.36	0.77

Judged by these assays, the lead content of the ore decreased progressively with depth whereas the zinc content first increased and then, from about 180 feet to the bottom level, decreased. Also, there does not appear to be any close relationship between the silver and the lead content, indicating the presence in the ore of some unidentified silver mineral.

LAVERLOCHÈRE TOWNSHIP

Extending westward across the southern half of Laverlochère is a belt of Keewatin-type volcanics which, in its western part, is largely concealed beneath overlying Huronian sediments. In the southeast corner, the volcanics are flanked on the south by overlying gneisses and schists of sedimentary origin. The whole of the northern half of the township is occupied by granitic rocks, and, at the headwaters of A la Loutre river, a tongue of the granite cuts southward across the volcanic belt and widens to occupy much of the south-central part. Gold mineralization has been found at numerous localities in shear zones in the volcanics, and at one place in quartz veins cutting granite adjacent to the volcanics.

Lots 35 and 36, Range IV.—On these lots, which are near the centre of the north shore of Rousselot lake, three and a half miles east of the Canadian Pacific Railway station at Lorrainville, *Aura Mines, Limited*, have done a considerable amount of stripping and trenching to explore shear zones in dacite which contain quartz veins mineralized with chalcopyrite, pyrite, and pyrrhotite. They strike north-south, across the strike of the flows, which is N.60°E. The largest shear zone has been stripped for a length of seventy-five feet and has an average width of two to three feet. It is reported that the quartz veins exposed in some of the trenches carry small amounts of gold (Henderson, p. 32).

Lots 34 and 35, Ranges IV and V.—On these claims, which extend eastward from near the centre of the south side of Rousselot lake, narrow stringers and small lenses of quartz, well mineralized with pyrite, chalcopyrite, and pyrrhotite, occur in a band, or bands, of iron formation interbedded with andesite. The veins have been exposed at several points by stripping and trenching (Henderson, pp. 32-33).

Lots 14 to 19, Range IV.—This property is about four and a half miles east-southeast of Lorrainville and a mile and a half due south of Trudeau lake. A considerable amount of trenching and test-pitting, and some diamond drilling, has been done here — most of it on lot 19 — at various times since 1922, to explore a number of mineralized quartz veins. In 1927, the *Bellehumeur Mining Company, Limited*, was organized to develop the property and was succeeded in 1934 by *United Gold Exploration, Limited.* Operations were suspended in 1938, in which year *Les Mines d'Or Bellehumeur, Limitée*, the then owners, shipped 792 pounds of selected material to the Temiskaming Testing Laboratory, at Cobalt, Ontario, from which it was reported that more than five ounces of gold was recovered.

The northwest part of the property is underlain by Keewatin-type volcanics and the southeastern part by granite, the contact between these striking N.30°E. Adjacent to the granite, the volcanics for a width of 450 to 900 feet are highly silicified and are cut by numerous aplite and granite dykes. The mineralized quartz veins and lenses occur within or close to the aplite dykes. At the north end of one such dyke, eight to ten feet wide, the veins traversing it are so numerous that the dyke, for a width of two feet, is essentially a quartz vein, and here it is reported to contain much free gold. About fifty feet east of this, a quartz vein lying between an aplite dyke and chlorite schists contains about five per cent disseminated pyrite and is reported to have yielded high assays for gold. At least fifteen other veins have been found cutting andesite or rhyolite and generally near aplite dykes. Some of these contain a considerable amount of galena and some sphalerite in addition to pyrite and occasional chalcopyrite (Henderson, p. 33; Ross and Asbury, pp. 15-16).

Lots 1 and 2, Range IV.—These lots are at the south boundary of Laverlochère township, about four miles east of the township line. Here, lying well within the granitic batholith that occupies this part of the township, is an elongated body of Keewatin-type volcanics, a quarter of a mile wide and a mile and a quarter long, trending north-northeast. Near the east side of lot 1, a shear zone, twenty-five feet wide, in chlorite schist — originally andesite — contains many small lenses of quartz, and both quartz and schist are well mineralized with pyrite. Gold assays of 0.06 oz. per ton or better are reported from samples taken over a width of two and a half feet. In the northeast corner of lot 2, a band of iron formation, two feet wide, is mineralized with pyrite and is reported to contain some gold (Henderson, p. 33).

Lots 21 to 23, Range XII.—These lots, near the east boundary of Laverlochère township, east of the north end of Honorat lake, form part of a property formerly owned by the Lorrainville Mining Syndicate. They are underlain by granite, which in places is cut by wide quartz veins. Three of these have been investigated by trenching and test-pitting.

The most northerly, known as the Gelinas vein, is about 360 feet southwest of lot-post 23-24, range-line XII-XIII. It strikes N.75°E. A trench, sixty feet long, across the vein shows, from north to south, 12 feet of quartz with disseminated pyrite, 9 feet of schist, and 20 feet of quartz, irregular fractures in which contain pyrite and chalcopyrite, together with a little sphalerite and molybdenite. The sulphides may form as much as three per cent of this part of the vein.

About half a mile to the south, in the south part of lot 22, a quartz vein (the Marotte vein), more than ninety feet wide, contains small amounts of pyrite and magnetite.

The third vein, known as the Germain vein, is near the northeast corner of the south half of lot 21, at 900 feet northwest of the Marotte vein. Where exposed in a cross-trench it is about twenty-seven feet wide and fractures in the quartz contain small amounts of pyrite, chalcopyrite, magnetite, and molybdenite.

Assays of samples from each of these veins are reported to have shown the presence of gold (Retty, 1931, pp. 86-88).

GABOURY TOWNSHIP

The belt of volcanics, continuing eastward from Laverlochère township, passes centrally across Gaboury with a width of about three and a half miles, flanked on the north by granitic rocks and on the south by gneisses and schists of sedimentary origin. Intruding the volcanics are a number of small bodies of granite and also of basic rock ranging in composition from diorite to peridotite.

There are several small stocks of the peridotite along the north shore and at the east end of McKenzie lake, which is about a mile and a half west of Timber (des Bois) lake. The rock is more or less completely altered to serpentine and in places is traversed by short, narrow veins of cross-fibre, and also slip-fibre, asbestos (chrysotile). Though somewhat harsh, the cross-fibre material is of fair quality, but the slip-fibre crumbles when rolled between the fingers. Prospecting for asbestos in this vicinity dates back to 1907, and pits have been sunk in a number of places to explore the downward extension of the veins. This work has failed to reveal any deposit of commercial interest (Retty, 1931, pp. 66, 75-78).

Prospecting has been active elsewhere along and adjacent to the belt of volcanic rocks, but, although sulphide mineralization has been found in a number of localities, the known occurrences consist of pyrite and pyrrhotite, with very little or no chalcopyrite. They are of small extent, and their gold content is negligible. In 1918 and 1919, particularly, large numbers of claims were staked around, and in the vicinity of, Timber lake, which is near the east boundary of the township, a mile or so south of the east-west centre line (T. C. Denis, 1920, p. 48.)

A considerable amount of work was done on the *Pedlow claims*, in the northern half of lots 28 to 31, range IV. These are about a mile and a half northwest of Timber lake, on either side of Timber creek. The northern boundary of the claims follows the contact between the volcanic rocks of the belt and the granitic rocks which flank them on the north, and the volcanics, which are chiefly andesite, are intruded by a number of feldspar porphyry dykes. Two easterly trending shear zones in the andesite, about 540 feet apart, have been exposed intermittently in trenches, for lengths of several hundred feet. They are mineralized with pyrite, and in places contain veins, lenses, and irregular masses of quartz. A dyke of porphyry exposed in one of the trenches also contains some pyrite. There are no published records of assays of material from these workings (Retty, 1931, pp. 78-80).

About half a mile to the northeast, on the *McClure claims*, some quartz veins occur in a shear zone in a highly altered granite rich in chlorite and containing many large inclusions of greenstone. The veins and enclosing schists are sparsely mineralized with pyrite (Henderson, p. 32).

Half a mile north of the east end of Timber lake, immediately south of lot 45, range IV, joint planes in a rust-coated outcrop of andesite, about 40 feet by 20 feet, are mineralized with pyrite, pyrrhotite, and occasional grains of chalcopyrite. Assays are reported to have shown the presence of gold, but in negligible amount (Retty, 1931, pp. 80-81).

A mile and a half farther south, on the south shore of the lake just east of its narrow south arm, two narrow bands of iron formation interbedded with andesite flows are impregnated with, and in part replaced by, pyrrhotite and pyrite. Nearby, a band of volcanic tuff and agglomerate, thirty feet wide, contains many stringers and lenses of quartz which are sparingly mineralized with pyrite and pyrrhotite. Low assays for gold are reported from both these occurrences (Henderson, p. 31). Westward from here, between Timber lake and McKenzie lake, *Guinard Gold Mines, Limited,* did some diamond drilling in 1941 to explore a similar mineralized zone (Herring and Lafontaine, p. 48).

On the *Landy claims*, at the extreme southern tip of the narrow South arm of Timber lake, pyrite and chalcopyrite occur in association with quartz lenses and stringers in a shear zone, about thirty feet wide, in actinolite-chlorite schist. This occurrence is within the sedimentary gneisses and schists about half a mile south of the margin of the belt of volcanic rocks (Retty, 1931, pp. 81-82).

BLONDEAU TOWNSHIP

At the west boundary of Blondeau township, the belt of volcanic rocks has a width of three and a quarter miles. Eastward from here, this central segment of the belt narrows and, passing along the south shore of Allard lake, it tapers out at the east end of the lake, two miles from the east boundary of the township. A mile and a half to the north, however, the eastern segment of the belt commences. It has a width of about five miles in Blondeau township and continues eastward with much greater width in Guillet and Devlin. North of the volcanics, the township is occupied by granite, and a width of about a mile and a half of the granite continues eastward from Allard lake to beyond the township line. On the south, the volcanics are flanked by schists and gneisses of sedimentary origin, as also is the granite east of Allard lake.

Surface work has been done on a number of claims, chiefly along the volcanic belt in the western part of the township, four to five miles north of the township line. As in Gaboury township to the west, such mineralization as has been found consists of pyrite and pyrrhotite with little or no chalcopyrite, and, although gold has been reported in most of the occurrences examined, assays generally have not been encouraging.

Half a mile north of Renaud lake, which is close to the western boundary, trenching has exposed quartz veins in sheared andesite, and also in a diorite sill that intrudes the andesite. In places they are well mineralized with coarse pyrite and chalcopyrite. About three-quarters of a mile to the southeast, a similar mineralized quartz vein cuts andesite on the south shore of Heart lake, and one mile northeast of this occurrence, at a point 500 feet west of Lett (Mud) lake, a band of iron formation, four to five feet wide, lying between rhyolite and andesite, has been impregnated and replaced by pyrite and pyrrhotite, with some chalcopyrite. Nearby are some narrow quartz veins containing pyrite (Henderson, pp. 30-31).

Three-quarters of a mile southeast of Lett lake and half a mile west of Kelly lake, a pit has exposed a width of ten feet of massive pyrrhotite, with some chalcopyrite, in andesite, but in trenches to the north the rock is unmineralized. One mile due east of here, on the east shore of Kelly lake, pyrite and pyrrhotite are abundant along a band of rusty-weathering iron formation, thirty to forty feet wide, which lies within andesite. It is exposed for a length of 200 feet along its east-west strike. This occurrence is about three and a half miles east of Renaud lake and one mile west of Allard lake, along whose south shore the volcanic rocks have a width of only a few hundred feet (Retty, 1931, pp. 82-84).

Some work has also been done on claims underlain by the volcanics in the northeastern part of the township. Trenching near the southwest end of Gauvin lake has exposed an eight-inch quartz vein, and also a mass of quartz five feet wide, both containing pyrite. Mineralization of somewhat different type occurs two and a half miles southwest of here, at the south end of a small lake southwest of Girard lake. The country rock here is granite which, immediately to the east, is in contact with a mass of earlier gabbro. Along a zone four to five feet wide which has been explored by test pitting at intervals for a length of 100 feet, the granite is traversed by quartz veins and stringers which contain a little pyrite and chalcopyrite. Some high assays for gold have been reported. During the summer of 1924, this occurrence was investigated by *McIntyre Porcupine Mines, Limited* (Retty, 1931, pp. 84-86).

GUILLET TOWNSHIP

In its eastward continuation, the belt of volcanic rocks widens to occupy the whole of the northern half of Guillet township, except for the northwest corner, which is underlain by granite. The rocks of the belt are chiefly flows of intermediate to basic composition, or 'greenstones', but for a width not exceeding one mile along the southern margin they are acidic flows with interbedded coarse and fine tuffs. In the eastern half of the township, these are followed southward by a belt, about one mile wide, of highly altered conglomerate and greywacke of Temiscamian type, now largely converted to quartz-biotite schists. Flanking the volcanics and these sediments on the south is a granitic batholith, but within this, at the southwest corner of the township and adjacent to the south boundary, is a band, very irregular in width, consisting chiefly of gneisses and schists of sedimentary origin.

In the west part of the township, the general strike of the volcanics is slightly south of east, but the trend swings to northeast, north, and even west of north at the eastern boundary. The Temiscamian-type sediments conform in attitude to the volcanics. A number of faults have been observed. The most important are the Mud Lake fault, which strikes N.60°E. through Guillet (Mud) lake, and the Mill Creek fault, 4,000 feet to the north, which also has a northeasterly trend.

Gold mineralization was first discovered in the township in 1933 near Soufflot lake, at the east boundary. This led to a rush of prospectors to the area and in the following years other discoveries were made in the vicinity of Guillet lake, some five miles to the west. This lake is in range IX. At its east end, which is less than three-quarters of a mile west of the centre line of the township, its width is about one-fifth of a mile. From here it trends south of west, gradually tapering along its length of a mile and a half. Claims were staked across the entire width of the volcanic belt for some miles east and west of the lake and on many of these a considerable amount of trenching, test-pitting, and diamond drilling has been carried out. Encouraging results have been obtained on several properties, but up to the present only one producing mine, the Belleterre, has been developed.

Belleterre Quebec Mines, Limited

Belleterre Quebec Mines, subsidiary of McIntyre Porcupine Mines, Limited, owns a large group of claims whose south boundary is about half a mile north of Guillet lake. A number of gold-bearing quartz veins were discovered on these claims in 1934-35 and in 1936 Belleterre Mines, Limited, was incorporated to develop the property and bring it to production. Shaft sinking was commenced immediately, a mill was erected, and production started before the end of 1936 and has been continuous since that time.

The deposits have been developed and mined on six or more levels from three shafts: No. 1, sunk on the No. 2 vein, is 1,288 feet deep; No. 2, 3,700 feet to the southwest, where No. 11 vein outcrops, has a depth of 550 feet with a winze extending to 750 feet; and No. 3, 3,000 feet in a direction S.70°W. from No. 1, at the west end of No. 12 vein, bottoms at 750 feet. A haulage-way on the 500-foot level connects the workings of all three shafts. The mill, which has a capacity of 350 tons per day, is near No. 2 shaft.

Total gold production to the end of 1944 was 226,702 ounces from 700,690 tons of ore milled, an average recovery of 0.323 oz. per ton. Ore reserves at that time were estimated at 631,660 tons averaging 0.351 oz. gold per ton.

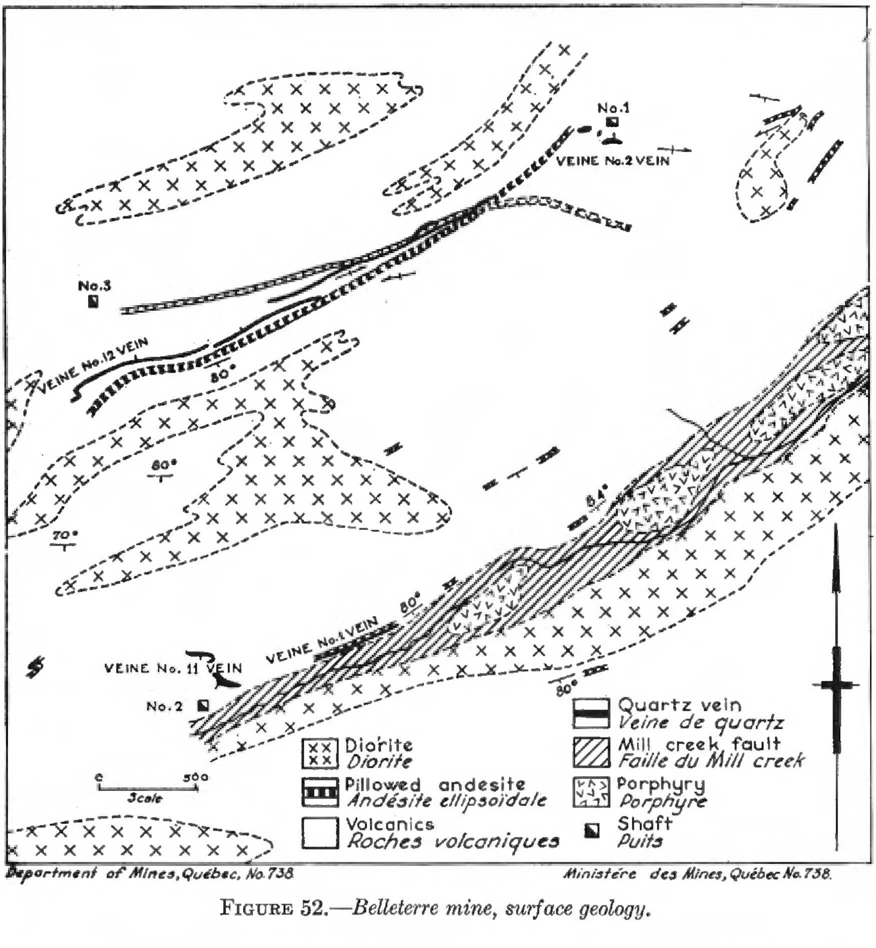

FIGURE 52.—*Belleterre mine, surface geology.*

The property is underlain by typical 'greenstones' which are generally fine grained, somewhat schistose, and high in chlorite. In many places they exhibit such structures as flow lines, pillows, and amygdules, and include bands of interbedded tuffs. Associated with them are some sill-like or irregular masses of altered diorite which, in the main at least, are believed to be intrusive. In the vicinity of No. 2 and No. 3 shafts, the volcanics strike N.70°E., but to the west of here, and also to the east, at No. 1 shaft, their trend is more nearly northeast. They dip southward, at 65 to 80 degress.

The Mill Creek fault zone, striking N.65°E., passes just to the south-east of No. 2 shaft. It has a width ranging from 125 to 400 feet and has been traced for a length of at least a mile and a half. Several masses of porphyritic granodiorite lie within this zone, and dykes which are apparently offshoots from one of the bodies cut veins Nos. 1 and 11. On the other hand, a quartz-feldspar porphyry dyke, ten to twenty feet wide, is cut by No. 12 vein at a point on the 500-foot level 1,200 feet east of No. 3 shaft. Later than all these rocks, and also the veins, are lamprophyre dykes. In most of these, the ferromagnesian mineral is biotite, but some contain hornblende with, or in place of, the biotite. The northern boundary of the property is within less than one mile of the granitic batholith that flanks the volcanic belt and extends far to the north.

The gold-bearing quartz veins occur within the greenstones or tuffs. Most of them strike N.65°E., about parallel to the containing rocks, but, unlike the latter, they dip northward. Some are quite narrow, and the wider and more important ones vary in width along their strike up to a maximum of four to eight feet, and exceptionally as much as twenty feet.

Vein No. 12 outcrops 425 feet south of No. 3 shaft. Underground work has shown that it extends almost continuously along its N. 56°E. strike to

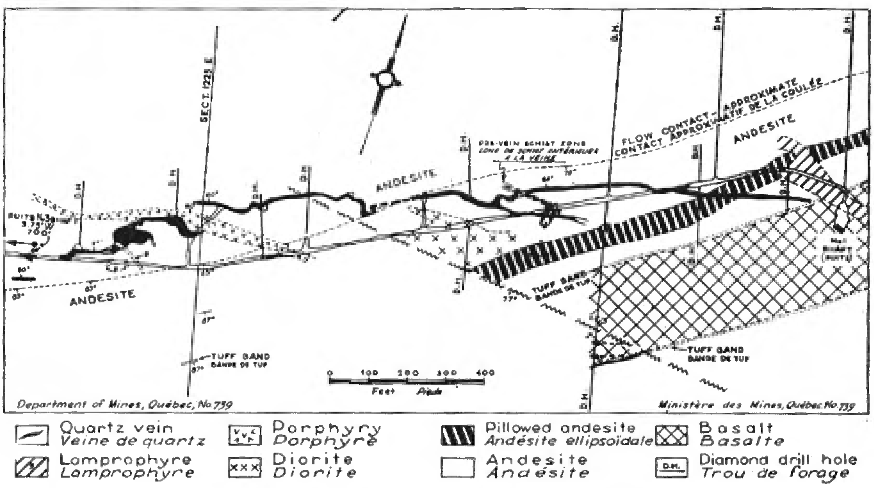

FIGURE 53.—*Belleterre mine, 500-foot level.*

No. 1 shaft, a distance of 3,000 feet. No exploration has yet been done eastward from the latter shaft. For a length of 1,300 feet eastward from No. 3 shaft, the vein between the first and second mine levels consists of two parallel bands, the more northerly of which has been designated vein No. 13. Eastward from this point, the north band is much the stronger of the two, or is present alone, and is referred to as vein No. 12. The vein crosses from one side to the other of a nearly parallel band of tuffs, ten to fifteen feet wide, and it has been found that it is relatively wide and of good grade where it lies in the greenstones on the north side of the tuff, but narrow and below commercial grade where it lies in the greenstones on the south. The vein has an average width of about four feet, but lens-like swellings along it are as much as fifty feet wide. Adjacent to the vein, the greenstones are highly carbonatized. A large proportion of the mine production has come from this vein.

No. 2 vein, known also as the Beauplace vein, outcrops just south of No. 1 shaft. It lies within greenstones and has been traced on the surface and underground for a length of some 500 feet, with width ranging from a few inches up to eight feet. It is thought that it may be the eastward continuation of No. 12 vein.

The No. 11, or McDonald, vein is exposed about 200 feet northeast of No. 2 shaft. In outcrop, it is *Z*-shaped, with general strike a few degrees south of east. It has a length of some 375 feet and an average width of fifteen feet. No. 1 vein outcrops about 500 feet east of the eastern most exposure of No. 11 and may be the continuation of the latter. It lies within a band of tuffs. This vein has been traced for a length of 1,500 feet in a direction N.65°E. and its width ranges from a few inches up to eighteen inches.

L. S. Trenholm, mine geologist, states that the vein quartz is of at least two ages: the older a bluish-grey to greyish-white type with somewhat cherty texture and dull lustre; the younger a vitreous type which occurs as narrow stringers transverse to the vein. Sulphide mineralization consists of pyrite, pyrrhotite, and very minor amounts of chalcopyrite and sphalerite. These minerals occur as grains disseminated through the quartz and as aggregates of small grains at and near the vein walls and along chlorite seams. The gold is most commonly present as very minute, separate particles, distributed through the quartz without apparent relation to fractures or to the amount or nature of the sulphide minerals, but some occurs as a film on quartz or chlorite along seams of the latter mineral. It is reported that, in No. 12 vein, the footwall side is richer in gold than the hanging-wall (B. T. Denis, pp. 71-74; Henderson, pp. 29-30; L. S. Trenholm, mine geologist, report and plans made available by management, 1940).

Other Occurrences in Vicinity of Guillet Lake

During the years 1934-36, numerous claims were staked in the country surrounding Guillet lake. The volcanic belt here has a width of four miles and the staking covered its entire width and extended from the western boundary of the township to well beyond the centre line, with some claims adjacent to Soufflot lake, at the east boundary. Gold mineralization of similar type to that on the Belleterre property was found at many points, either in the greenstones or tuffs, and the more promising occurrences were explored by extensive trenching and test-pitting. High assays for gold were reported from many of the veins, but, in general, the exploration indicated that they were too narrow, and lacked sufficient continuity, for profitable mining. As a consequence, many of the claims were allowed to lapse (for descriptions, see B. T. Denis, pp. 70-79). On several properties, however, surface work and diamond drilling were still in progress in 1944 (see *The Quebec Mining Industry* for years 1939-44).

Claims Adjacent to Soufflot Lake

The southwest arm of Soufflot (or Travers) lake extends for about one mile into range VIII of Guillet township, the main body of the lake lying in township *81*, which adjoins Guillet on the east. It was in township *81*, near the dam between Loken lake and the north arm of Soufflot lake, that the first discovery of gold in this general area was made, in 1933, on the *Loken claims*. This was in a quartz vein which, where exposed by trenches, is from thirteen to sixteen feet wide, striking N.10°E. It is bounded on its east side by a 10-foot width of banded tuffs, beyond which is a dyke of granite porphyry, 150 feet wide. Similar tuffs border it on its west side for a width of two feet and are followed by andesite. Other gold-bearing veins have been found on adjacent claims farther westward, in Guillet township (Retty, 1935, pp. 28-34).

Some three and a half miles south of the Loken claims, gold-bearing veins have been explored on claims, formerly held by the *Mud Lake Gold Mines Development Company*, which extend westward from the southwestern arm of Soufflot lake. A westerly trending band of Temiscamian-type sediments, about 3,000 feet wide, passes across the claims, flanked on the north by Keewatin-type volcanics and on the south by granite. Near their contact with the granite, the sediments are in places mineralized with pyrite and a little chalcopyrite (B. T. Denis, p. 77).

FABRE TOWNSHIP

Fabre township lies immediately east of lake Témiscamingue, at its southern end. It is adjoined on the north by Duhamel and Laverlochère townships and on the east by Laperrière.

Crossing the township centrally from northeast to southwest is a wide zone of granite, flanked on its southern side by the complex of gneisses and schists of sedimentary origin and intrusive granite and gneiss which extends far to the south. The northern and western part of the township is largely drift covered. The outcropping rocks are chiefly Huronian sediments, but in places they are Keewatin-type volcanics, and these doubtless underlie the sediments throughout this part of the township. Cutting the volcanics are dykes of acidic composition and also diabase dykes, and a large mass of diabase similar to the dykes extends westward from Fabre station, lying at the north margin of the zone of granite. The diabase is known to be younger that this granite, but it has not been observed cutting the Huronian sediments. In the Cobalt district, Ontario, however, diabase of the same type intrudes Huronian rocks, and, by analogy, the occurrences in Fabre township are tentatively regarded as post-Huronian (Keweenawan) in age.

In a number of localities, quartz veins and sulphide mineralization occurring in the volcanic rocks, or in granitic dykes and masses cutting them, have been investigated. The most interesting of these are in the vicinity of Fabre Station, near the centre of the township.

In 1907, the *Pontiac Mining and Milling Company* did some surface work and sank a 50-foot prospect shaft on lot 5, range V North, to investigate some sulphide mineralization in a feldspathic dyke, three feet wide, cutting dacite. Calcite veinlets along fractures in the dyke contain disseminated galena, pyrite, and chalcopyrite. A sample taken by M. E. Wilson gave an assay of 3.12 ounces silver per ton. In 1909-10, *Terra Nova Mines, Limited,* explored similar zones of fracturing in an aplite dyke and in the adjacent dacite on lot 3. Smaltite as well as chalcopyrite was reported here in the fractured aplite. These occurrences are about a mile and a half north of Fabre station, to the west of the railway (S. H. Ross *et al.*, p. 28; Harvie, pp. 30 and 31).

In 1936, sulphide mineralization of interest was discovered on a group of claims owned by the *Touton Mining and Exploration Company, Limited,* which include parts or the whole of lots 7 to 12, range V South, and lots 8 and 9, range V North, immediately north of Fabre station. Shear zones in the granodiorite underlying these claims contain a number of quartz veins mineralized with pyrite and chalcopyrite, the latter predominating in some of the veins. Most of the veins have a northeasterly strike and they have been exposed in trenches for lengths up to 500 feet, with widths from a few inches to as much as five feet. Assays of 0.02 to 0.10 oz. gold per ton and 2.33 to 3.68 per cent copper are reported from four of the veins. In 1943, the downward continuation of the veins was explored by upwards of 4,000 feet of diamond drilling (Ross and Asbury, pp. 16-17; Ross *et al.*, pp. 28-30).

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THE GRENVILLE SUB-PROVINCE

(See Volume II, pp. 162-226)

In the foregoing pages, this volume treats of the mineral resources of two great series of rocks, the Keewatin and the Temiscamian. These two rock series, with later intrusives and sedimentary outliers, make up the Temiscamian sub-province. The next major geological division on the southeast is called the Grenville sub-province, since it is composed of the Grenville series of rocks, together with large areas of intrusives and minor outliers of later rocks.

The boundary between the 'provinces' is a definite and a very important one. It marks the limit between two great prospecting areas, the one for gold and copper on the northwest and the other for iron ores, mica, graphite, phosphate, feldspar, magnesite, kaolin, ochre, and other non-metallics on the southeast. Zinc, lead and molybdenite are found in both provinces. The provinces are effectively separated by a zone of gneiss and granitic intrusives, and the stratigraphic sequences in the two provinces are strikingly different.

This geological boundary line can be easily traced on the map of southern Quebec, West Sheet (No. 703*A*) accompanying Volume II. From the southern part of the township of Fabre on lake Temiscamingue, which is here the Quebec-Ontario boundary line, it runs northeasterly to the vicinity of lake Mistassini in the district of that name, a distance of some 360 miles. Farther north, the geology is as yet too little known to be described in detail.

The rocks of the boundary zone are assigned to the Grenville province, with which they agree in structural conditions. In the Temiscamian province, the trend of rock types and of their cleavage is toward the east, while in the Grenville province it is distinctly toward the northeast.

The oldest rocks of the Grenville province are the Grenville series. Originally a normal sequence of sandstones, clay shales, and limestones, they are now quartzite, gneiss, and crystalline limestone, all highly altered and greatly disturbed. Later granitic and gabbroic intrusive rocks occupy large areas. Especially in replaced limestones, a large variety of minerals occur. These include ores of zinc, lead, iron, and titanium, and, among the 'industrial' minerals, magnesite, feldspar, quartz, apatite, mica, graphite, ochre, and kaolin. The principal known deposits of these minerals are described under their respective headings in subsequent pages of this volume. In contrast with the Temiscamian province, no gold or useful amounts of copper have been found in the Grenville province.

On the whole, the Grenville is a separate and distinct prospecting field from the preceding Temiscamian province, or from the succeeding Palæozoic province on the south side of the St-Lawrence river.

THE PALÆOZOIC SUB-PROVINCE

This geological division occupies that part of Quebec which lies on the southeast side of the St-Lawrence river and includes a narrow band of Palæozoic rocks which overlap the Grenville series in places between the Saguenay and Ottawa rivers. In age, the strata range from Cambrian to Carboniferous. They consist of sandstones, quartzites, shales, slates, and limestones. Volcanics are found interbedded with sedimentary rocks and both classes are cut by intrusives that have a wide range of composition, from granite to ultrabasic.

The structure generally agrees in direction with the south shore of the St-Lawrence river and estuary. It is thus northeasterly from the boundary line with the United States to the vicinity of mount Albert in Gaspé peninsula, thence easterly, and, finally, somewhat south of east to cape Gaspé. This variation in structure is broadly parallel to the order of deposition of the strata as may be seen on Map 705*A*, *Southern Quebec, East Sheet* (accompanying Volume *II*). Pre-Silurian strata are tightly folded in many areas, while in later rocks there is less deformation.

The mineral products in this 'province' are generally different from those in the Temiscamian and Grenville, yet they are of quite considerable value. Asbestos, chromite, talc, and soapstone are the principal minerals now mined. Placer gold and bog iron ore have been recovered, and for many years there was a very considerable production of copper from mines in the region. The mineral 'building materials', granite, quartz or silica sand, lime, marble, slate, cement rock, ochre, sand, and gravel, are common products.

Placer gold deposits are described below. Those of industrial minerals and building materials are dealt with under these headings on later pages

Placer Gold, Eastern Townships

Operations for the recovery of placer gold were carried on intermittently in southern Quebec between the years 1847 and 1912. The history of these operations is very incomplete and official records of production of the early decades are practically non-existent. Estimates, however, would indicate that the total value of the placer gold recovered was between two and three million dollars (Denis, p. 48; MacKay, p. 14), which, at $20.67 per ounce, would represent some 100,000 to 145,000 ounces. This may be a low estimate as many of the operations were conducted by private individuals who paid no royalty to the government and from whom no official returns of production were received. Since 1912 there has been very little recovery of placer gold, and in recent years none at all.

Distribution

The most extensive known placer gold deposits are in the counties of Beauce and Compton, with lesser occurrences in Sherbrooke, Richmond, and Wolfe. McGerrigle (1936) has shown that all lie southeast of the Sutton range and between the St-Francis-Massawippi valley on the southwest and the vicinity of Chaudière river on the northeast. This entire district is about one hundred miles long in a northeasterly direction and nearly fifty miles wide. Within it are several areas that vary in size from single occurrences to deposits several miles in extent, in which gold-bearing gravels are found in the valleys of many creeks.

Geology

Deposits of commercial interest are known only in, or near, beds of gravel or, more rarely, clay, which are of pre-glacial age and which have been protected by their position from removal by ice action or other agents of erosion. Not all parts of these old gravels contain gold, but it is only in the older beds that gold has been found in significant amounts. Though generally fine and water worn, the gold may be coarse and somewhat angular. Nuggets of one to thirty ounces have been found in several places and may be seen in the mineral collection of the Geological Survey of Canada, Royal Victoria Museum, Ottawa.

These gravel beds are variable in thickness. In twelve shafts near Gilbert river, Chaudière district, the depth from the top of pay gravel to bed-rock, as given by Chalmers (p. 158), ranges from one foot to twenty-three feet, and averages eight feet.

Above the pre-glacial gravels, boulder clay of glacial origin is usually found, succeeded upward by assorted, bedded sands and clays. Quicksands are common. In the broad valley of the Chaudière, the sequence of geological events seems fairly clear. This river flows in a northerly or north-westerly direction across the marine plain of the St-Lawrence basin, and several tributary streams enter it from the northeast and southwest. An ice-sheet moving up the main valley evidently carved and scoured the channel, removing pre-glacial materials, but in crossing the branch valleys, it filled or obstructed them and thus preserved the remnants of the gold gravels now found in them.

Of the distribution of the gold now known in the district, Chalmers wrote (p. 137): "It is quite an easy matter to find placer gold almost everywhere within the gold-bearing districts in minute quantities, on the higher as well as on the lower levels; but the difficulty is to get it in quantity sufficient to pay for working. As already pointed out, even in the valley bottoms, where gold has undergone the greatest amount of concentration, it is only in spots that pay gravels are found".

Gold-bearing Areas

The areas that have been most worked are the *Chaudière* valley in Beauce county, and the vicinity of *Ditton* river in Compton. Both have been officially credited with considerable production, much the greater amount coming from tributaries of the Chaudière. The more important of these, which are commonly termed rivers, were *Gilbert* river, which was the first worked and gave the largest output; *Meule* creek, a branch of Mill river; *des Plantes* river, where pre-glacial gravels in places attain unusual thickness; and *Du Loup* river, which, with several tributaries, rises in the higher land near the International boundary. On one branch, the Metgermette, "gold has been found at the unusual heights of 50 to 150 feet above the present stream bed" (McGerrigle, personal communication). Gold is also found in several smaller branches of the Chaudière.

The Ditton area is some fifty miles south-southwest of the Chaudière area. The geological conditions are broadly similar to those of the latter area but the pre-glacial gravels are less deeply buried. The area actually worked is less than two miles in length, along Mining brook, or Little Ditton river. For some fifteen years ending about 1883, a small crew carried on hand work and sluicing here for the owner of the land, but no official returns of recovery are on record. Some isolated occurrences of gold are known also on Salmon river and its branches, between five and ten miles from Ditton river.

The *Stoke Mountain* area, some twenty-five miles west-north-west of Ditton, comprises a range of hills of granite and related rocks surrounded by sedimentary slates and sandstones. Streams that run off the 'mountain' in a southeasterly direction to St-Francis river carry gold; those that run north-westerly to the Wattopeka have little if any. In both directions, the streams have steep gradients, falling as much as 600 feet in four to five miles. Their passage from the granite to the sediments at the edge of the mountain is often marked by steep chutes.

Of the southeast-going streams, six that show gold in rock crevices and small gravel beds take their rise in a swamp-covered area amidst the granite hills. Neither the possibility of pre-glacial gravels beneath the swamp, nor deep gravels and sand where the streams descend upon the sedimentary rocks, seem ever to have been seriously investigated.

Where streams run across the granite they are generally shallow and swift, and, as a consequence, they deposit little gravel. However, along one of these streams—Kingsley brook—an area 500 feet long and 20 feet wide was intensively prospected about 1896. Of it, Obalski (p. 65 wrote: "The work of this company yielded about $4,000 worth of gold, the largest nuggets being worth $45, $39, and $27". McGerrigle (1935, pp. 90-102; 1936, pp. 45-49) has made the latest and most complete study of this area, from which, up to the present, there has been no production of moment.

Moe river is in the western part of Compton township. In the recent gravels of the stream, gold is deposited on bars in times of high water, in such amount as to suggest that some buried pre-glacial deposit is being eroded by this river (McGerrigle, 1936, pp. 33-36).

Other areas, some twenty in number, have recently been examined by H. W. McGerrigle a geologist on the staff of the Quebec Department of Mines. These are systematically described in his report for the year 1935 (1936).

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METALLIFEROUS DEPOSITS

(Except Gold)

ALUMINIUM

There are no known deposits, or even occurrences, of bauxite—the only mineral used as an ore of aluminium—in Quebec or, for that matter, in Canada. However, a large percentage of the world's supply of the metal aluminium is produced in the Province, in the plant of the *Aluminum Company of Canada, Limited,* at Arvida, on the Saguenay river about thirty miles east of lake St-John. The factors that led to the establishment of the industry here were the vast water-power resources of the district, developed by the Company, particularly at its Shipshaw plant, on the Saguenay river, and the favourable transport facilities for bringing in the ore and other materials needed and for shipping the aluminium and other products of the plant.

From the following data, furnished by an official of the Aluminum Company, it will be very evident that a plentiful supply of hydro-electric power, and adequate transportation facilities, are essential to the successful operation of the plant.

"Arvida, in the Saguenay valley, is the site of a large aluminium reduction plant operated by the Aluminum Company of Canada, Limited. This plant produced more than two million pounds of aluminium per day during its peak production period in World War II. The smelting of aluminium ore requires large supplies of hydro-electrical power—around 20,000 kw.hr. per ton—and for that reason the Saguenay valley, with its abundance of water power, was a natural choice for the development of an aluminium industry. Moreover, the site chosen is close to the head of deep-water navigation, another advantage, since Canada has no known deposits of bauxite, the ore of aluminium, and lacks practically all of the other basic raw materials required in the smelting of the ore. Bauxite is shipped to Arvida from British Guiana, cryolite is brought in from Greenland, and fluorspar from Newfoundland. Most of the other materials for aluminium production are also imported, with the exception of soda-ash, small quantities of processed lime used in the bauxite refining process, and small amounts of silicon used in making aluminium alloys. The soda-ash comes from Ontario, the processed lime is made from Quebec limestone, and silicon is derived from quartzite and quartz quarried in Quebec. During the war, as an emergency measure, limestone quarried at Ste-Anne-de-Chicoutimi was utilized".

ANTIMONY

Many years ago, some small shipments of antimony ore were made from a deposit in lot 56 (formerly numbered 28), range I, South Ham township, Wolfe county. The occurrence is a few hundred yards southeast of the Gosford road, and about ten miles west of the town of Garthby, which is on the Quebec Central railway.

The antimony ore occurs in a vein in strongly sheared and silicified arkosic sediments which, immediately to the north, are intruded by pyroxenite, now largely converted to serpentine. The shear zone and the vein strike N.50°E., with vertical dip. The ore minerals are native antimony (chiefly), stibnite (Sb_2S_3), kermesite (Sb_2S_2O), and valentinite (Sb_2O_3).

This occurrence has been known at least since 1863 (Logan, p. 876), in which year it was investigated, and in a small way mined, by Willis Russel. Subsequently, the property passed into the hands of Dr. James Reed and, later, of his estate, *Reed Realties, Limited,* who did further work. In addition to trenching, two or more shafts have been sunk, the deepest to 100 feet, and an adit was driven into the hillside on which the deposit outcrops. This adit, which is 380 feet long, connects with the bottom of the 100-foot shaft.

It is reported that the vein was traced along its strike for a length of half a mile and that it attained in places a width of two feet on the surface and in the shafts. A concentrating plant, which included a battery of five stamps, was installed on the property, and 180 tons of concentrates were shipped (Obalski, pp. 55-56).

Stibnite has been reported at two localities in Gaspé peninsula. One of these occurrences is on lot 9, range VI of New Richmond township, where the mineral occurs in quartz veins and lenses which cut Ordovician quartzite and conglomerate (Mailhiot, p. 55). The other is on the north half of lots 7 and 8, range II, and the south half of lots 5 and 6, range III, of Carleton township. On claims that were staked in the latter locality in 1931, trenching along the foot of a hill 200 feet west of Stewart river, at a point 1½ miles from St-Omer station, exposed narrow veinlets and small pockets of quartz containing fine needles of stibnite, and narrow streaks of this mineral up to a quarter of an inch in width. The rocks in the vicinity seem to be interbedded volcanic slates and limestone. The amount of work done was insufficient to show the extent or possible value of the deposits (Jones; Alcock, p. 131).

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ARSENIC

The arsenic produced from Quebec mines is all recovered (in the form of arsenious oxide, or 'white arsenic', As_2O_3) as a by-product in the course of treating gold ores containing arsenopyrite. This mineral is present in the ore of a number of Western Quebec gold mines, and in two of them it is in very appreciable amount. When such ores are roasted, it is compulsory for the operators to eliminate the highly toxic arsenic fumes from the roaster gases before releasing them into the atmosphere. Prior to, and during the first years of, World War II, the market for the white arsenic recovered was very limited, or non-existent, and, as a consequence, the production had to be stored at the mines. Soon, however, an extraordinary demand arose, and Quebec operators found no difficulty in disposing not only of their current output but also of material that had accumulated from operations in past years. As a result, shipments of white arsenic in 1943 totalled 6,349,074 lb., valued at $428,562. That was the peak year. In 1944, shipments were 2,268,067 lb., valued at $153,944. Throughout this period, the market price of white arsenic was between 6 and 7 cents per lb., or considerably more than double the pre-war price.

The whole of the white arsenic shipped during these years came from two Western Quebec operators: *O'Brien Gold Mines, Limited*, Cadillac township (see pp. 197-199), and *Beattie Gold Mines, Limited*, Duparquet township (see pp. 84-96).

BISMUTH

Native bismuth and bismuthinite are present in appreciable amount in the molybdenite ores of the La Corne and Indian Molybdenum mines, in La Corne and Preissac townships, respectively, and it occurs in other molybdenite deposits in that general section of Western Quebec (see under *Molybdenite*, p. 412). Concentrates produced from La Corne ore, for example, contain 2.5 to 3.5 per cent bismuth. In marketing such concentrates, not only is nothing paid for the bismuth content but its presence may render them unsalable, or at least subject to a penalty.

Recently, a flotation process has been developed by F. K. McLean, of the Bureau of Mines, Ottawa, whereby the objectionable bismuth in the La Corne concentrates can be eliminated, with recovery at the same time of a bismuth tailing as a valuable by-product.

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CHROMIUM

(See Volume II, pp. 444-446)

Eastern Townships

Chromite, the mineral from which virtually the whole of the world's supply of chromium is obtained, is almost invariably present as an accessory mineral in dunite, peridotite, and pyroxenite, and its occurrence in these rocks in the 'Serpentine belt' of the Eastern Townships of Quebec was recorded more than one hundred years ago. In places, the mineral was found in more or less massive form and in 1861 a small shipment of ore was made from such an occurrence in South Ham township, Wolfe county. It was not until 1894, however, that regular mining of chromite commenced. There were shipments each year until 1911 and again, in much larger volume, during the four years 1915-18 of the first World War. No chromite at all was produced during the next twenty-three years, and very little until 1941, when, again under the stimulus of wartime demand, production was intensified and continued at a high level until the end of 1944. In the course of these fifty years, the total output of chromite from Quebec mines probably did not exceed 250,000 tons, of which nearly 75 per cent was produced in eight war years: 115,000 tons in 1915-18 and 70,500 tons in 1941-44. There has been production from well over one hundred deposits. From most of these, shipments have amounted, at the best, to only a few hundred tons; a dozen or more have each produced a few thousand tons; and from only six has there been an output in excess of 20,000 tons.

In all operations, the chromite has been mined in open pits or other surface workings, and most of these have been less than fifty feet, and very few as much as one hundred feet, deep. In the larger operations, however, workings have extended to depths of 300 feet, and even 500 feet, and on at least three properties mining has been carried on underground, from shafts, as well as in open pits.

Mode of Occurrence

Nearly all of the deposits are, at least in the main, of the 'banded disseminated' type. In these, bands of normal serpentinized rock—dunite, peridotite, or pyroxenite—alternate with bands in which there is a heavy concentration of disseminated grains of chromite, to the extent that some bands consist of practically solid chromite. Stockwell, who made a detailed study of the deposits during the years 1940-42, found (p. 76) that, with few exceptions, these bands of heavy chromite concentration are confined to the dunite. At the Sterrett mine, near St-Cyr, Cleveland township, however, some ore lies between dunite and peridotite, and at the Montreal pit, on lots 25 and 26, range II of Coleraine township, some is in peridotite.

Generally, the bands have a northeasterly trend, paralleling that of the serpentine belt and also the folding in the adjacent sedimentary rocks. They are usually narrow, half an inch to an inch and a half wide, with a tendency for the rock bands to be narrower than those with high chromite content. Series of such bands form ore zones which range in width from a few inches to many feet. Most of those mined have been six to twenty feet wide, but, exceptionally, the ore zone has a width of as much as sixty feet. The bands wedge out along their strike and also with depth, so that the orebodies tend to be lens-like or chimney-like. Some, however, are highly irregular in form. Lengths and depths of the order of fifty feet are common. Several such bodies may occur closely adjacent to one another, and on two properties the ore zones have been traced for a length of 1,500 feet and extend to a depth of four hundred feet and possibly more.

In a few of the deposits, and notably those in the Asbestos Corporation pit on lot 28, range I of Ireland township, and in the Standard pits in Block *A* of Coleraine, an interesting type of ore, known as 'grape ore', accompanies the banded disseminated ore. The 'grapes' are rudely spherical or ellipsoidal nodules, single or in clusters, consisting of practically solid chromite. They range in size from a quarter of an inch to about two inches.

Origin of the Chromite

There is general agreement among those who have studied the deposits that the chromite is of magmatic origin. In this connection, Stockwell says (p. 80): "All the chromite is believed to be of magmatic origin, although deposition probably extended from early to late magmatic stages. The close association of the deposits with dunite suggests a magmatic origin, for ore deposited by circulating solutions should not be closely confined to one rock type, especially when this rock is intimately mixed with other types. Solutions should follow shear zones or other openings, but there is no evidence that the tabular and lenticular deposits were formed along such passages. Massive and disseminated chromite, in tabular and lenticular deposits, are cut by dykes of pyroxenite. The dykes are probably late differentiates of the basic magma and consequently place the period of chromite deposition within the magmatic phase. Banded ores, in which layers of disseminated chromite alternate with layers of dunite, contain some dunite layers that cut sharply across chromite layers; this chromite must, therefore, be of early magmatic origin and must have crystallized even before the rock was completely solid. The same conclusion is indicated for those lenses of massive ore which, though enclosed in dunite, are intersected by dykelets of dunite that branch from the enclosing rock. In some disseminated ore, the chromite grains hold inclusions of fresh olivine that apparently have been protected from the magmatic waters that elsewhere have thoroughly serpentinized the matrix and wall-rock; this indicates that the ore formed prior to serpentinization, which probably took place toward the end of the period of crystallization of the rock.

"The irregular small masses of chromite that send branch veinlets into enclosing rock, and the chromite that fills irregular fractures or spaces between fragments of breccia, are clearly younger than the rock. Since, however, this ore is confined to dunite, it must be of quite local origin. This chromite, like that of the tabular and lenticular deposits, is cut by dykes of pyroxenite, thereby indicating that the ore is of magmatic origin. It is suggested that the chromite may have been partly or almost completely crystallized and mixed with still liquid olivine-rich magma when it was forced into the openings in the rock.

"The heavily disseminated to nearly massive chromite that was introduced along shear zones is younger than the chromite of the disseminated lenticular deposits . . . This ore is of minor importance, occurs only in association with other types of occurrence, and appears to be of local origin. There is no reason to suppose that it did not form in the same way as the ore that fills the fractures, although it may be slightly younger".

Cooke (p. 148), however, found veins of solid chromite filling fault fissures in the peridotite and replacing that rock at the vein walls, and he concluded that such ore could have been formed only by the introduction of chromite-bearing solutions into faults and associated fissures.

Denis (p. 31), also, observed, though very infrequently, chromite filling fractures in the serpentine, but he noted that this chromite had a fine, brown, earthy appearance and was "obviously crushed chromite which had been mechanically introduced along small fault planes". In some deposits, also, he found chromite enclosing small fragments of serpentine, and tongues of chromite penetrating that rock. These occurences, he thought, might be explained as the result of "interpenetration of two immiscible portions of a partially solidified rock mass". He agrees (p. 52) that some chromite may have been deposited from solutions: "During the period of final consolidation of the intrusive mass and the partial serpentinization of the more basic phases, mechanical readjustments were effected, notably by fracturing of the solid portions, and it is possible that some of the chromite was redistributed by solution and redeposition, but the writer believes that any such redistribution by solutions was of no importance in the formation of the orebodies".

Composition of the Chromite

The chromite in these deposits nowhere approaches very nearly the theoretical formula $FeO.Cr_2O_3$, with 68 per cent Cr_2O_3 and 32 per cent FeO. Analyses show that some MgO is invariably present, isomorphously replacing FeO, and that some of the Cr_2O_3 is similarly replaced by Al_2O_3 and Fe_2O_3. In twenty analyses of selected chromite (free from gangue) appearing in reports by Poitevin (p. 19) and Denis (p. 47), the range in composition is as follows:

Cr_2O_3.........	45.00 to 57.81%	FeO...........	8.70 to 23.29%
Fe_2O_3.........	0.44 to 11.50%	MgO..........	7.09 to 17.62%
Al_2O_3.........	9.07 to 23.63%	CaO...........	*Trace* to 0.95%
Chromium-iron ratio.....................		1.77 : 1 to 3.34 : 1	

Uses of Chromite

Chromite finds its chief use in the manufacture of alloy iron and steel. The presence, in steel, of a small amount of chromium increases the hardenability, the strength at high temperatures, and resistance to corrosion. Normal specifications for 'metallurgical' chromite call for a hard, lumpy ore containing a minimum of 48 per cent Cr_2O_3 and having a chromium-iron ratio of 3:1 or higher. Although from the bulk of the ore mined in the Eastern Townships it is possible to produce a concentrate containing 48 per cent Cr_2O_3, the chromium-iron ratio in this concentrate is generally below 3:1 and probably averages nearer 2.5:1. This, in large part, explains the excessive difficulty that Quebec operators have found in maintaining profitable operation except under abnormal conditions such as are likely to obtain in time of war. During the second World War, 'metallurgical' chromite containing 40 per cent Cr_2O_3, or even less than this, was marketable. It may be pointed out that in chromite of theoretical composition $FeO.Cr_2O_3$, the chromium-iron ratio would be somewhat below 2:1. As already mentioned, however, the mineral, as it occurs, is invariably an isomorphous mixture, and it so happens that in many of its deposits there has been more replacement of iron than of chromium by other metals, with consequent raising of the chromium-iron ratio.

Chromite is also used by the metallurgical industry for making linings and hearths for basic open-hearth and other furnaces. For such purposes, the ore must be high in Cr_2O_3 plus Al_2O_3 and low in iron and silica. It is processed into plastic cement and brick, and sometimes is used in combination with magnesia. Several types of chrome-magnesia refractories are manufactured by *Canadian Refractories, Limited*, in their plant at Kilmar, in Grenville township, Argenteuil county.

Chromite is the raw material for making a variety of chromium salts that find uses in numerous industries—for example, as dyes and pigments, for tanning leather, and for chrome plating. The chemical industry requires an ore high in chromium and low in silica.

Some Eastern Townships Deposits

Production of chromite in the Eastern Townships has come chiefly from deposits in Coleraine township, Mégantic county, in the area extending southward and eastward from Black Lake. Outside of this area, the only important producer has been the Sterrett mine near St-Cyr, in Cleveland township, Richmond county, about forty miles southwest of Black Lake. Twenty miles still farther south, there has been some production from deposits in the vicinity of Webster lake, in Orford township, Sherbrooke county. Brief descriptions are given below of the more important operations in each of these areas.

Reed-Bélanger Deposit

This deposit is on lot 19, range X, Coleraine township, two and a half miles south of Black Lake station. It is by far the largest chromite deposit yet discovered in the Province. Chromite was first found here in 1894 and in that and the two following years there was a production of a few hundred tons of high-grade ore. What have since become the main orebodies were discovered in 1916, and from then until 1921, when operations were suspended, some 55,000 tons of ore were mined, 30,000 tons from the northwest part of the property, mostly from underground workings, and the balance from open pits in the southeast part. The property lay idle until 1942, when it was taken over by Wartime Metals Corporation and operated under the name *Chromeraine Project*. A new shaft was sunk to a depth of 500 feet, and connection made at that horizon with the old shaft workings by a drift 300 feet long. A concentrating mill with a capacity of 375 tons per day commenced operation early in 1943 and production continued until late in 1944. At that time, adequate supplies of chromite for war purposes had become available, and all operations were discontinued.

The orebodies consist of a series of lenses lying within serpentinized peridotite, the main one having a length of 500 feet and a width of eight to sixty feet. The ore zone as a whole has been traced for a length of 1,500 feet, with width up to 100 feet, and it has been estimated that originally it contained at least 150,000 tons of milling ore. The ore is chiefly the banded disseminated type containing 12 to 15 per cent Cr_2O_3, but within this are 'pockets' of high-grade ore.

Greenshields Pit

The workings known as the Greenshields pit, or the No. 1 pit of the Black Lake Asbestos and Chrome Company, are in block *A*, Coleraine township, on the west slope of Provençal hill, two miles south of Black Lake station. The deposit was discovered in 1898 and between that year and 1909 it produced some 30,000 tons of ore, more than the combined production of all the chromite mines of the Eastern Townships up to that time. Apparently, the whole of this came from one continuous, pipe-like orebody, 60 feet long, 5 to 50 feet wide, and extending to a depth of 340 feet. When the open pit had reached this depth, an inclined shaft was put down from the surface nearby and cross-cuts were driven from this to the pit at the 250- and 340-foot levels. The workings were unwatered in 1916, but no ore was produced. Some shipments of ore were made in 1943 and 1944, however, during the second World War.

Montreal Pit

This pit is on lots 25 and 26, range II of Coleraine township, about six miles southeast of Black Lake station. It is known also as the Black Lake quarry, or the Paré pit.

Between 1894 and 1900, 3,200 tons of ore was produced from this deposit, and in 1903 about 500 tons of concentrates were shipped. The most active years, however, were during the first World War, when, between 1915 and 1918, production amounted to 20,000 tons. Appreciable shipments were made from this property during the years 1943-44.

The workings consist of a number of pits spaced over a length of 425 feet, the largest having dimensions 125 by 75 feet and a maximum depth of 60 feet. The ore is of the disseminated type with discontinuous small pockets of massive chromite. The original orebody, which dips northwest at a low angle, was followed to the pit bottom. It was fifteen feet thick at the surface. Where this ore has been removed, several boreholes have been sunk to test the underlying rock. One hole, inclined northwest at 60°, encountered six bands, or lenses, of ore, one to ten feet thick and totalling thirty-one feet, in a depth of ninety-eight feet. The log of this hole as reported shows the intervening rock as 'serpentine', but some of the rock classed as serpentine is granite (Dresser, p. 86).

No. 6 Pit of Black Lake Asbestos and Chrome Company

This pit is on lots 27 and 28, block *B* of Coleraine township, one mile east of Black Lake station. Some comparatively large lenses of ore were mined in this pit in 1916-17. Production in 1916 amounted to about 14,500 tons and the total ouput in the two years was probably well over 20,000 tons. The pit has been operated also for the production of asbestos.

Caribou Deposits

These deposits, in block *A*, Coleraine township, a few hundred feet northwest of Caribou lake, are among the largest known in the Black Lake district. A pit was opened here in 1895 and production from this and neighbouring pits was continuous until 1909 and again, after a five-year interval, from 1915 until late in 1918. In the latter year, the *Black Lake Asbestos and Chrome Company*, then owners of the property, sank a shaft on the deposit and a considerable tonnage of ore was mined on levels at 115 and 188 feet as well as from the main open pit, which was 150 feet in diameter and 60 to 70 feet deep. It is estimated that the total production of chromite from this property exceeded 21,000 tons. In 1942, the deposit was explored by diamond drilling, carried out by *Asbestos Corporation, Limited,* on the recommendation of C. H. Stockwell and J. W. Ambrose, of the Geological Survey. This drilling indicated a considerable body of ore beneath the old underground workings. Mining operations, however, were not resumed.

In his description of the ore occurrence, Stockwell says (pp. 84-85): "The deposit consists of several lenses in a zone 1,200 feet long and up to 170 feet wide, which strikes easterly and dips 30 to 40 degrees north. The lenses tend to be concentrated in certain sections, but are too widely scattered to permit economic mining of the whole zone. There is no information on the average chromium-iron ratio of the ore, although it is reported that a sample of crude ore containing 43.2 per cent Cr_2O_3 had a ratio of 2.8 to 1 and that three samples of cleaned chromite containing 52.2 to 55.5 per cent Cr_2O_3 had ratios from 3.1:1 to 3.3:1".

Sterrett Mine

This mine has been the only large chromite producer outside of Coleraine township. It is in lots 7 and 8, range X of Cleveland township, two and a half miles southeast of Saint-Cyr station on the Canadian National railway. This locality is some forty miles southwest of Black Lake. During 1917-18, about 15,000 tons of crude ore and 823 tons of concentrates were shipped from the property. This came from several open pits and also from underground workings on two levels from a shaft 196 feet deep.

In 1940, the property was acquired by *Chromite, Limited.* A new shaft was sunk to a depth of 400 feet and a concentrating plant was installed and commenced operating in 1942. It had a capacity of 150 tons per day. Production, including crude ore and concentrates, reached as high as 1,500 tons per month, and from 1942 until operations were suspended after the end of the war, the Sterrett mine was the largest producer of chromite in the Province.

Numerous pits have been opened along the ore zone, which has been traced for a length of 1,400 feet. The ore occurs in a series of lenses, from a few inches to eighteen feet wide, lying within a band of serpentine.

Webster Lake Area

The most southerly deposits from which there has been production are in the vicinity of Webster lake, Orford township, about twenty miles south of St-Cyr. During the first World War, a few hundred tons of ore was shipped from a property on lot 4, range XII, owned by the *Fletcher Pulp and Lumber Company.* When the demand for chromite again arose during the second World War, the area was examined by Stockwell.

Eighteen deposits, all within an area four miles long and a mile wide, were found and mined. Almost all the production came from what is known as the Orford No. 4 deposit, which consists of numerous pockets and pod-shaped bodies of chromite lying along a zone 180 feet long and 20 feet wide. The largest body was 16 feet long, 35 feet deep, and 5 feet thick. The chromite was of very good quality, car lots grading 35 to 40 per cent Cr_2O_3 with chromium-iron ratio 2.9 to 3.5:1. All operations were suspended late in 1942 (Stockwell, p. 83-84).

Other Occurrences of Chromite

Awantjish Township, Matapédia County

About ten miles southwest of the west end of Matapédia lake, in the southern part of ranges III and IV, Awantjish township, Silurian sediments are intruded by a body of rock which consists in large part of serpentinized peridotite. It has a length, east-west, of three miles and a maximum width of 2,000 feet. The village of La Rédemption is a few hundred feet beyond its western end. The rock contains disseminated grains of chromite with, here and there, small 'pockets' of massive ore. The occurrence was described in 1941 by Aubert de La Rüe (pp. 24-25). At that time some surface work had been done, chiefly on lot 5, range III, and lots 10 to 12, range IV, and had exposed a lens of chromite, fifteen feet long and ten inches wide. Further surface exploration and some diamond drilling was carried out in 1944 by the Alchrome Prospecting Syndicate on lots 11 to 14, range IV. It was reported that the results of that work were not encouraging.

Gaspé Peninsula

Mount Albert.—It has long been known that chromite occurs in the serpentinized peridotite mass of mount Albert, Gaspé Nord county and that, in many places, loose blocks of chromite float are to be found. The mountain is within the limits of Gaspé National Park, but, as a war measure, some prospecting permits were granted in 1942, and prospectors found chromite in several localities, chiefly in Lapotardière and Courcelette townships. In 1943, the Chromium Mining and Smelting Corporation investigated these discoveries, but operations were suspended in the following year.

Weir Township, Bonaventure County.—Some surface work was done in 1942 by the Chromium Mining and Smelting Corporation on a group of chromite claims in Weir township, not many miles from the southeast shore of Gaspé peninsula. Silurian sediments are intruded by a body of peridotite, now much serpentinized, which has been traced for a length (northeast) of about two miles and has a width ranging up to 1,000 feet. Grains of chromite are disseminated through the rock, and in some places McGerrigle, who examined the occurrence for the Quebec Department of Mines, found some blocks of chromite float. He did not observe any heavy concentration of chromite in the rock in place.

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COBALT

Veins containing smaltite and other Cobalt minerals have been found at several localities in Fabre township, Témiscamingue county, on the east side of lake Témiscamingue. Some years ago, a considerable amount of development work, including the sinking of prospect shafts, was done on some of the occurrences but it failed to reveal any deposits of economic interest.

The rocks outcropping along the east shore of lake Témiscamingue are of Huronian age, consisting chiefly of quartiztes of the Lorrain formation. These are followed eastward by conglomerate, quartzite, and greywacke beds of the underlying Gowganda formation, the two formations occupying a rudely triangular area whose apex is well beyond the north-south centreline of Laverlochère township, some sixteen miles east of the lake shore. Scattered through this area are numerous. relatively small, bodies of post-Huronian diabase. As a result of detailed mapping in Fabre township, Harvie concluded that all the outcrops of diabase in that township represent parts of a single horizontal intrusive sill.

The Huronian sediments on the east side of lake Témiscamingue are the eastward continuation, and the termination, of a belt of these rocks which have wide distribution in the Province of Ontario, westward from the lake, where, also, they are intruded in places by sills of diabase. In Ontario, the rocks of the two formations have been designated the Cobalt series and, in the Cobalt, Gowganda, and other districts they, and also the diabase intruding them, have been found to contain veins carrying native silver and smaltite, with lesser amounts of cobaltite, niccolite, native bismuth, and other minerals. Not only has there been a very large production of silver from mines in these districts, but for many years they furnished almost the whole of the world's supply of cobalt and they remain the only mines in Canada producing cobalt ores.

Following the discovery and development of the silver-cobalt veins of the Cobalt district there was much intensive prospecting in Fabre township in the hope of finding similar veins there. A number of veins containing small amounts of smaltite and with pink staining of 'cobalt bloom' (erythrite) were found, and native silver was reported but was not seen by Harvie. These veins are all in the diabase; apparently none were found in the Huronian sediments. The following descriptions of some of the occurrences are reproduced from Harvie's report (p. 30).

"The diabase of the lake shore in the vicinity of Quinn's point, on lots 35 to 41 of range II (Fabre township), contains numerous veins. On lot 35, on the slope overlooking Lavallée's bay, a shaft twenty feet deep has been sunk on a calcite vein two inches wide traceable for several chains and showing abundant cobalt bloom. On the west side of the same hill there are two shafts, one of them fifty feet deep, on an aplite dyke two inches wide showing cobalt and nickel blooms, pyrite, and smaltite; the other, on a calcite vein also showing pyrite and smaltite, had reached a depth of forty feet when visited. On lot 37, a shaft seventy feet deep has been opened on a calcite vein five inches wide in places and showing small amounts of pyrite, chalcopyrite, and smaltite.

"On the Mill claim, lot 44 of range IV, there are very numerous veins cutting the diabase, and a few cutting a Keewatin greenstone. These have a gangue chiefly of calcite, and carry a considerable amount of smaltite. A shaft twenty-seven feet deep has been sunk on a two-inch calcite vein. The area of diabase exposed is very small, but on account of the exceedingly abundant small veins, all displaying cobalt bloom, this property has locally been considered very promising.

"Lot 3 of range V North has been prospected by the *Terra Nova Mines, Limited*, with a well equipped steam and compressed air plant. The diabase is in contact with the Keewatin, and cobalt-bearing veins are found in both rocks. The main shaft in the Keewatin is 110 feet deep with about 100 feet of drifting and cross-cutting at the 100-foot level. The main vein is a shattered zone four or five inches wide, but containing a clean vein in places three inches thick. The filling is calcite, smaltite, hematite, chalcopyrite, and fragments of aplite".

These various operations did not reveal deposits of sufficient size or grade to be of commercial interest, and all were abandoned many years ago.

Reference

Harvie, Robert, *Geology of a portion of Fabre Township, Pontiac County;* Mines Branch, Dept. Coloniz'n, Mines & Fisheries, Que. (1911).

COPPER

Western Quebec

Copper sulphide mineralization has been found at numerous localities in the Rouyn-Bell River area of Western Quebec. In most of these occurrences, the copper is closely associated with gold mineralization and, as a matter of convenience, the deposits are described in the preceding section of this volume dealing with the gold deposits. More detailed descriptions, however, are given below of the two properties from which nearly the whole of the copper production of Western Quebec has been obtained: those of Noranda Mines, Limited, and Waite Amulet Mines, Limited. Descriptions of other copper sulphide deposits and occurrences may be found by referring to the *Index* at the end of the volume.

Noranda Mines, Limited*

The property of Noranda Mines, Limited, is in the northwest quarter of Rouyn township, extending westward from the shore of Tremoy (Osisko) lake, immediately north of the town of Noranda. The claim in which most of the ore occurs was staked by Edmund Henry Horne in 1920, and the mine that was subsequently developed is known as the *Horne Mine.*

In 1922, the Horne claims were acquired by the Thompson-Chadbourne Syndicate, who owned other groups of claims in the vicinity, and Noranda Mines, Limited, was organized to develop the property. Trenching on the Horne claims in 1923 exposed a large body of copper and iron sulphides now known as the *A* orebody, and, following encouraging results from diamond drilling, the sinking of No. 1 shaft was commenced. Numerous other orebodies were discovered in subsequent years by diamond drilling and in underground workings. They have been developed and mined from six shafts. In 1940, No. 2 and No. 3 shafts, from which most of the mining has been carried on, had depths of 2,754 feet and 2,975 feet, respectively, No. 5 shaft was down to 4,094 feet, and No. 6 shaft, commencing at 2,975 feet, was being sunk with an objective of 5,000 feet.

A smelter was erected and started operation late in 1927. To the end of 1945, production had amounted to 4,182,386 ounces of gold, 8,358,971 ounces of silver, and 1,154,372,817 pounds of copper. The mine is thus one of Canada's leading gold and copper producers.

The annual report to shareholders, issued by the Company at the end of 1945, gave indicated ore reserves above the 2,975-foot level, as of January 1st, 1946, as follows:

Type of Ore	Amount	Copper	Gold
Sulphide ore, over 4%.	5,127,000 tons	7.08 per cent	0.148 oz. per ton
Sulphide ore, under 4%. . . .	15,228,000 "	0.68 "	0.197 " "
Siliceous fluxing ore	853,000 "	0.10 "	0.107 " "

Copper anodes produced at the smelter are shipped to the Montreal East plant of Canadian Copper Refiners, Limited, subsidiary of Noranda Mines, Limited, where, in the process of refining, their appreciable content of selenium and tellurium is recovered, and also gold and silver.

General Geology

The Noranda property is situated within an area occupied entirely by Early Precambrian rocks, characterized by the complexity of rocks types and structures common in such terrain. The mine presents features of unusual interest in the size, number, and variety of orebodies, their mineralogical associations, and their rather exceptional content both of gold and copper.

The rock formations in the immediate vicinity of the mine, with the exception of some dykes and relatively small intrusive bodies, are of Kee-

*By Peter Price, Chief Geologist, Noranda Mines, Limited.

watin-type. No rocks corresponding to the Temiscamian or Cobalt series are present. The rocks with which the orebodies are in intimate association may be tabulated as follows:

INTRUSIVES

Younger diabase: *D* dykelets
E.-W. diabase dyke
N.-S. diabase dyke
Syenite porphyry dykes and stocks
Metadiabase (quartz diabase, 'older gabbro')

KEEWATIN-TYPE EXTRUSIVES

Quartz porphyry
Rhyolite, rhyolite breccia and agglomerate, rhyolite tuff, andesite, etc.

Keewatin-type Rocks

Immediately to the north of the mine is a major structural break to which the name *Horne Creek fault* has been given. About 2,000 feet south of this fault is another important dislocation, known locally as the *Andesite fault.* Between these is a wedge-shaped area of acidic flows, breccias, and tuffs. It is in these rocks that the orebodies occur.

The Horne Rhyolites

Extensive work on the 2nd (200-foot), 9th (975-foot), 21st (2,475-foot), and 33rd (3,975-foot) levels has given a fairly comprehensive picture of the composition and structure of the rhyolites and related rocks. The accompanying plans (Figures 54-56) and sections (Figures 58, 59) show their chief features. Most important among this group of rocks is a large mass of *rhyolite breccia* and *interbedded tuffs.*

From the surface down to the 975-foot level, the mass is predominantly breccia. It is at least 1,500 feet long, has an average width of 800 feet, strikes roughly N.45°W., and dips vertical to steeply southwest. It is cut off to the north by the Horne Creek fault. On the south it does not reach the Andesite fault but becomes involved in, and is finally terminated by, a large northeasterly striking fault and shear system yet to be described.

The rock is a coarse fragmental, with fragment size ranging from four feet to a quarter of an inch, but averaging probably an inch and a half. It is believed to be agglomeratic, but subsequent alteration has rendered it highly quartzose. Hence its origin is still in doubt, especially when its relations to the tuffs are considered (see below).

From the 975-foot level down to the 3,975 foot-level, the breccia interfingers both horizontally and vertically with considerable masses of finely banded rhyolite tuffs. The tuff beds reach thicknesses up to 400 feet and include frequent interbeds of fragmentals ranging from six inches to twenty feet in thickness. Often, the tuffs abruptly terminate along their strike against breccia, with no distortion of the bedding.

The bedding strikes N.45°W. on the 975-foot level but gradually changes to N.75°W. on the lowest levels, where it about parallels the Andesite fault. Dips are generally very steep to the southwest. Structural data have proved meagre, but the tops of the beds appear to face northeast, indicating a slight overturn.

To the west of this breccia and tuff mass lies a group of *acidic fine grained rhyolites*. Alteration has been so intense, however, that little or no evidence remains to make possible their subdivision into separate flows or the determination of their structure.

Farther to the west of this group, another series of breccia and tuff bodies occur. It is possible that this group may belong to the same horizon as the main breccia mass, representing its folded extension, but now cut off by the Andesite fault (see under *Structure*).

To the east of the main breccia lies another group of acidic rhyolites followed unconformably, still farther to the east, by a series of andesites striking north-south and dipping 45° east. Indications point to this being a fault contact.

Rocks North of the Horne Creek Fault

Work on the Horne, the Joliette (Brownlee), and the Quemont properties has shown that the extrusives in the area north of the Horne Creek fault are acidic flows, breccias, and tuffs. Their general strike is N.60°E. to east-west and they continue with this trend across the north shore of Osisko lake. The whole group appears to dip steeply south and to face in the same direction. In this area, also, there are large masses of quartz porphyry (see under *Intrusive Rocks*).

Rocks South of the Andesite Fault

The Andesite fault forms the north boundary of a series of lavas of intermediate composition, locally known as '*the andesites*'. Original textures and structures are fairly well preserved and this belt of lavas is seen to consist of thin flows, generally north-facing. They form a belt having an average width of 600 to 800 feet. The general dip is about vertical. So far as is now known, the strike of the andesites closely conforms to that of the Andesite fault.

Intrusive Rocks

Metadiabase

The term *metadiabase* was applied in the early days of the mine to a group of intrusive rocks which, with one possible exception, are the oldest of such rocks in the area. The name has been retained in mine usage, although it is now known that this 'metadiabase' includes intrusives of at least four different ages, and of composition ranging from gabbro to quartz diorite. One peculiar type has been termed albite diabase. These rocks have sometimes a granitic, sometimes a diabasic, texture, and frequently the one type grades into the other. The albitic type usually has a radial texture.

Near the surface, a large mass of metadiabase lies to the north and northeast of the main orebodies, and extends north of them along the Horne Creek fault. Numerous dykes extend from this large mass southwestward toward and beyond No. 3 shaft. In general, they follow — and are apparently controlled by — the northeasterly trending shear zones and have a general southeasterly dip.

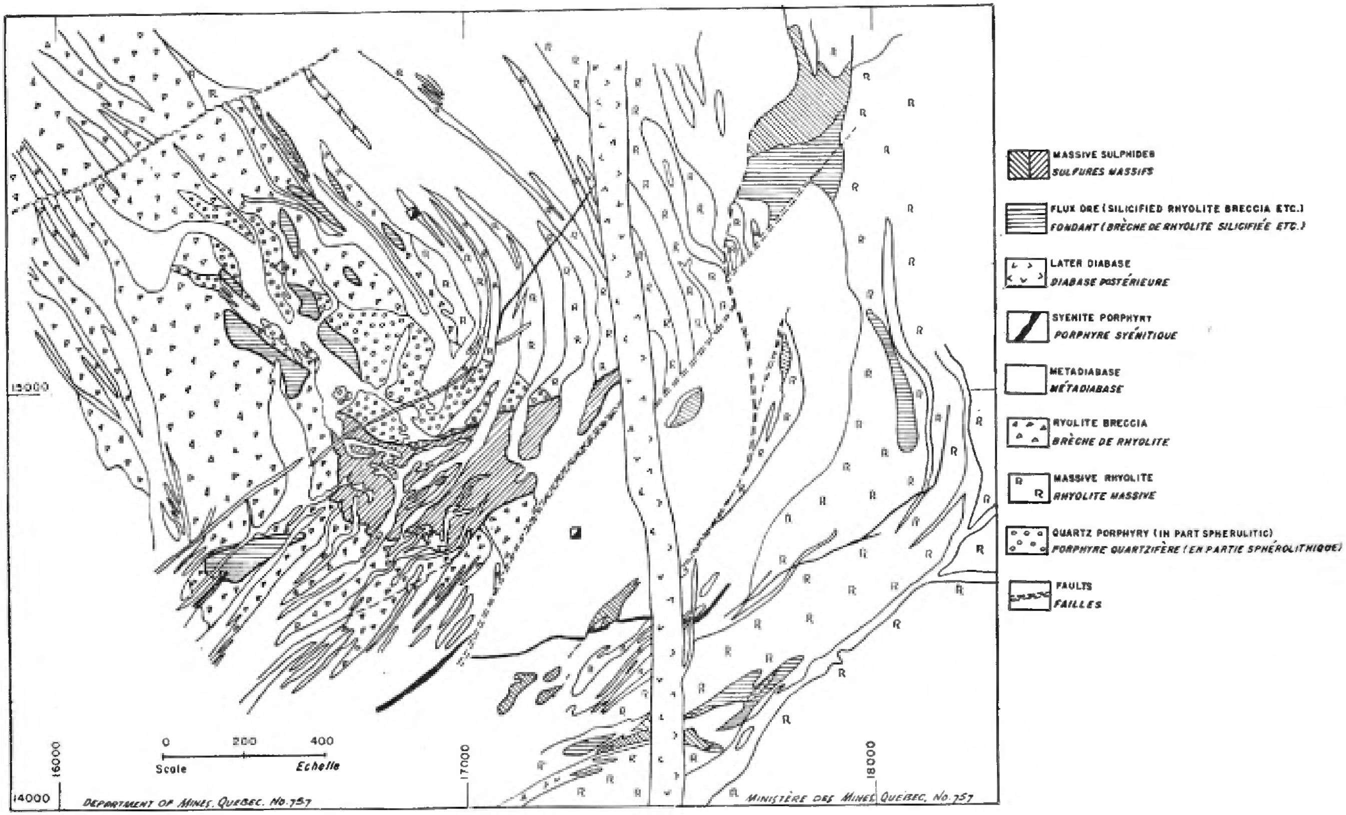

FIGURE 54.—*Horne mine, geological plan of 2nd level.*

In detail, the structure of the metadiabase intrusives is complicated. They vary greatly in thickness, sudden changes in dip and strike are common, and they tend to split and finger-out laterally and vertically. In general, they form a great network all through the upper portions of the zone in which the orebodies occur, but their easterly dip carries them out of the main ore zone at the lower horizon (compare 2nd and 21st levels, Figures 54 and 56).

Syenite Porphyry

This rock occurs in the mine area as well-defined dykes which range in width from six inches up to twenty feet. To the east and also to the

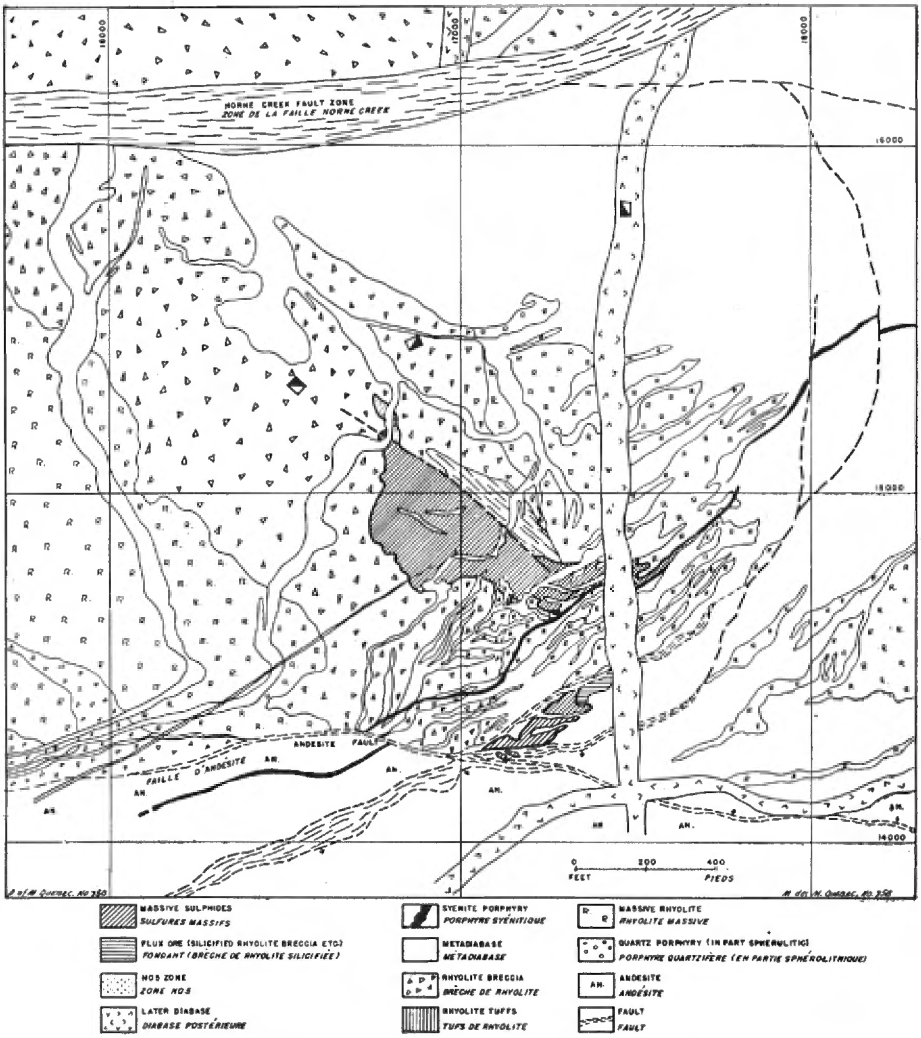

FIGURE 55.—*Horne mine, geological plan of 9th level.*

southwest of the mine, large, stock-like masses of syenite porphyry have been found. They are from 300 to 1,000 feet long and from 200 to 600 feet wide. The mine dykes are no doubt offshoots from these larger masses. One of these dykes in the central mineralized zone has been traced from the surface down to the lowest levels of the mine.

The rock ranges in colour from reddish-pink to dark grey and generally presents a distinctly porphyritic appearance. Variations in composition, both of the original rock and as a result of alteration, are common, with a range from granite porphyry to syenite porphyry. The porphyry cuts, and is chilled against, the rhyolites, andesite, and metadiabase. It is thus the second oldest of the intrusives.

Powell Granite and Quartz-Feldspar Porphyry

No Powell granite, and only doubtful representatives of the porphyry, have so far been found in the mine area. Immediately north of the Horne Creek fault, however, these rocks occur in large quantity.

North of the fault, at the surface, the eastern margin of the Powell granite batholith is 4,000 feet west of the mine. At the 3,975-foot level, however, drilling through the fault has shown that here it lies immediately north of the mine, indicating that the granite surface has a strong easterly plunge. Quartz-feldspar porphyry, however, is present from the surface to the lowest levels north of the mine.

The age relations of the granite are fairly well known. It is older than the 'later diabase' and younger than the metadiabase. Its exact age relationship to the syenite porphyry is still in doubt, but it is believed to be younger.

The age relationships of the quartz-feldspar porphyry are confused. It is probable that the large masses are related closely in time to the Powell granite, but some of the dykes and flat sills appear to be older even than the metadiabase. In any case, there is strong evidence that most, at least, of the occurrences of quartz-feldspar porphyry are intrusive.

Later Diabase

Two 'later diabase' dykes, each having a known length of at least four miles and averaging more than eighty feet in width, intersect south of No. 3 shaft. They are members of the great suite of such dykes that cross the region and are locally named the *North-South dyke* and *East-West dyke*, respectively. Both are practically vertical, but the north-south dyke shows a slight dip to the east and the east-west dyke a slight dip to the south. Their positions are shown on the accompanying plans (Figures 54, 55, 56).

Where fresh, the rock is a typical quartz-augite diabase, moderately coarse grained, and black to greyish-green in colour. Characteristically, the dykes show much wider marginal chilling (3-inch) than the metadiabase.

These dykes, and their small offshoots, cut all the other rocks at the mine. The east-west dyke is believed to cut the north-south dyke, but conclusive evidence on this point is lacking, despite the fact that one crosses the other and they appear to intersect. No age correlation involving such terms as Keweenawan or Matachewan is attempted here, but the evidence at hand points to the former age. Discussion of the age of these dykes rela-

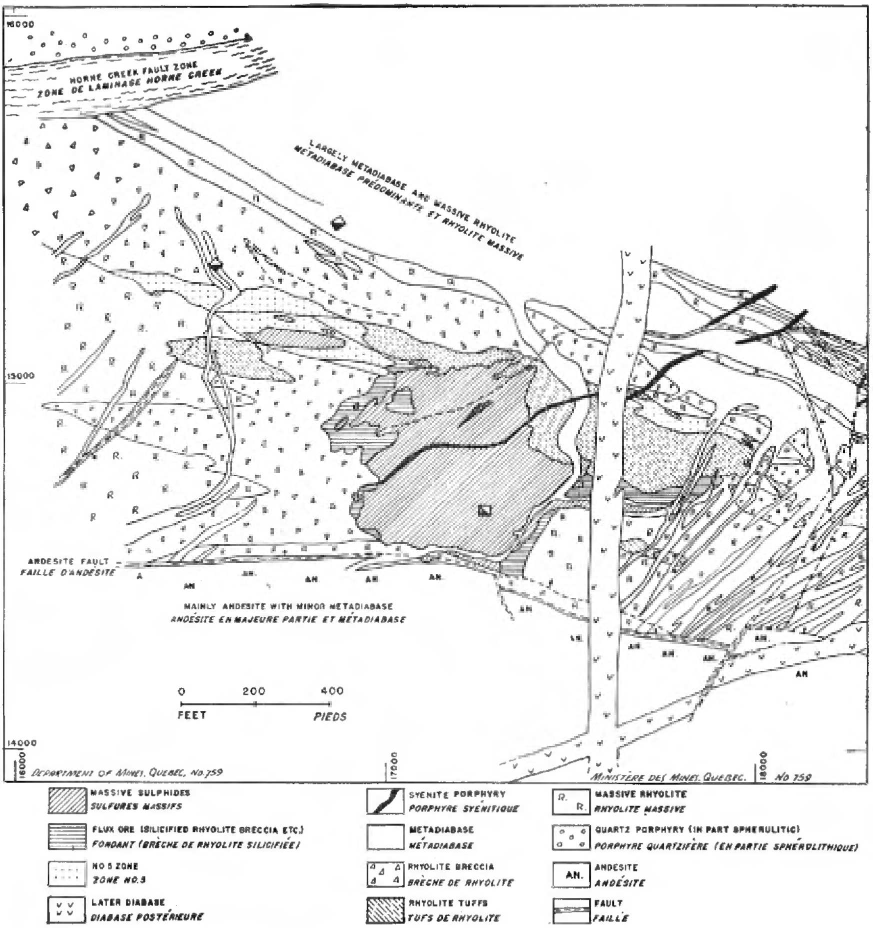

FIGURE 56.—*Horne mine, geological plan of 21st level.*

tive to the ore is deferred until more data on structure and ore deposits have been given.

Structure

Figure 57 (A, B, C, D, E) is a series of partly diagrammatic sketches to show the probable sequence of events giving rise to the present structure.

Figure 57-A presents possible trend lines as they may have appeared before the intrusion of the metadiabase. It illustrates the belief that, for the most part, the folding and faulting took place before this intrusion. Moreover, whilst movement along both the Horne Creek fault and the Andesite fault was no doubt several times repeated, the formation of these major structural breaks was caused by, and is coincident with, the period of folding.

The Horne rhyolites are, according to this conception, a wedge-shaped fragment of a folded structure, faulted between two distinct structural units.

The magnitude of the movement on these faults is shown by the fact that, on both, the horizontal component is at least 2,500 feet, with a maximum which, in the case of the Horne Creek fault, may run into miles. To date, it has not been possible to trace any member of the Horne rhyolites over a sufficient length to outline their detail structure positively. Reference was made, in describing the rhyolites, to the possibility that the breccias and tuffs to the west are actually the same horizon as the main breccia mass. This possibility is indicated in Figure 57-A and would mean an anticline with an axial strike of S.60°E. and most of the crest and part of one limb sliced off by the Andesite fault.

However, the question as to whether the structure of the rhyolites is anticlinal or synclinal, or where the remainder of the fold is at present, has only a minor bearing on the ore deposition. The most vital fact is that folding, and particularly large-scale faulting, had reduced a block of favourable rocks to a state of structural weakness sufficient to afford a relatively easy passage for later intrusion and mineralization.. Further, the large throughgoing and depth-searching faults, shears, etc., acted repeatedly as planes of weakness up to and during the critical time of the mineralization.

Into this highly disturbed area, and obliterating much of the older faulting, a swarm of metadiabase bodies were intruded (see Figure 57-B.) The general structure of this intrusion has already been discussed and its close relation to the old lines of weakness pointed out.

Faulting was then renewed (Figure 57-C). There were at least two distinct periods of movement, giving rise to a complex series of faults. In part, the faulting followed the old directions (*i.e.*, the major breaks and their minor offshoots), but large, curving shear and fault zones also cut the metadiabase, while conforming roughly in strike and dip to the general structure of the latter.

The intrusion of the syenite bodies and dykes followed or accompanied the post-metadiabase faulting.

The next event was the intrusion of the later diabase dykes (see Figure 57-D). It should be noted that there is difference of opinion as to whether the mineralization preceded the later diabase dykes or followed them closely. Hence the sequence given in Figure 57-D and E should be accepted with this reservation. However, it represents the most logical interpretation of existing evidence, subject to other considerations to be discussed under the caption *Age of Mineralization* on page 360.

The dykes were intruded up and along regional lines of weakness bearing little relation to previous faults and structures. Displacement along these dyke fractures appears to have been of a very minor nature.

Figure 57-E follows the present geology closely and shows the area after the mineralization period, and after the last movement along the Horne Creek fault. Even the last movements along this fault are difficult to diagnose. Going north, the north-south dyke shows a horizontal displacement of 600 feet to the west. The Powell dyke, however, which is 9,000 feet to the west, shows a displacement of about 800 feet *to the east*..

Apparently no *major* movements took place along the Andesite fault after the post-metadiabase faulting, but there were minor movements and

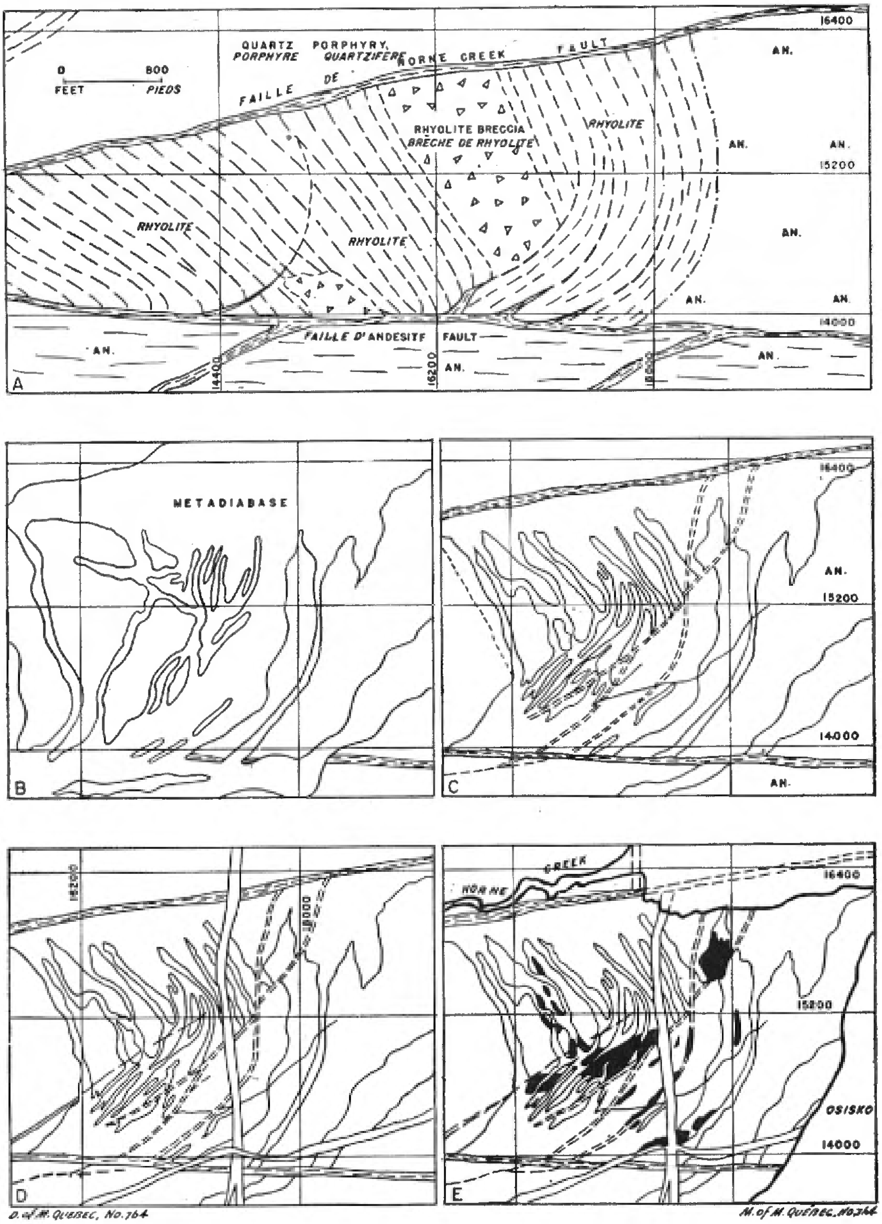

FIGURE 57.—*Horne mine:* diagrammatic sketches to show sequence of events in the formation of the Horne orebodies.

A.—Possible trend lines in the region surrounding the Horne mine before the intrusion of the metadiabase.
B.—Central area of Fig. A after the metadiabase intrusion.
C.—Same area as Fig. B subsequent to post-metadiabase faulting and the intrusion of syenite porphyry dykes.
D.—Same area as Fig. C subsequent to the intrusion of the later diabase dykes.
E.—Same area as Fig D subsequent to mineralization period and renewed faulting along the Horne Creek fault.

these were of critical importance, as will be shown in the discussion of the ore deposits.

Rock Alteration

Three main types of rock alteration are met with, *viz., silicification, sericitization,* and *chloritization.* These processes are widespread, with generally, though not invariably, a lessening in degree as one leaves the main mineralized area. All three are interrelated in age and localization.

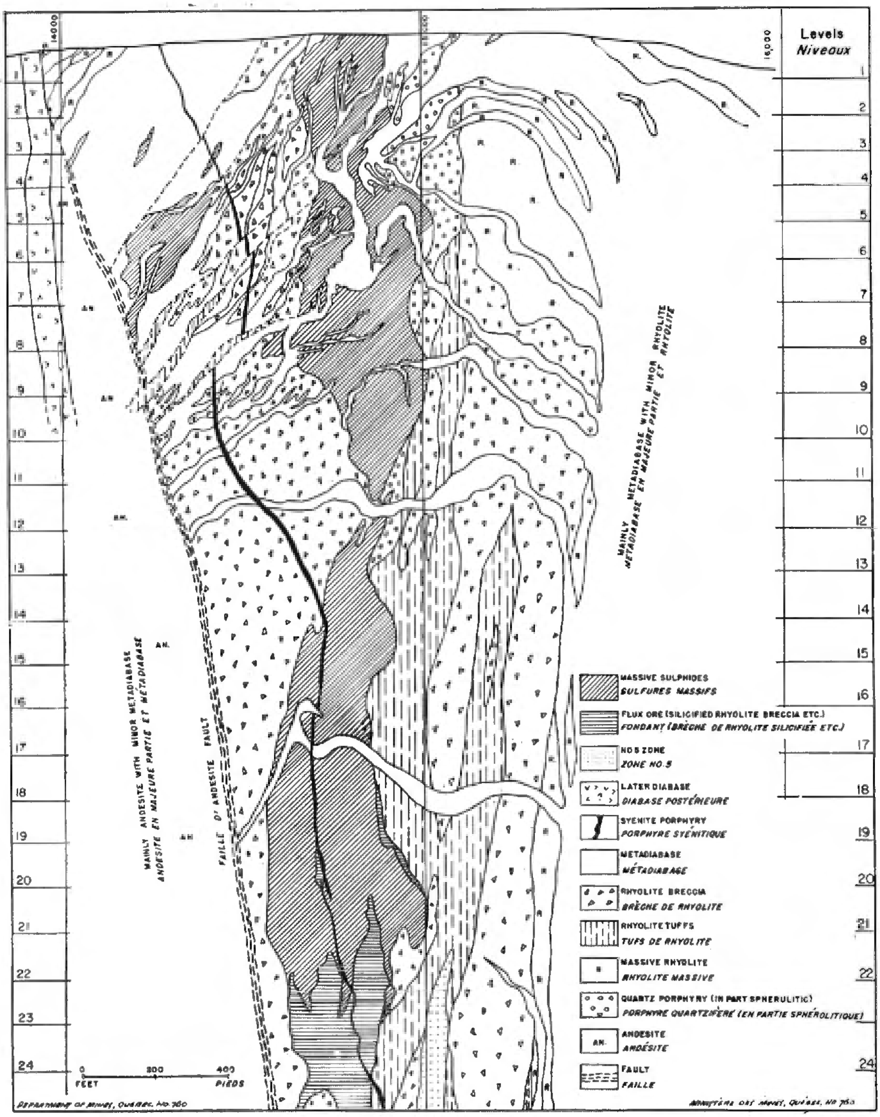

FIGURE 58.—*Horne mine, vertical section, 17015 E coordinate.*

(1) *Silicification*

Exclusive of other minor alteration products, such as sericite, chlorite, pyrite, etc., the so-called Horne rhyolites consist mainly of quartz. This is true not only of the rocks in the main mineralized areas, but of those some thousands of feet away from any known ore deposits; and it is true of all types, whether, breccia, banded, or flow.

There is a characteristic absence of microstructure in the rhyolites. For instance, the breccia is often so intensely silicified that, in thin section under the microscope, fragment is indistinguishable from matrix. The fragmentary character is obvious, however, in hand specimen, even in the most intensely silicified areas. This persistence of primary textures is a feature also of the banded and flow rhyolites, so that, in the recognition of the several types, the hand specimen has proved of greater value than the thin section.

Attempts have been made to use silicification as a guide to prospecting for new orebodies, but these have not been very successful. Not only is it difficult to decide how much quartz is original and how much secondary, but the presence of other alteration products (see below) may actually *lower* the silica content of the rock close to its contact with orebodies.

(2) *Sericitization*

The formation of sericite has also been widespread. It has been developed (1) as a stress mineral consequent to the folding, (2) in highly faulted and sheared zones (sericite schists), (3) as veinlets of later origin with pyrite and chlorite, formed during the mineralization period, and (4) as massive sericite consequent to the replacement of sheared and mashed rhyolites by sulphides.

Types (3) and (4), and especially type (3), are proving of value in outlining the general areas through which mineralizing solutions have travelled. The white to fawn colour so characteristic of the rhyolite flux bodies is due to the large number of minute sericite veinlets traversing the rock. The fourth type of sericitization seems to be confined closely to the margins of the large sulphide bodies.

(3) *Chloritization*

This type of alteration is also widespread. In a large number of cases, the chlorite has evidently been formed contemporaneously with the sericite. It is present in the shear zones, forms a general alteration product (together with sericite, epidote, clinozoisite, etc.) of the ferromagnesian minerals in the intrusive rocks, especially the metadiabase, and accompanies sericite and pyrite in the small veinlets traversing the rhyolites.

This last type of chloritization is evidently related to the general mineralization period. It varies greatly in intensity, bearing very little relation to the proximity of ore contacts. Thus one sees in the rhyolites, at their contact with huge sulphide masses, all degrees of chloritization, ranging from small veinlets and isolated patches to occurrences in which the chloritization has been so intense that the original rhyolitic character of the rock is recognized with difficulty. In this latter type, chloritization has often proceeded to a stage where the rhyolite-metadiabase contacts have been obliterated, and the rock grades from massive chlorite to definite meta-

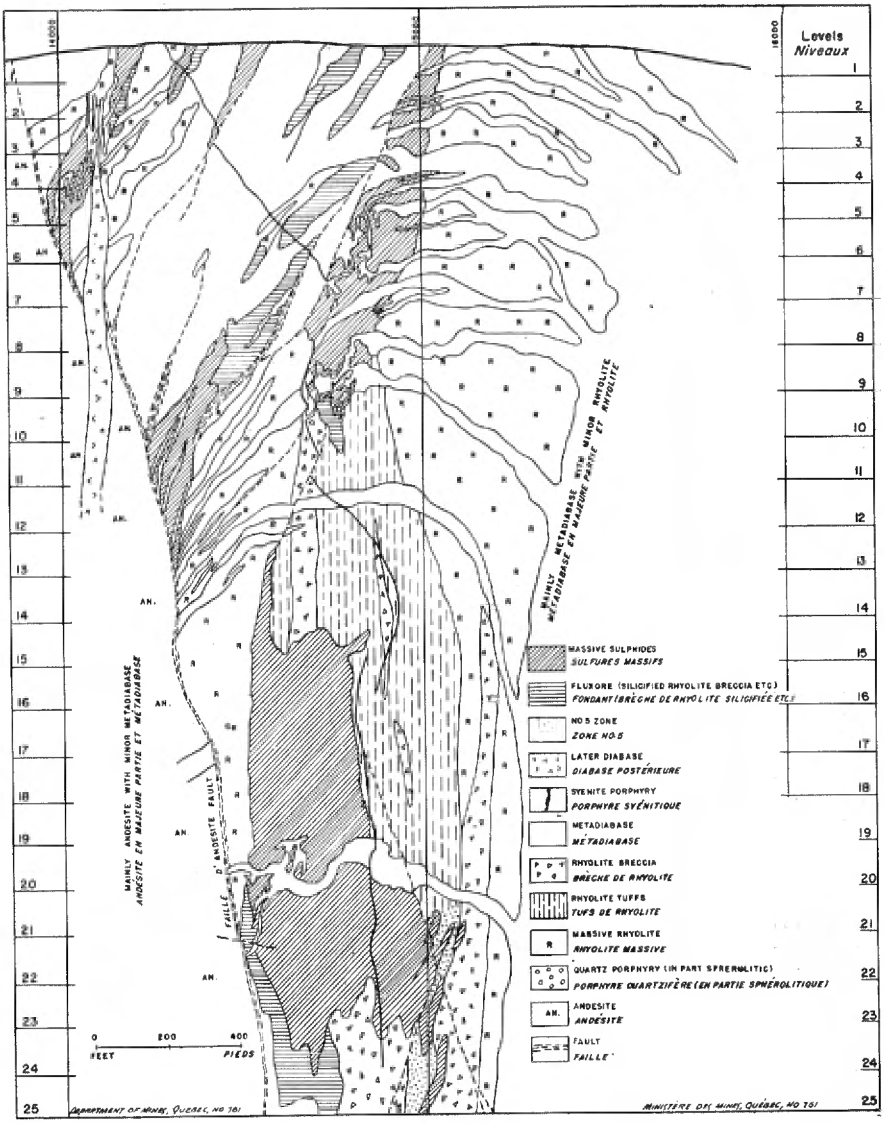

FIGURE 59.—*Horne mine, vertical section, 17320 E coordinate.*

diabase. It is in occurrences of such intensely chloritized rock that high-grade gold orebodies have been formed.

Chloritization of the syenite porphyry, also, reaches some intensity in or near sulphide bodies and has an interesting influence on gold tenors, as will be explained below.

The Ore Deposits

There are thirty-one distinct orebodies now recognized at the Horne mine. At the beginning of development, as successive bodies of ore were discovered, each was designated by a letter, but, on account of the number found, it was decided to change the letters to numbers. For certain orebodies, however, the letter or some other popular name is still in current use. In order to avoid confusion, the accompanying table has been prepared showing both systems of nomenclature and the class to which each body belongs. As may be seen from the table, some orebodies include more than one class of ore (*e.g.*, *F* and *Lower H*).

Nomenclature and Types of Orebodies

Number	Corresponding Letter or Popular Name	Type of Orebody			
		Massive Sulphide	Flux Ores		High-Grade Gold (Chloritic) Bodies
			Gold	'Self-Flux'	
1	*A*	x			
2	*B*	x			
3	*C*	x	x		
4	*D*	x			
5	*E*	x	x		
6	*F*	x	x		
7	*G*	x	x		
8	*Upper H*	x	x		
9	*I*				x
10	*J*	Zinc ore			
11	*K*	x			
12	*Crusher*			x	
13		x			
14	*Sewer*	x			
15				x	
16			x	x	
17		x			
18		x			
19		x			
20			x		
21	*Lower H*	x	x	x	
22	*617-517-317*				x
23				x	
24		x			
25			x		
26			x		
27			x		
28		x	x	x	
29			x		
30			x		
31	*No. 5 zone*	x	x		

Relation of Ore Deposits to Structure

The orebodies as listed in the table show a considerable variety of structure, size, and mineralogical composition. The accompanying plans of the 2nd (Figure 54), 9th (Figure 55), and 21st (Figure 56) levels, and the two sections (Figures 58 and 59), show their relation to the rocks and struct-

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ure in general. Figure 60 shows their progressive outlines as one proceeds downward at alternate levels.

In the section describing the rocks and structure, a brief account was given of the possible history and causes of the structure up to the time of the mineralization. It was brought out that the latest movements were largely confined to fairly well defined zones or were concentrated in definite areas. Thus, not only were channels or areas available for penetration by mineralizing solutions during the critical periods, but they were sufficiently localized that excessive migration of these solutions was prevented. Hence it is only natural that the positions of the several orebodies and their relationship to one another and the surrounding rocks should show abundant signs of this control.

It is believed that, so far as the actual ore deposition is concerned, *the prime factor was the influence of the Andesite fault and its subsidiaries.*

The Andesite fault dips north at an average of 82°. To date, no ore has been found south of the fault. Subsidiary to it are numerous northeasterly striking shear and fault zones, with dips ranging from vertical to 45° southeast. They slice across the rhyolites and intrusives to the north of the fault, a feature best seen on the upper levels of the mine. Generally speaking, these subsidiary faults are in greatest abundance around local changes in dip and strike of the andesite fault.

The junctions of these northeasterly trending fault zones with the Andesite fault have, in numerous cases, been the loci for the commencement of an orebody (*e.g., C, E, 19*), or have led to one or more orebodies farther up the zones (*e.g., A. B, D*, etc.). Moreover, the junctions of favourable breccia masses (having a vertical or steep south dip) with the Andesite fault have also been the starting point for the emplacement of very large bodies of sulphides (*e.g., Lower H*).

The structural controls of the *Lower H* and No. 5 zones from the 2,975-foot (25th) level to the 1,975-foot (17th) level are fairly simple. They lie roughly parallel to the Andesite fault and the strike of the breccias and associated tuffs. The cause of the large bulge on the 21st and contiguous levels is due to the junction of the *Lower H* and No. 5 zones at this point.

Above the 17th level, a change takes place. As the breccia strike takes a more northwesterly direction, so does the strike of *Lower H* change (see 13th level, Figure 60). Moreover, the first of the smaller orebodies (No. 19) makes its appearance at the 13th level.

From the 13th to 9th levels, the following takes place: *Lower H* dies out at about the 11th level and *Upper H* starts. At the 9th level, this latter body has still a major northwesterly trend, but the influence of the northeast shear zones coming up and in from the east begins to take effect. This is shown in the northeasterly strike of the east end of *Upper H. No. 19* orebody has now taken a definitely northeast strike, as also has *No. 20* at its eastern end.

From the 9th level to the surface, one sees a steady diminution of the northwest control and an increasing domination of the northeast control. Coupled with this is the appearance of several other small orebodies — all

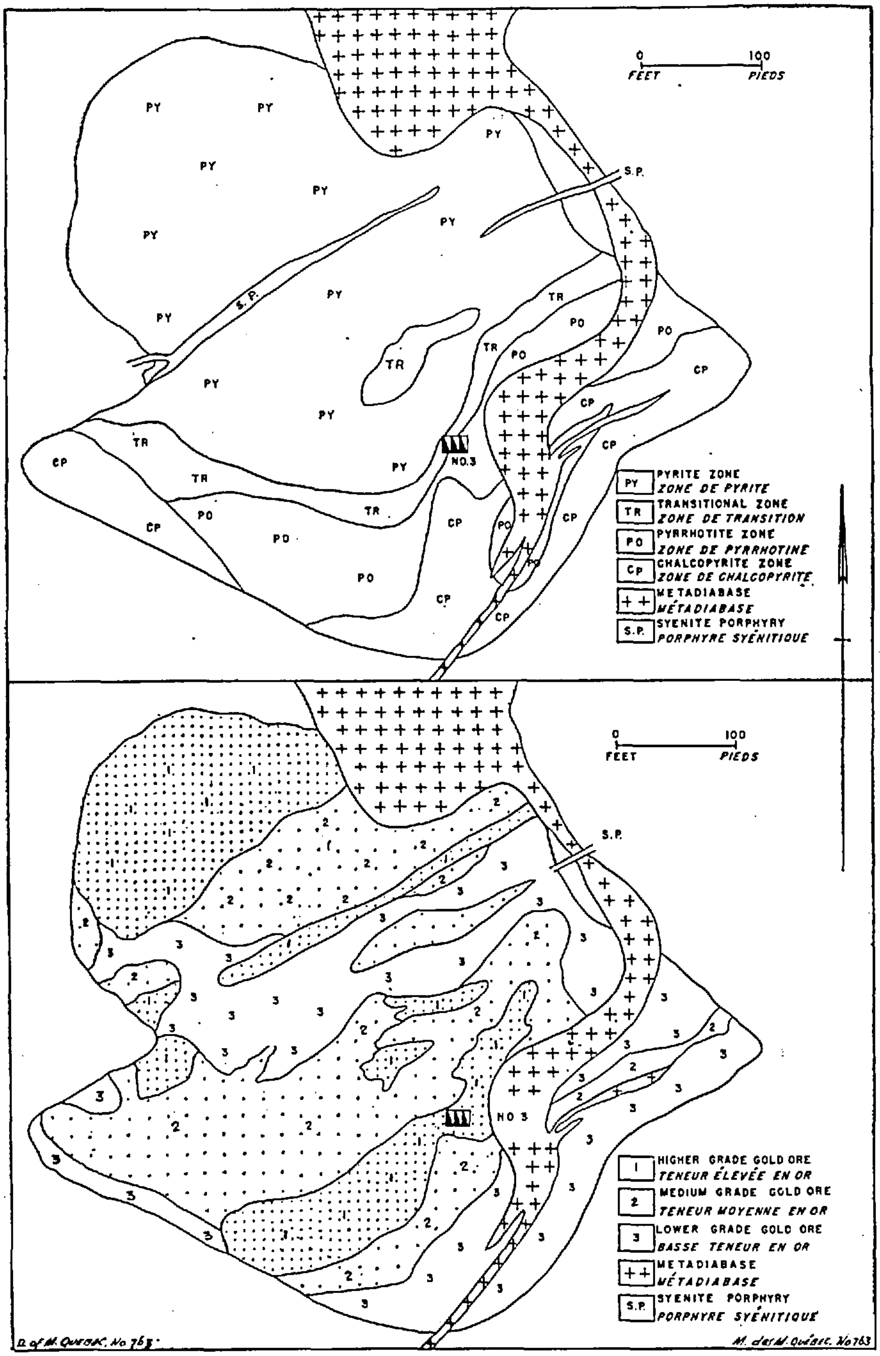

FIGURE 61.—*Horne mine, gold grade plan, Lower H, 20th level.*

showing a decided northeast control — which, so far as the southern ones are concerned, either commence at or in the Andesite fault or else start in northeast zones at some distance up and away from it.

Parallel to the development of the smaller orebodies to the south is an almost sudden appearance of several small orebodies stretching in a northwest direction away from the northwest extension of *Upper H*, *e.g.*, *F*, *13*, *J*, *26*, etc.

Summing up, it is evident that faulting and shearing was the governing factor controlling ore deposition. For example, the large sulphide masses of *Lower H* and *Upper H* show little regard to any postulated folding, intrusions, etc. Their contacts repeatedly cut across the strike of the surrounding rhyolites and, through the upper levels, *Upper H* maintains its steep dip through an intricate assemblage of large and small metadiabase dykes (see Figure 60). Also, one sees insignificant faults which were successful in forming a wall beyond which replacement could not proceed, *e.g.*, northeast contact of *H* orebody, 7th to 10th levels.

Thus the fundamental fact underlying ore deposition at the Horne mine is the existence of a highly disturbed structure. All other contributing features, such as rocks favourable for replacement, damming effect of the metadiabase, etc., are subordinate. This structurally favourable block is bounded by strong through-going, depth-searching breaks, which were the loci of repeated movements and, most especially, were open at the critical period of mineralization. The 'inlet' to the solutions was directly under *Lower H*. From this point they spread up and through the overlying rocks, guided by the faulted and sheared channelways. They took any available route open to them, especially up the Andesite fault. A spreading-out is plain toward the present surface, and indications are that a large number of rich orebodies were removed by erosion.

Under this conception, the Horne mine is a tree-like 'cluster' of orebodies, the 'trunk' of which is represented by the two *H* bodies. The parent intrusive for this cluster is not known to date.

Relation of the Ore Deposits to the Keewatin Rocks

Andesites.—To date, no orebody has been discovered wholly in the andesite. While it is probable that andesite would be more difficult to replace than rhyolite, it is thought that the lack of orebodies is due rather to the impermeable barrier set up by the highly sheared rocks in the Andesite fault than to any unfavourable chemical composition of the rock.

Rhyolites.—Excluding those deposits which have obviously replaced highly schistose and broken zones, *e.g.*, in metadiabase, the generalization can be made that the remainder have been formed by the replacement (wholly or in part) of various types of rhyolite. There is abundant structural and microscopical evidence in support of this statement. The ease with which the solutions were able to penetrate the rhyolite, and so commence replacement, varies not so much with the type of the rock as with its structural condition and previous alteration at the time of mineralization. Of the three main types (breccia, banded, and massive), breccia was probably the easiest and most favourable rock for replacement, but both banded and massive types have been replaced with ease where other conditions were favourable.

The original texture of the rock, of course, imposes some difference in the appearance and mode of replacement. Contacts are frequently gradational. In the *breccia*, as one approaches a sulphide contact, the process starts most often with small, isolated patches of sulphides replacing the groundmass. Nearer the contact, these become stronger, and finally a stage is reached where only isolated fragments remain unreplaced. In some cases, the reverse is true, and replacement has proceeded apparently by a selective attack on certain fragments. In the *banded types*, the tendency has been for veinlets of sulphides to form parallel with the banding, increasing in frequency until the whole rock consists of massive sulphides. In other cases, bands have formed sharp, linear contacts with the sulphides.

In *massive rhyolites*, the replacement texture is somewhat different. These have fractured complexly under stress. Relief was obtained not only by the development of conjugate joint systems but by a host of incipient linear fractures crossing the rock in all directions. Along these lines of weakness, replacement took place, producing the highly characteristic texture of the flux ore, *e.g.*, *16* and *G* orebodies. There is a definitely gradational contact between the flux ores in *G* and *20* orebodies and the adjoining sulphide bodies.

Thus, replacement of the three main types of rhyolite has resulted in the formation of ore deposits of diverse types. The sulphide minerals have replaced breccia and banded types with almost equal ease, *e.g.*, *Lower H*, and, in various places, sulphide masses have formed in the massive types *e.g.*, *C* and *E* orebodies. This fact is contributory evidence of the prime importance of faulting and shearing in the emplacement of the ore.

Relation of the Ore Deposits to the Metadiabase

By reason of its varied attitude and alteration, this extremely complicated group of intrusives has affected, and has been affected by, the deposition of the orebodies in various ways.

As previously mentioned, some ore deposits progress upward through an intricate swarm of the metadiabase dykes, with little regard for their general structure. *H* and *Lower H* (especially the former) are typical (see Figure 60). Other examples are *12*, *F*, and *22* orebodies.

Other orebodies have conformed fairly closely to the structure of the dykes, *e.g.*, *16* orebody.

Yet another type occurs. This is the case where the orebody is completely surrounded by metadiabase, *e.g.*, *B* orebody. Here, irregular 'plums' of sulphides are surrounded by metadiabase. It is probable that, in this case, the sulphides completely replaced irregular bodies of rhyolite left as remnants within the metadiabase intrusive.

Numerous cases are known, notably in *Upper H* orebody, where the sulphides have replaced the metadiabase itself to an important degree. Commonly, the small (one-inch) chill seems to have been completely effective in keeping out the replacing solutions, but, where replacement has occurred, the contact is highly irregular and fretted, and tongues of sulphides cut completely across the dyke. All the sulphides take a share in this type of replacement so that the metadiabase is obviously older than the mineralization period.

The relation of the rich gold-chloritic deposits to the metadiabase was mentioned in the section on *Rock Alteration.* Further discussion appears in the section on the gold minerals.

Relation of the Ore Deposits to the Syenite Porphyry Dykes

The syenite porphyry dyke referred to on page 342 maintains its identity through parts of *A, D, 19, 24, H,* and *Lower H* orebodies (see Figures 54 to 56, 58, 59). The dyke as a whole has been remarkably resistant to replacement, but veinlets and small irregular masses composed of all the sulphides replace the dyke in various places. In one case (*24* orebody), the dyke is cut off by a flat fault, but sulphides have followed the fault as an irregular sheet before proceeding upward along another shear zone. Hence, pre-ore age of this intrusion is obvious. Its importance as a localizer of gold on the lower levels will be discussed in the section on gold.

Consideration of the relation of the ore deposits to the 'later diabase' dykes, and of the accompanying problem of age of mineralization, is deferred until such features as paragenesis, grade, etc., have been discussed.

Types of Ore Deposits

Mineralogically, the ores at the Horne mine can be grouped conveniently under three main types:

(1) *Massive Sulphides*

(2) *Flux Ores*

- (*a*) Gold-bearing siliceous rhyolites (flux ore)
- (*b*) Copper-bearing (and some gold-bearing) siliceous rhyolites ('self-flux' ore)

(3) *High-Grade Gold Deposits* (chloritic type)

(1) *Massive Sulphide Deposits.*—In number, total tonnage, and economic value, the deposits of this type are the most important. Mineralogically, they consist mainly of pyrrhotite and pyrite, these two minerals comprising about 90 per cent of the actual sulphide masses of these deposits. Chalcopyrite is very widespread; its distribution and concentration are discussed in the section on *Grade.* Magnetite is next in importance, being far more plentiful than would appear from a casual examination of the ores.

These orebodies are characterized by the insignificant amount of gangue or (excluding the metadiabase) unreplaced country rock within their boundaries.

It has been found that the distribution of the major minerals — not only of the chalcopyrite but also of the pyrrhotite and pyrite — is proving of great importance in the mining and metallurgical practice. This is discussed in the section following.

(2) *Flux Ores.*—It is a fortunate circumstance that there is, on the property, material of high silica content essential to the smelting of the sulphide ores. Moreover, this material is ore in its own right by reason of the gold and copper it contains. There are two types:

(a) *Gold-Bearing Siliceous Flux Ores.*—These consist typically of the more siliceous types of rhyolite (50 to 70 per cent SiO_2) carrying from 0.20 oz. to 0.10 oz. gold per ton, with copper low to negligible. They may be subdivided as: (i) bodies adjacent to and along the strike of large sulphide masses, *e.g.*, *G* and *20* (flux) (see 2nd and 9th level plans, Figures 54 and 55); (ii) small scattered bodies occurring notably in rhyolite breccia not related to any sulphide mass, *e.g.*, *25*, *26*, *29*, and *30* orebodies; and (iii) contact areas with large, massive sulphide deposits *e.g.*, some areas of *Lower H;* these are of somewhat the same type as (i), but their mineralogy and grade as compared to the adjacent sulphide body requires explanation (see under *Grade*).

(b) *'Self-Flux' Ores.*—These bodies contain sufficient chalcopyrite to warrant the designation 'copper ore', but they also contain enough silica to be classed as flux. Generally, they also carry gold. The chief distinct representatives of this class are the *12* (or crusher), *15*, and *16* orebodies, but of far greater importance in point of tonnage is the material that occurs in some areas as a transitional zone from massive sulphides rich in copper to unmineralized country rock, *e.g.*, southeast margin of *Lower H.*

(3) *High-Grade Gold Ores* (*chloritic type*).—Although only two of the thirty-one known orebodies at the Horne mine are of this type, and both are comparatively small, they are, by reason of their high gold content, extremely important. They are known as *No. 22* (317-517, etc.) and *No. 9* orebodies. Mineralogically, they consist mainly of heavily chloritized rhyolite breccia and metadiabase, with scattered chalcopyrite and minor pyrrhotite and pyrite. Native gold and various tellurides occur in abundance, and the average gold content is above 1.5 oz. per ton. Some sections are extremely rich (up to 250 oz. gold per ton over five feet). It is in this type of body that the best examples of native gold and tellurides have been found, thus making it of special mineralogical interest. The silica content is only 45 to 50 per cent and the chlorite is an iron-rich variety. As was mentioned in the section on *Rock Alteration*, chloritization in these orebodies has frequently been so intense that the contacts between the rhyolite and metadiabase have been obliterated. The location of these orebodies and their high gold content have an interesting bearing to the question of the mineralization and its sequence, as will be explained below.

The Mineralization and its Sequence (Paragenesis)

The Pyrite-Zinc Mineralization

The sulphide first deposited was pyrite. It is not certain yet whether all the high-pyrite bodies are closely related in age, but it is most probable they are. The principal masses of pyrite are now widely scattered.

The largest so far discovered is *No. 31*, or *No. 5* zone. This collection of large and small pyrite masses extends from at least the 5,000-foot level to the 1,475-foot level. Between the 2,725-foot (23rd) and 1,965-foot (17th) levels it effects a junction with, and was probably the cause of, the large pyrite mass occupying the northwest area of *Lower H*. These two orebodies together show at least forty million tons of massive pyrite, with a tremendous amount of disseminated pyrite accompanying it.

Other pyrite bodies are *G* (sulphide portion), *E*, *C* (top portion), *D*. parts of *F*, many smaller masses that occur within the breccia body, and the west end of *Upper H*. The pyrite occurs as interlocking mosaics, idiomorphic crystals, large, coarse-grained, columnar and radiating growths, and irregular veinlets. There is no means of knowing how much of the orebodies now consisting of pyrrhotite was originally pyrite. It is believed, however, that the present pyrite bodies show, if not the *limits* of mineralization at this stage, at least a fair approximation of the main channels that were available during its emplacement.

There appears to be a close association of the zinc mineralization with this period. *No. 5* zone has some zinc all through it, and in certain areas around No. 5 shaft, from the 5,000-foot level to the surface, sphalerite is in sufficient quantity to warrant classing the material as zinc ore.

The sphalerite is coarse to medium grained and is dark coloured, with a fairly high iron content (marmatite). It is definitely later than the pyrite but earlier than the main copper mineralization.

Very minor amounts of gold and copper probably accompanied this mineralization.

The Magnetite-Pyrrhotite-Chalcopyrite Mineralization

The minerals next to be deposited were magnetite, pyrrhotite, and chalcopyrite. Each of these veins the pyrite and, though there were certain reversals and repetitions, it is believed they formed essentially in the order named. A certain amount of pyrite was deposited late in the series.

There is considerable evidence to indicate that the three minerals were closely related in age. Further, it is believed that there was a definite break, or a least a lull, in mineralization after the deposition of the pyrite and before the appearance of the three later minerals.

It is interesting to note that the sulphur content of these three minerals is lower than that of pyrite. There is a possibility that the later solutions were either higher in original iron content or became so by reaction with and replacement of the pyrite.

The magnetite-pyrrhotite-chalcopyrite mineralization in some places far exceeded the pyrite mineralization (*e.g.*, *Lower H* and *Upper H*). In other places, however, it was dammed back by the earlier mineralization (*C* orebody) or found new channels (*19* orebody), or did not reach places where pyrite had been previously deposited (*G* orebody). The important bearing of these features on ore grade is evident and will be discussed below in the section on *Grade*.

The Gold Mineralization

The gold-bearing and associated silver, tellurium, selenium, etc., bearing minerals are complex and widely distributed. They are, chiefly, native gold, electrum, hessite, petzite, sylvanite, krennerite, calaverite, altaite, tetradymite, rickardite, and three other indeterminate, complex, tellurides. Klockmannite is doubtfully present.

The time relations of the gold, silver, and associated mineralization are fairly definite. They replace, and are thus later than, pyrite, sphalerite, magnetite, pyrrhotite, and chalcopyrite. High copper and gold sometimes occur together (see next section), but in the majority of cases the high-copper ore tends to be rather low in gold, and *vice-versa*. There is a bare possibility that the gold mineralization may belong to a distinctly later geological period, but the weight of evidence points to its being late in the sequence, following closely upon the other minerals.

Types of Gold Mineralization.—Gold mineralization is of several types. It not only varies in character according to the nature of the orebody, but several different types are found in one individual body. In practically every case examined, the gold is present both as native gold and as tellurides. It is very seldom that one is not accompanied by the other. The following are the main types:

(1) Gold and tellurides forming minute veinlets (as low as 0.2 microns in width), irregular areas, and pipe-like threads in pyrite crystals.

(2) Veinlets of gold and tellurides along the borders of pyrite crystals, between the pyrite and adjacent sulphides or gangue minerals.

(3) Gold-telluride patches replacing pyrrhotite, the gold being surrounded or 'sheathed' by tellurides.

(4) Gold and tellurides replacing chalcopyrite.

(5) Minute quartz veinlets carrying gold and tellurides cutting the sulphides and gangue minerals. This type is prevalent at contacts with syenite porphyry where the latter is surrounded by massive sulphides.

(6) Gold and tellurides in veinlets and angular shapes replacing chlorite aggregates in the massive sulphides, and a large development of the same type in the chloritic high-grade gold ores.

(7) Gold and telluride veinlets cutting chloritized metadiabase.

(8) Gold and tellurides replacing magnetite.

(9) Gold and tellurides replacing sphalerite.

This tabulation is about in the order of frequency of the several types. It is a result of the study of a large number of polished specimens undertaken primarily as an investigation into the nature and distribution of the gold-bearing minerals and their consequent relation to metallurgical practice.

Grade of Ore

Underground development of the major orebodies has now reached a stage where an accurate picture of the distribution of the copper and gold is possible. Further, mapping of the *mineralization* zones in the major sulphide masses has also been accomplished in detail. The information now available has thrown much light on such subjects as: (1) the position and shape of the various channelways along which the ore-bearing solutions moved during the mineralization periods, (2) the approximate time relations between them, and (3) the mineral characteristics of the several periods.

The subject is complex and involves a detailed knowledge of the mine. A full discussion is beyond the scope of this article. The ensuing summary presents merely the highlights.

The Horne orebodies have the following general characteristics:

(1) Within any orebody, there are extremely wide variations in copper and gold content.

(2) Many of the orebodies become relatively rich in copper as the bottom is approached.

(3) In some cases, orebodies have roots rich in both gold and copper, but, as one proceeds upward, the high-tenor copper and high-tenor gold zones diverge and occupy separate areas within the orebody.

(4) Except for the above, it is characteristic that high-grade copper ore (*i.e.*, above 15 per cent) is relatively low in gold.

(5) Considerable *individual* spottiness of gold distribution is prevalent. It is possible, however, to outline and trace definite higher gold zones through the orebodies. These show, as noted under (3), considerable divergence from the high-copper zones.

(6) While the high-tenor gold zones occur in, and pass through, *both* pyrite and pyrrhotite areas, the high-copper zones occur almost without exception in the pyrrhotite areas. The occurrence of high-copper ore with pyrite is rare.

(7) Small local concentrations of gold and copper occur both above and below dykes of metadiabase within the massive sulphides. On the whole, however, the metadiabase dykes, no matter how numerous locally, have little influence on the upward course of either the gold or the copper zones.

(8) Quite often, the outline of the gold and copper zones bears little relation to the sulphide boundaries of an orebody. Copper and gold will often stop short of the sulphide contact, but just as often will invade the surrounding rhyolites.

Of all the orebodies, *Upper H* and *Lower H* best illustrate the several features listed above. Moreover, in these bodies, the individual zones are so large that they can be traced with considerable exactitude. In *Lower H*, a large body of pyrite extends from the 23rd to the 17th level. Figure 61 shows a typical cross-section. This pyritic mass averages 75 per cent pyrite, 15 per cent pyrrhotite, and 5 per cent magnetite. Bordering it to the south is a transitional zone in which pyrrhotite and pyrite are about equal in amount, and south of this is a zone in which pyrrhotite predominates. All of these are low in copper. Lastly, and forming the whole southern margin of the orebody, is a zone rich in chalcopyrite, with pyrrhotite the dominant iron sulphide.

This copper-rich zone starts below the 23rd level and, to above the 13th level, forms the marginal zone of *Lower H* orebody on its south side. It starts again at or near the 11th level, in the roots of *Upper H*, and appears similarly at the south margin of that body to above the 6th level before it finally dies out. Thus there is an almost continuous copper-rich zone that extends for a vertical distance of 2,250 feet.

The high-tenor gold zones are entirely different. One starts below the 25th level, joins with the copper-rich zone at about the 23rd level, but from there upward diverges northward (see Figure 61) and can be traced up the north contact to the 11th level in *Lower H*. Here it passes into the west end of *Upper H* and follows up this contact almost to the surface.

Numerous examples showing the same features could be cited for all the small orebodies. One extreme case is worth mentioning. *No. 22* orebody starts in a highly chloritized zone 200 feet south of the south contact of *Upper H* on the 700-foot level. It travels north and upward in a pipe-like zone, joins the sulphides of *Upper H* at the 300-foot level, enriches them greatly, and travels through them and beyond the north contact, before dying out near the surface.

Note on Relations of the Ore Deposits to the Later Diabase: Age of Mineralization

This highly controversial matter is like many of the problems that plague the geologist. Arguments, equally valid to both sides, can be presented with only a remote possibility that enough evidence will be found to settle the question. Actually, there are three views on the subject:

(1) That the orebodies are pre-later-diabase.
(2) That the orebodies are post-later-diabase.
(3) That the dykes are later than the pyrite mineralization but earlier than the copper-pyrrhotite mineralization.

In a previous paper (Price, 1934), a summary of the evidence at that time was given and it was stated (p. 140) that while "none of the evidence so far accumulated is conclusive either one way or the other . . . the most logical interpretation is that the orebodies are post-later-diabase in age."

Since that time (1934), a mass of detail has accumulated both in the Horne mine and in the surrounding district. In the mine, further occurrences of chalcopyrite and pyrrhotite have been found cutting or entering the north-south dyke from adjacent orebodies, and in one case (*C* orebody) these sulphides were found intimately replacing, and cutting, the east-west dyke. Among those who have worked in the surrounding district, there appears to be a growing conviction that the close association of copper deposits at, or near, the main later-diabase dykes of the district is too frequent to be accidental. Hence the belief has grown that the main copper-pyrrhotite mineralization was post-later-diabase in age. No real evidence has accumulated to prove that the *pyrite* was post-diabase. With regard to the theory that the dykes were post-pyrite and pre-chalcopyrite-pyrrhotite, it should be noted that this postulates a time gap of considerable length in the mineralization sequence and there is a growing belief that such may have been the case.

Summary of the Mineralization Period and Causes of Grade

The Horne mine presents a complex picture of at least three mineralization periods, the times and effects of which are becoming increasingly well understood. The emplacement of the orebodies affords, as noted in the preceding pages, abundant evidence of structural control, with faulting and shearing the dominant factors. Decreasing pressure and temperature also played an important part — this is evident in the paragenetic sequence. Geologically, a fairly continuous time sequence is postulated, with only one major lull, *i.e.*, after the pyrite.

But there is little evidence of a *close* connection in time and space distribution between the copper and the gold mineralization. Rather, the picture is one in which the effects of later mineralization periods have been imposed, sometimes along the boundaries of older ones, but more often directly on and through the same areas.

This complex situation is the result of the following factors. Movement of this already highly disturbed block of country continued during the whole period of mineralization and only to a very minor extent following it. *A continual slight shifting of source, means of travel, and extent of penetration was imposed on the ore-bearing solutions.* This is by far the most reasonable explanation of the features mentioned in the section on *Grade.*

The deposition of the pyrite (and minor associated sphalerite) occurred along certain well defined channels over a vertical range of at least 5,000 feet. In some areas, these minerals and their accompanying alteration products closed these channels permanently. In others, the channels were reopened. Continued movement allowed the solutions which produced pyrrhotite and chalcopyrite either to travel these old channels again or to seek new ones. A certain amount of damming took place in the old channels, probably accounting for the copper-rich lower portions of the sulphide masses. The gold-bearing solutions brought further complexity as they, in turn, sought out what channels were later available.

Thus the effects of three distinct mineralizing periods have been superimposed on one another. It is believed that this is the logical explanation of the complexity in grade and in its disposition in this rather remarkable assemblage of orebodies.

Waite Amulet Mines, Limited*

About six miles northwest of the Horne mine, a group of copper and zinc bearing orebodies occur on the property of Waite Amulet Mines, Limited. The present Company was incorporated in 1933 to consolidate Waite-Ackerman-Montgomery Mines, Limited, and Amulet Mines, Limited. The initial discovery on the Amulet ground was made in 1924 and others followed in 1925, 1929, and 1937. The Waite orebodies were discovered in 1925.

Production started at the Amulet in 1928 and at the Waite in 1930, and to the end of 1945 the two properties had produced a total of 325,218,087 lb. copper, 207,694,418 lb. zinc, 92,126 oz. gold, and 3,338,229 oz. silver.

While, in a general way, the Waite-Amulet orebodies bear some resemblance to the Horne orebodies, their higher zinc, lower gold, and higher silver content reflect many interesting differences in the mineralization, its sequence, and accompanying rock alteration. Moreover, structural control at the two properties is dissimilar. The Waite-Amulet orebodies tend to occur in groups, and are flat-lying rather than vertical. The considerable distance between the two properties of itself constitutes a reason why differences might exist. As will be shown below, however, the orebodies in the two areas are probably closely related in time of formation, so that the variations present some interesting problems.

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General Geology

With the exception of intrusives, the rocks of the area are all of Keewatin-type. In order of increasing age, they are as follows:

Intrusives
- 'Later diabase' dykes (Powell dyke)
- Flavrian granite
- Dufault granodiorite
- Feldspar porphyry dykes
- Andesite dykes
- Quartz diorite dykes and masses
- Quartz porphyry dykes
- Feldspar porphyry dykes
- Diabase dykes and masses

Extrusives
- Andesite group (dacite, andesite, etc.)
- Rhyolite group (breccia, tuffs, and massive siliceous types)

Keewatin-Type Rocks

The rhyolite and andesite groups represent the northerly continuation of the similar rocks exposed at or near the Horne mine. Whereas in the latter locality these rocks are highly folded, with steep to vertical dips, folding tends to die out as one proceeds north until, on the Waite Amulet property, they have an almost north-south strike, dip gently (10° to 45°) east, and are only gently folded into broad anticlines and synclines. The andesites occur to the east of and are underlain by the rhyolites.

Rhyolites

This group consists of four main types: (1) a highly siliceous massive type; (2) dark, massive types, slightly porphyritic, sparsely amygdaloidal, and in places faintly pillowed; (3) flow and agglomeratic breccias; and (4) tuffs. The highly siliceous type is most prominently developed to the east and north of the Waite mine. It is a uniform, white, fine grained, highly quartzose rock, and differs from the normal rhyolite in the entire absence of flow and agglomeratic breccia. Thinly laminated areas are prominent but are not continuous over distances greater than 100 feet. Spherulitic textures are common. In thin section, the rock is very similar to the typical fine grained siliceous rhyolites of the Horne mine. Quartz is predominant, feldspar is sparse, and the usual alteration products — pyrite, chlorite, sericite, epidote, and others — are present in varying amounts.

The dark, massive types are very extensive and occur in ill-defined flows all through the Waite and Amulet areas. They are massive and even grained. Generally, they are slightly porphyritic, and amygdaloidal types are common. Spherulitic facies are present but do not adhere to any well defined horizons. Some poorly pillowed members are also present.

In all the rhyolite belts, irregular areas of varying extent are found in which the rock consists of angular fragments of rhyolite, ranging from an inch to twenty feet in diameter, enclosed in a rhyolitic matrix. This is believed to be a flow breccia; it is not a pyroclastic. The fragments are most often cherty, somewhat amygdaloidal and porphyritic, and exhibit flow lamination at their borders. They are not confined to any particular horizon.

It is believed that some agglomeratic material is present in isolated areas. Especially is this true in the deeper portions of the Waite mine. Here, considerable thicknesses (over 300 feet) of breccia, remarkably similar to the Horne breccia, have been discovered at and below the 1,000-foot level. The fragments are heterogeneous, somewhat angular, range from half an inch to four inches in diameter, and show little evidence of deformation.

Finely banded tuff beds occur in the rhyolites, especially at or near the main contact with the andesites. They are not confined to one horizon, however, and are discontinuous both laterally and down the dip. Most frequently, they are selectively mineralized with bands of pyrite, pyrrhotite, and more rarely sphalerite. Microscopically, all these rocks are very similar to corresponding types at the Horne mine and probably they belong to the same group.

It has not yet proved possible to outline continuous individual flows in the rhyolites, as has been done in the andesites (see below). It is believed, however, that they form an essentially continuous group of irregular flows of varying extent and thickness. The whole pile must aggregate at least 2,500 feet in normal thickness.

Andesites

Overlying the rhyolites to the east and essentially conformable with them is a group of fairly thin flows of intermediate composition. They have a surface exposure approximately 6,000 feet wide and are at least 3,000 feet thick in the aggregate.

Detailed work, especially on the southeastern part of the property and on the neighbouring Lake Dufault ground, has delimited nine individual flows immediately overlying the rhyolites and having a surface exposure of 4,000 feet. This would indicate an average normal thickness of about 250 feet for each flow.

These flows range from dark, well pillowed andesites to light grey, porphyritic, dacitic types. Some of them are massive and even grained. Others contain considerable flow breccia, sometimes adhering closely to one horizon. Rude columnar jointing is prominent in places. Lamination is scarce and tuffaceous material extremely rare.

Some of the flows are rhyolitic in character, but in thin section they all show, in varying degree, the rod-shaped laths of plagioclase and the trachytic texture common to the andesites of the district. The plagioclase ranges in composition from oligoclase to basic andesine.

Field relations show clearly that the andesites overlie the rhyolites and that, farther east, they are in turn overlain by another belt of rhyolite. The whole assemblage is essentially conformable, strikes north and south, and dips 10° to 45° to the east. It lies at the crest of a broad anticlinorium whose major axis strikes somewhat south of east.

A second flow or groups of flows of intermediate composition appears in the west of the central part of the property. This group strikes northwest across the West Amulet (formerly the Rhyolite-Rouyn) property and continues as far as Duprat lake and probably beyond. The rock is well pillowed, generally rusty in outcrop, and appears to dip beneath the rhyolites. It was once thought that this group of flows represented a folded remnant of the eastern andesites, but present information points to their being conformable with, and underlying, the rhyolites to the east.

Structurally, they are a minor group. Their importance lies in the possibility that future exploration may show that they afford another favourable, deeper contact similar to the main contact with which the majority of the presently known orebodies are associated (see below).

Intrusive Rocks

In few areas in the surrounding district is there such a complex assemblage of intrusive rocks as are found on the Waite Amulet property. They are of many different ages, their composition ranges from highly acidic to basic, and their structural relations are extremely complicated. Moreover, correlation of the several types is difficult and, in numerous cases, impossible. Expecially is this true of the older, and smaller, intrusive bodies. The following brief description merely indicates the main types and does not attempt to list the evidence for their succession, or for the many reversals in succession that are met with. So far as is known, the succession shown in the table on page 362 is approximately correct.

Diabase Dykes, Sills, and Masses

Intrusives of this type are present throughout the area but are especially numerous in the vicinity of the Waite mine. They are of at least four different ages. Structurally, they occur as sills, dykes, and masses with irregular shape. Delimitation of these is difficult, especially underground, because of splitting, branching, and projecting offshoots.

The earliest of these intrusives occur mainly as dykes, up to 200 feet wide, which are generally fine grained and resemble closely some of the andesites. Some doubt yet exists as to their true relation to the andesite, but structural evidence indicates clearly that they are intrusive and possibly contemporaneous with the flows. Next in age are coarse grained dykes, with wide chilled margins, which strike north-south or northeast and dip east or southeast. Later than these are numerous dykes and sills which resemble the earliest type in texture. Associated with them are dykes and sills of feldspar porphyry, which are described below. This intimate association, which is becoming increasingly clear and widespread as development proceeds, is also discussed below. Lastly, there are some diabase dykes cutting the feldspar porphyry and quartz porphyry. These are narrow and of limited extent.

It should be noted that the term 'diabase' applied to these intrusives is a general field term. Strictly speaking, they are rather to be classed as quartz diorite or diorite. In all cases, alteration has been severe and fresh specimens are extremely difficult to obtain.

Their emplacement presents a rough picture of the oldest period of folding and faulting, since the later faults bear no relation to their present structure.

Feldspar Porphyry Dykes

As noted above, an increasing number of feldspar porphyry dykes or sills are being delimited. In the early years of the mine, these had been

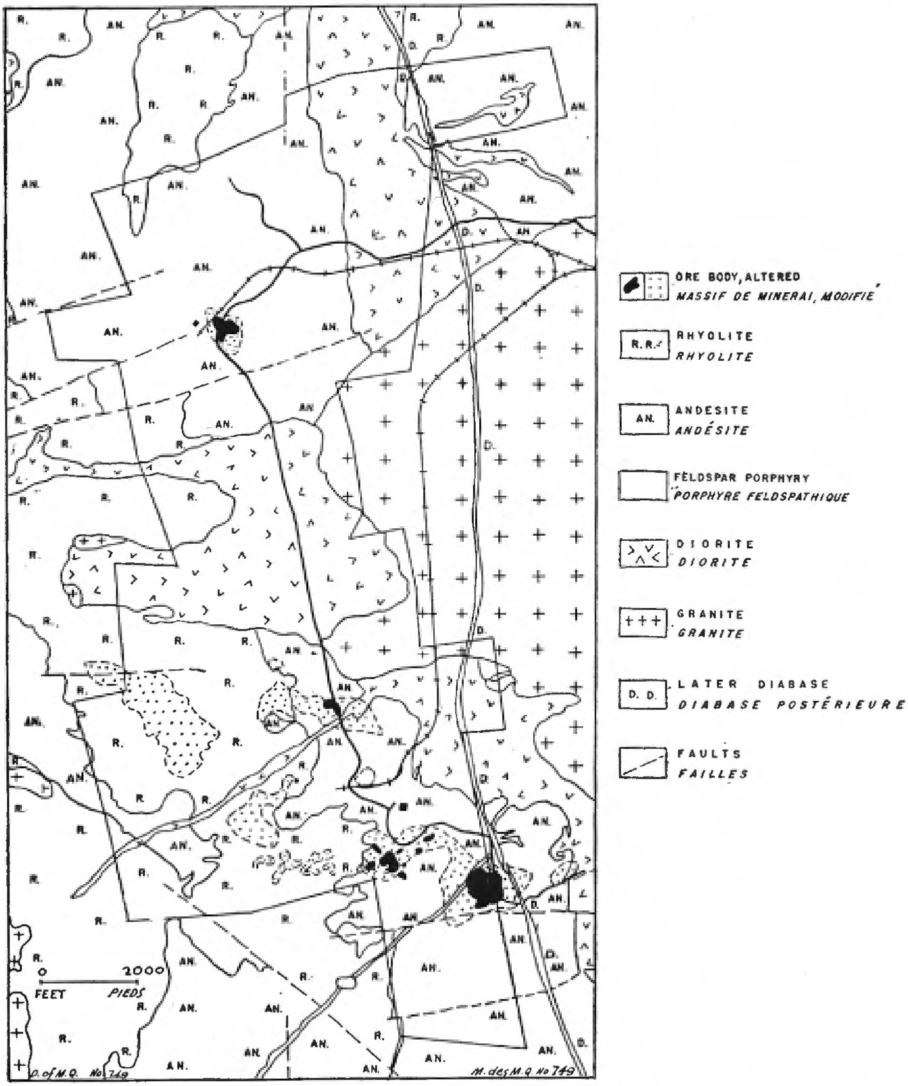

FIGURE 62.—*Waite-Amulet mine, general surface plan.*

variously referred to as diabase, rhyolite, and even andesite. Drilling and underground work, particularly in the *A* orebody area, and recent re-mapping of the *Waite* and *F* orebody underground workings, has shown their true character.

Generally, they are dark and fine grained. Their porphyritic texture is not always evident, but under the microscope their true character is revealed. Quite often, the rock is more porphyritic at the centre of a dyke than at its borders. The phenocrysts of feldspar average 2 mm. in length;

only rarely are quartz phenocrysts seen. The groundmass consists of an intricate micropegmatitic intergrowth of quartz and feldspar, sometimes radial in texture.

For the most part, the bodies of feldspar porphyry are sill-like, but in detail their structure is exceedingly complicated (see Figures 65 and 68). Like the diabase dykes and sills, they fork and branch, send offshoots into the adjacent rocks, and make sudden changes in dip and strike. Often they accompany — and are frequently bordered on both sides by — diabase dykes of the third type described above, to which, it would appear, they are closely related in age. These feldspar porphyry bodies range in thickness from one foot to 120 feet. Actually, due to their generally flat attitude, they do not outcrop in proportion to their true extent, a factor that was doubtless largely responsible for the failure, in early years, to appreciate their importance. As will be shown below, they have had a considerable local bearing on the emplacement of orebodies.

Quartz Porphyry Dykes

These dykes are best developed in the Waite area. They are similar in matrix and texture to the feldspar porphyry dykes but quartz forms the predominant phenocrysts, with feldspar subordinate, and they are generally coarser grained. They form dykes from 50 to 100 feet in thickness and some in the Waite area have been traced for lengths of more than 4,000 feet. They cut all the intrusive rocks discussed above, but their similarity in composition and texture to the feldspar porphyry dykes suggests that they are closely related to these in time and origin.

The quartz phenocrysts, whose longest dimension is usually about 5 mm., are to some extent embayed and resorbed. The feldspar, which is near albite in composition, is usually in smaller crystals than the quartz. Micropegmatitic intergrowths of feldspar and quartz make up a large part of the groundmass, which quite often has a radial texture. Ferromagnesian minerals are present in very minor amount and the rock might be classed as an alaskite porphyry.

Quartz Diorite Dykes and Masses

Throughout the Waite Amulet ground, and especially in the eastern portion, are large intrusions of quartz diorite. The controlling body is an elongated mass up to 4,000 feet wide and at least five miles long in surface outcrop, with strike north-south and dip 30° to 70° east.

Numerous dykes and irregular offshoots extend away from the main mass in a southwesterly direction. The dykes are from 10 to 100 feet wide and dip northwest at about 60°. They, in turn, send offshoots into the rocks they traverse. Underlying the swamp area between the two mines, a large, coarse grained diorite mass extends for 6,000 feet westward from the main body, and there are other large, westerly striking branches north of the Waite mine.

The rock is usually coarse grained and similar in all respects to the quartz diorite occurring elsewhere in this general area. It cuts, and is thus younger than, all the rocks previously mentioned. For a time, in the early days of exploration in the district, it was considered a differentiate of the

Dufault granodiorite mass. Its structure and field relations preclude this, however, and it is now believed to be closely similar in age to the quartz diorite body west and south of the town of Rouyn.

'Andesite' Dykes, Feldspar Porphyry Dykes, and small Diabase Dykes

All through the area are a considerable number of dykes, some acidic and others basic, which cut all the intrusives discussed in the foregoing pages and whose origin is somewhat in doubt. They range from typical fine grained feldspar porphyries, through fine grained green dykes of andesitic composition, to fine grained diabases. Structurally, they are small and unimportant, but they serve usefully in certain local areas in indicating the throw of faults.

Flavrian Granite and Dufault Granodiorite.

These two large batholiths approach within 9,000 feet of one another in the central part of the area. The Flavrian mass, which is the more westerly of the two, is not as well known as the Dufault mass. Lithologically, however, they are dissimilar. There is no field or other evidence at hand that might throw light on their relative ages, but it is thought possible they may be differentiates of one and the same large underlying batholith. They have not, to date, been found in close proximity to any of the orebodies, although recent work has shown that, at a depth of 500 feet, the *F* orebody of the Amulet mine is within 400 feet of the margin of the Dufault mass (see p. 379).

Later Diabase Dyke (Powell dyke)

The northerly trending 'Powell' dyke of later diabase, 50 to 100 feet wide, traverses the eastern part of the area and continues far beyond, both to north and south. In the Noranda area, immediately south, this dyke parallels, and is about a mile and a half west of, the north-south diabase dyke referred to in discussing the Horne mine. Unlike the latter, which dips steeply eastward, the Powell dyke dips at a high angle to the west. Lithologically, the two dykes are similar. This is the youngest rock of the district.

Structure

The major difference between the structure of the Waite Amulet area and that in the vicinity of the Horne mine is in the attitude of the extrusives which, at the Horne, have steep to vertical dip whereas at the Waite Amulet they are relatively flat (10° to 45°). Also, the folding is open and broad compared to the tightly compressed folding present to the south. The effects of this type of structure on the emplacement of not only the intrusives, but also the orebodies, are many and varied. They are discussed partly in this section and partly in the description of the orebodies.

As was mentioned on page 363, the extrusives form a thick series occupying the crest of a broad anticlinorium. The general pitch of the latter is 25° to 45° to the east and the general strike of the crest appears to be slightly south of east. On the surface, therefore, the trace of individual contacts has a general north-south strike, but in detail the contacts are quite irregular. This is due to three causes: (1) the flat dip of the lavas, together with the comparatively rugged topography of the area; (2) faulting; and (3) original folding, referred to above.

One of these contacts has received particular attention due to its outstanding importance in regard to ore deposition in the area. It is known as the *Main Andesite-Rhyolite Contact* and its surface trace is shown in Figure 62. Considerable detailed knowledge has accumulated on this contact, both on the surface and underground. When due allowance is made for faults, topography, and variations imposed by the original irregularities in the flows themselves, it shows a succession of open anticlines and synclines with, here and there, areas that are almost dome-like. The dip of the axial planes of these folds is not definitely known, but it may be at a low angle northward.

It is believed that only a minor amount of faulting accompanied the preliminary folding. The term 'minor' here is used relatively as compared to the heavy, continued faulting and shearing that has affected the Noranda area to the south. Such faults as are present have, in general, small displacement (50 to 400 feet). A considerable amount of flat thrusting and slicing of the flows must have taken place. The predominant dip of this type is south, varying from 10° to 60°.

Into this relatively undisturbed area was injected an extremely complex series of diabase, quartz diorite, and acidic porphyry intrusives. In part, they followed flow contacts and can thus be classed as sills. Others must have followed the flat, south-dipping thrust and slice zones mentioned above. Offshoots from all of them were injected into the nearby faults which, even at this period, must have followed a northeast trend, with a north dip. These intrusives are composite, and their individual structures are extremely difficult to delineate. The more basic of these early intrusives are found in greater abundance to the north, in the Waite area, whereas the porphyries are more abundant in the southern Amulet area. Plentiful representatives of each class, however, are present over the entire district.

Following this period of intrusion, the country must have been warped to produce a complex series of fault and fracture zones. These must have been predominantly in two directions. The more important had a strike slightly west of north with dip 10° to 70° east. The second and subsidiary set had a northeast strike, with dip approximately 60° northwest.

Into the major set, large quartz diorite masses were intruded, and at the same time a considerable number of offshoots from these invaded the subsidiary fractures. It will be seen that these directions cut across the old lines and thus further complexity was added to the pattern of intrusives.

Further faulting and minor intrusions followed. In general, these dykes were small and they are of two complementary types, basic and acidic. The basic (so-called 'andesite') dykes are generally vertical and strike N.30°E.; the acidic (feldspar porphyry) dykes strike N.60°W. and also are vertical. Small diabase dykes (D_5 in Waite nomenclature) also cut the diorites and follow much the same pattern as the andesite dykes.

Major batholithic intrusion then took place. During this period, the Dufault granodiorite and Flavrian granite masses were emplaced to the east and west of the area, respectively (see Figure 62). As noted previously, the two masses are believed to be genetically related, but no data are available to indicate their relative ages.

Either accompanying these intrusions or closely following them, faulting was resumed. Several of the old lines of weakness were reopened but there is plentiful evidence that a considerable number of entirely new faults originated at this time, their predominant direction being within the range N.60°E. and due east (see Figure 62). In general, these faults dip steeply north and appear to be normal, but, especially in the northern section of the area, south-dipping thrust faults are fairly numerous. While all these faults are long and continuous, none approach the classification of 'major' faulting, 400 feet being the maximum known throw on the north-dipping faults, with possibly greater throws on the thrust faults.

The final igneous activity in the area was the intrusion of the 'Powell' diabase dyke. Possibly coincident with this intrusion, an extensive system of joints paralleling the dyke was developed over the whole area. Although some of this jointing may be pre-diabase, there is plentiful evidence that in very large part it was contemporaneous with, or later than, the injection of the dyke.

There is little evidence of any *major* movement after the Powell dyke was intruded.

Rock Alteration

The main types of rock alteration in this area are the same as at the Horne mine, that is, *silicification, sericitization,* and *chloritization.* Silicification and sericitization are most prominent in proximity to the orebodies, and have affected the rhyolites in greater degree than the andesites. Bleaching of the normally dark coloured rhyolites is common, and in some areas sericitization of breccia masses has reached considerable intensity. These alteration types can be used to some extent as a guide to prospecting, but in each of the mineralized areas the alteration 'halo' is so wide that it is of little diagnostic value. Especially is this true of the rhyolites.

In the andesite, silicification and sericitization are not as widespread. Silicification and bleaching of the rock in close proximity to the orebodies is common, especially toward their ends, but the effect is quite local. In intensely mineralized areas — and, in some cases, for a considerable distance above or away from ore — silicification, with other types of alteration, has proceeded along joints in the andesite. Where this has happened, narrow intersecting seams of material harder than the normal andesite weather as criss-cross ridges. Locally, this has been termed *grid structure.*

Chloritization appears to be less widespread than at the Horne mine. The more intensely chloritized areas usually occur in the rhyolite, and they very seldom extend far from the margin of an orebody. The typical chloritized rhyolite is blotchy and dark in colour. Close to its contact with sulphide bodies, chlorite often becomes so abundant that the rock is greenish in colour and quite soft. This is especially noticeable close to, and below, the bottom of *Lower A* orebody. Elsewhere, as in the Waite mine, roundish chlorite aggregates in the rhyolite give rise to a pseudo-spherulitic texture.

Reference may be made to three further types of alteration which are of particular interest in this area:

Epidote.—In some places, there has been a 'spotty' transformation of the andesite, and rarely of the rhyolite, to aggregates consisting chiefly of epidote and quartz (Wilson's *epidosite*). These are pale yellow in colour, usually round to oval shaped in outline, and from a few inches up to eight feet in diameter. Similar material occurs also in joints, as an alteration of plagioclase, and as a selective replacement of amygdules. Generally, the oval masses occur in the pillowed type of andesite, but they are often observed also in the 'ragged' flow-top breccias. This alteration to epidote does not appear to be related to the mineralization. Possibly it was brought about at the time of the emplacement of one of the larger intrusive bodies, *e.g.*, diorite or granodiorite.

Dalmatianite.—The close relationship of this type of alteration with the ore deposits is beyond question. Its major development took place in the Amulet area but, as will be shown below, similar sub-types are present at the Waite mine.

On weathered surfaces and underground, the rock presents a distinctive spotted appearance, in allusion to which it became known locally as 'spotted dog'. Later, it was given the previously established name *dalmatianite.*

The rock is basic, highly aluminous, and contains a considerable percentage of magnesia. Under the microscope it is seen to consist of anthophyllite (gedrite), quartz, biotite, cordierite, spinel, ilmenite, and chlorite, in varying amounts. Feldspar and epidote are rare. Usually one or more of the following sulphides are present: pyrrhotite, pyrite, chalcopyrite, sphalerite. Two main types of the rock may be distinguished.

The first type is characterized by the development of rounded aggregates of quartz, gedrite, biotite, and (more rarely) cordierite, which give the rock its spotted appearance. This type occurs as an alteration of both andesite and rhyolite. In some occurrences, the development of the spots has undoubtedly proceeded from the selective replacement of amygdules in the andesite, but massive rhyolite has also been replaced by radial aggregates of the minerals named. It is believed, from a thorough study of this rock, that the chief minerals responsible for the spotted appearance are quartz and gedrite. Cordierite, though frequently present, is not the dominant mineral. The matrix is generally quartz, with the minerals mentioned above as secondary.

The second type is restricted, so far as now known, to the rhyolites. In it, there has been development of small, perfect rosettes of gedrite, together with green spinel and biotite. This rock is not spotted but is hard, siliceous, and has a somewhat hackly fracture. In some localities, it occurs in the neighbourhood of the typical spotted material, but in others, as in the Waite mine, it is the sole type present.

Weak dalmatianite alteration in the andesite and rhyolite tends to be reddish-brown, due to the presence of considerable microscopic biotite. This is largely a border type, or appears where the degree of alteration is diminishing vertically.

Occurrences of typical dalmatianite are numerous at the Amulet property (see Figure 62). They range in size from small isolated patches to very large masses, one of which, near the western boundary of the property, is 2,500 feet long by 1,300 feet wide. Their structure shows considerable variation and has a close relation to ore deposition. This will be discussed in some detail in a later section.

Not only does the dalmatianite form abundantly in andesite and rhyolite, but, in areas where this type of alteration is particularly intense, diorite, diabase, and (to some extent along its borders) feldspar porphyry, have been converted to typical dalmatianite. This is especially noticeable in the *A* orebody area and also in the dalmatianite area west of *F* orebody.

Talc and Sericite.—A type of alteration which has its largest development in *Lower A* orebody is the development of talc-sericite zones. Generally, these occur within the massive sulphide bodies, and, in particular, near their lower limits. They are irregular in shape and show little regularity in distribution. The origin of these zones is obscure. but they appear to be remnants of country rock that has been completely converted to talc and sericite by solutions rich in magnesia and potassium. Quite often, they carry appreciable amounts of copper, but very little zinc.

The Ore Deposits

The Waite Amulet orebodies can be divided into four distinct groups, or 'clusters'. The following table shows their distribution, and the estimated original tonnage of the deposits:

Section	Group	Orebody	Estimated Tonnage
Amulet.............	A	*A* and *Lower A*	4,200,000 tons
"	C	*B, C, D,* and *E*	250,000 "
"	F	*F*	150,000 "
Waite.............	Waite	*Surface* (zinc)	300,000 "
"	"	*Upper* (copper)	500,000 "
"	"	*Lower* (copper)	300,000 "
Total Tonnage......	....	....	5,700,000 tons

The positions of the four groups are shown in Figure 62. Distances between them are approximately as follows: *A* to *C*, 1,600 feet; *C* to *F*, 3,600 feet; and *F* to *Waite*, 8,000 feet. The three Amulet groups are thus relatively close to one another while the Waite is somewhat isolated. Moreover, while a number of similarities exist between all of them, the three Amulet groups show a closer resemblance to each other in mineralization, structure, and accompanying alteration than does any one of them to the Waite. Hence, in the following discussion, the Amulet groups will frequently be considered as a unit in comparison with the more isolated Waite orebodies.

Relation of Ore Deposits to Structure

Broadly described, *the Waite Amulet orebodies are flat-lying lenses of various dimensions.* This holds true for the individual lenses, but their relation to one another in any one group can be stated under another, almost contradictory, generalization, *viz.,* that *the lenses in any one group may be* *said to occur in an essentially vertical, pipe-like channel of mineralization and alteration.* Not only is this true of the areas in which the groups occur, but present indications point to the same generalization holding for the numerous and extensive dalmatianite areas in the western Amulet area.

In the description of the structure, it was brought out that the majority of the extrusives and intrusives in the ore areas tend to have flat dips. Hence the general ore picture is one in which solutions, travelling vertically in rudely pipe-like channels, worked their way through numerous flat-lying flows and dykes. The relative permeability and ease of replacement, and the general flat structure, of these rocks all have had a varying influence on the emplacement of the ore lenses.

Since this imposes such a variety of individual controls, it will simplify matters to list here the general controls common to all the groups. They are:

(1) The mineralizing solutions seem to have been able to maintain their upward vertical course, irrespective of the diverse types of flows, the frequency and variety of intrusives, and the attitude and strength of the numerous thrust and normal faults they may have encountered.

(2) None of the groups shows a clear relation to through-going faults or 'breaks'. Rather, from the underground work that has been carried out to date, the impression is gained that movement at the times of mineralization was very minor. It was probably a minor shifting of the already faulted blocks which produced practically vertical joint and fracture zones extending to a considerable depth. Development has not proceeded to sufficient depth to allow any statement as yet as to the ultimate trend of these zones or their general cause. The grouping of the mineralization areas at the Amulet would point to their being confined to a zone roughly two miles long by one mile wide, striking S.60°E. (see Figure 62). It should be stated at once that no major faulting with such a strike is known in this area. The Waite group seems to be confined to an alteration and mineralized zone striking north-south and dipping steeply west, whereas the numerous faults in the Waite area all have a northeast strike.

(3) The horizon at, or close to, the main andesite-rhyolite contact includes the greatest number of orebodies which, in themselves, account for a preponderance of the tonnage. Not more than 500,000 tons, out of a total of 5,000,000 tons, is contained in orebodies which are separated from this contact by barren, altered andesite. Moreover, only four of the twenty or more individual lenses known come under this last classification, *viz.*, *A*, *B*, *D*, and *Waite Surface* (zinc) orebodies. Further, the large dalmatianite areas to the west may also have been responsible for orebodies close to the contact zone, but which have since been removed by erosion. In this respect it is probable that the small sulphide masses in the dalmatianite area immediately west of *F* orebody are the roots of such an eroded orebody.

(4) That other favourable flow contacts exist there is not much doubt. *A* orebody probably occupies one of these. Similarly, the existence of other favourable contacts below those explored to date is a distinct possibility.

(5) The retarding and guiding effects that the dyke contacts must have had on solution flow is abundantly plain in all the ore groups. It is especially well shown in the two larger groups, *viz.*, *A* and the *Waite.*

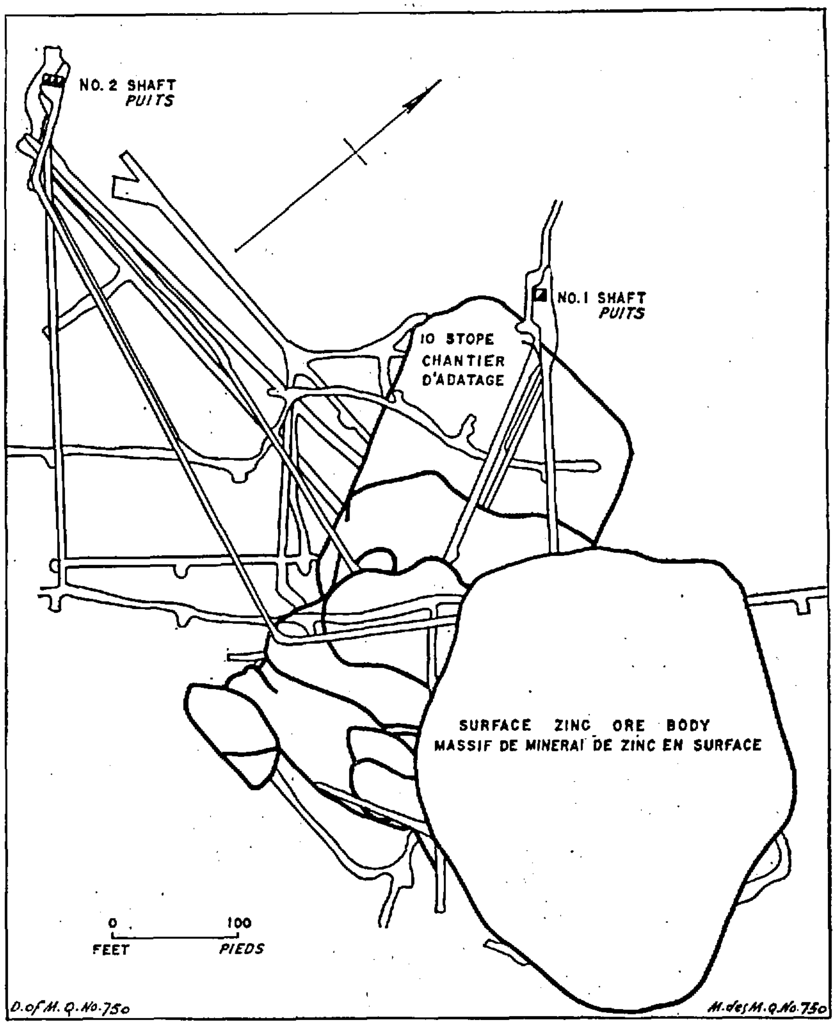

FIGURE 63.—*Waite section, composite orebody.*

In the first, an intricate series of feldspar porphyry dykes, together with some earlier diabase dykes, must have greatly influenced the emplacement of *Lower A* orebody (see Figures 67 and 68). In fact, it is possible that these relatively impervious rocks had a greater influence in this regard than the main contact in this area. It is worthwhile repeating here that, to date, no major fault has yet been discovered in the near vicinity of this, the largest orebody on the property.

No other group shows the effect of the above mentioned control as well as the Waite. Here, in no fewer than twenty separate sulphide lenses (see Figures 63 and 64), there is an estimated total of more than 1,000,000 tons of ore. They occur from the surface to the 1,050-foot level. The major-

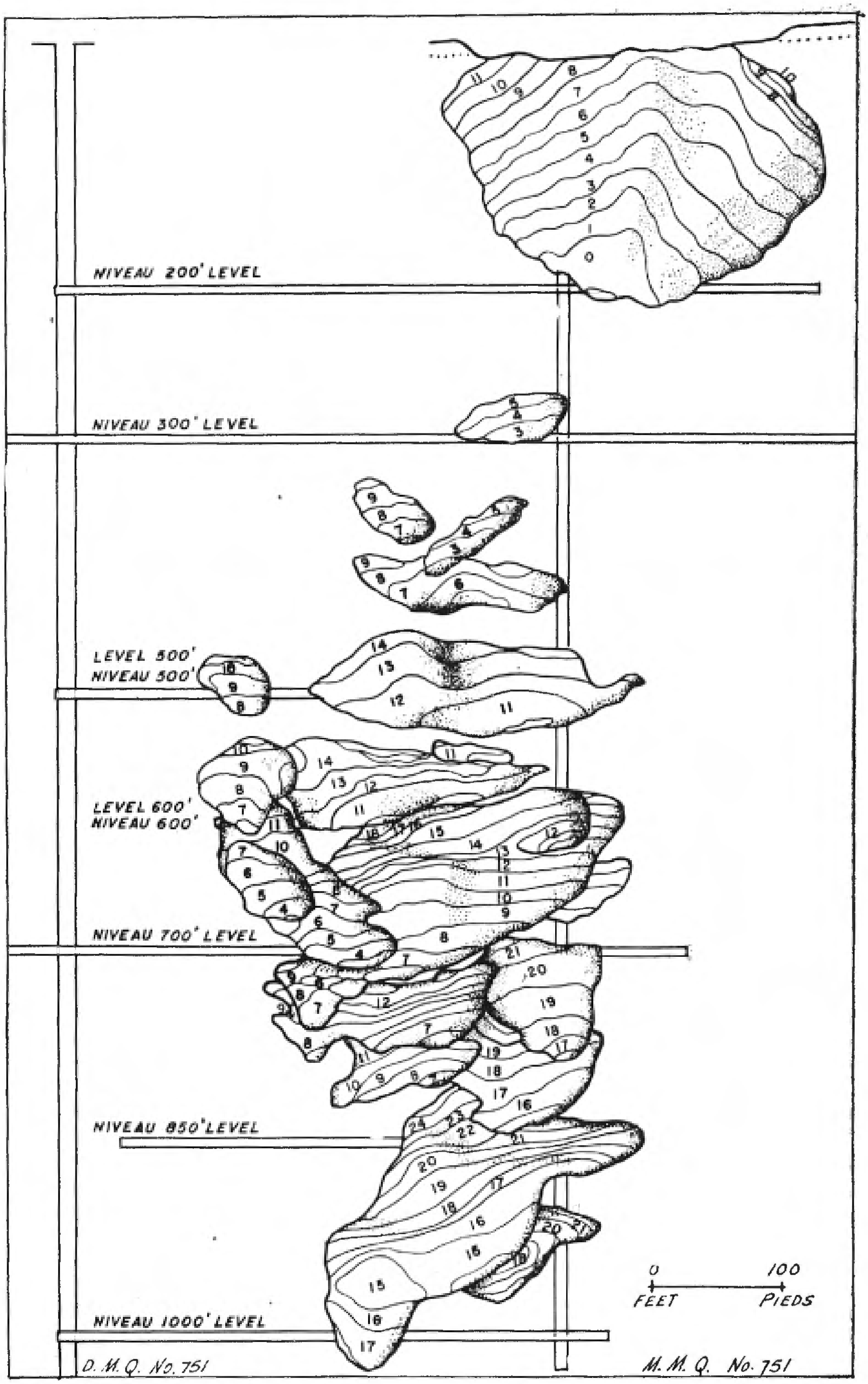

FIGURE 64.—*Waite section, vertical projection of orebodies looking N.50°W.*

ity undoubtedly have replaced remnants of rhyolite and rhyolite breccia lying between the numerous flat-dipping diabase, feldspar porphyry, and quartz porphyry dykes (see Figures 65 and 66).

Only in the case of the surface orebody and some of the small lenses near and between the 200-foot and 300-foot levels may the rock replaced have been andesite. It is obvious that, here, the major control was by the dykes, with the main contact zone merely a secondary factor. A further control by the steep north-dipping fault was exerted toward prevention

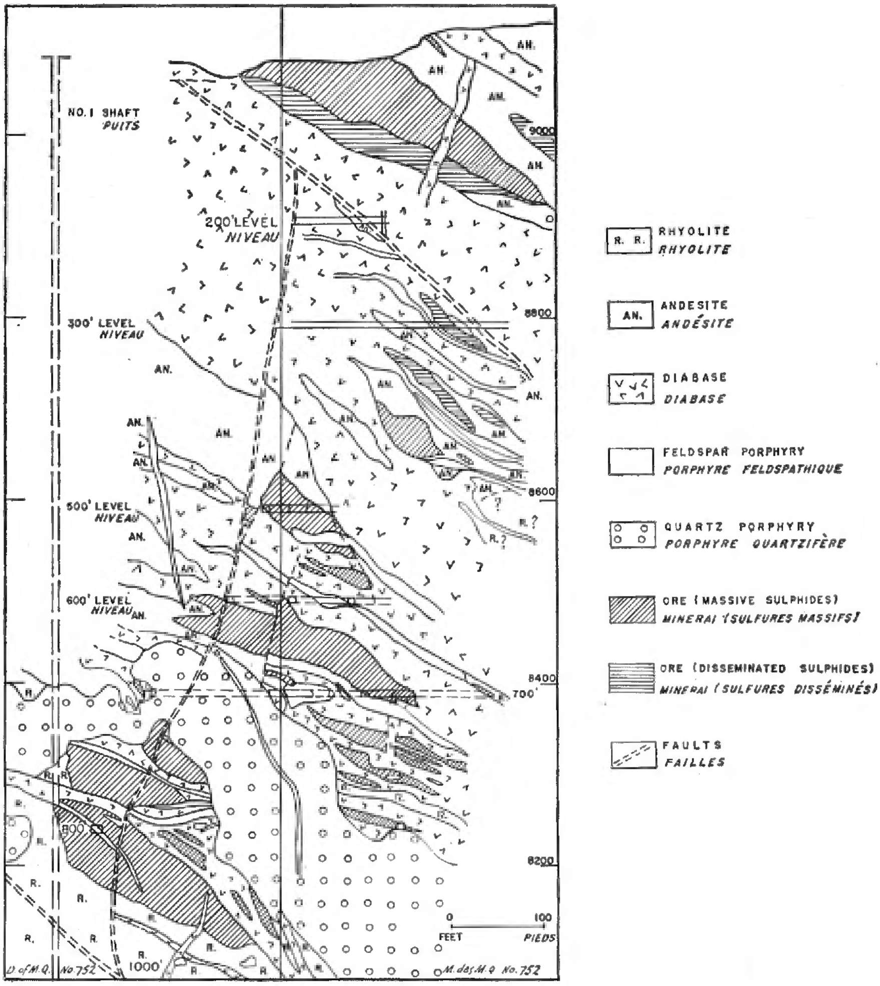

FIGURE 65.—*Waite section, vertical projection of orebodies looking N.40°E.*

of a too great migration of the ore-bearing solutions in the lower and central zone at this mine. In passing, attention is called again to the fact that the ore and alteration zone maintains an apparently undisturbed course upward through a maze of flows, dykes, and flat-dipping thrust faults without any major deviation. So far as is known at present, this is true down to 1,500 feet below the surface.

(6) Previous descriptions of this area have laid considerable stress on a supposedly close relation between folding in the flows and the emplacement

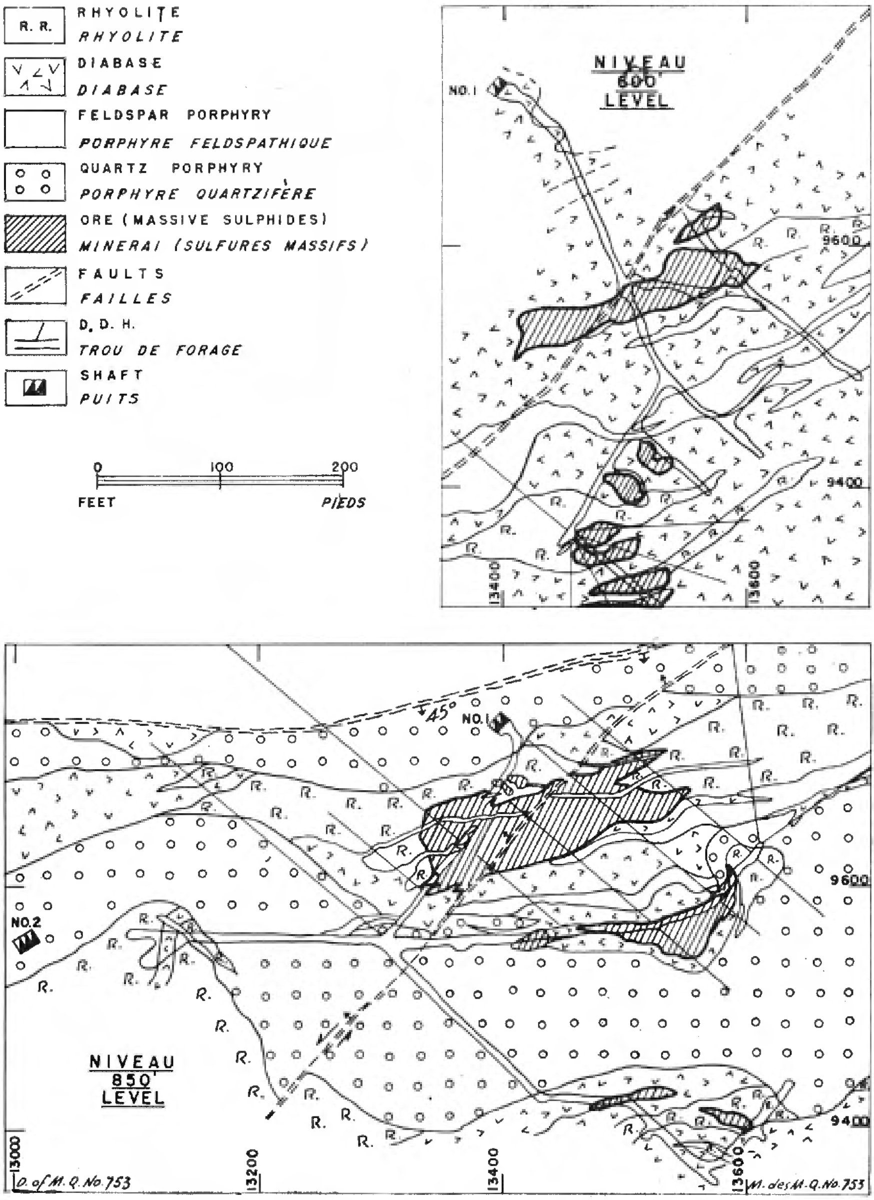

FIGURE 66.—*Waite section, 600-ft. and 850-ft. levels.*

of the orebodies. No doubt certain small flexures in the flows have produced favourable structures in the main contacts, *e.g.*, tilted domes. It is possible, also, that original regularities, as well as folding, may have had some effect. Unfortunately, definite information on these points is lacking owing to the virtual impossibility of tracing the actual flow contacts in the intensely altered, mineralized areas. The original rock textures tend to be obliterated by dalmatianite and other alteration products. In a number of cases, the intrusives are so plentiful and complex that they make structure determination almost impossible. Sometimes, all that can be done is to map the unaltered flows around the borders of the mineralized areas and attempt, from the results of this study, to reconstruct the structure. The detection of slight folds in the contact — such as the above theory postulates — is therefore very difficult. In any event, the features described in the preceding paragraphs would indicate that the major factor in the emplacement of ore was

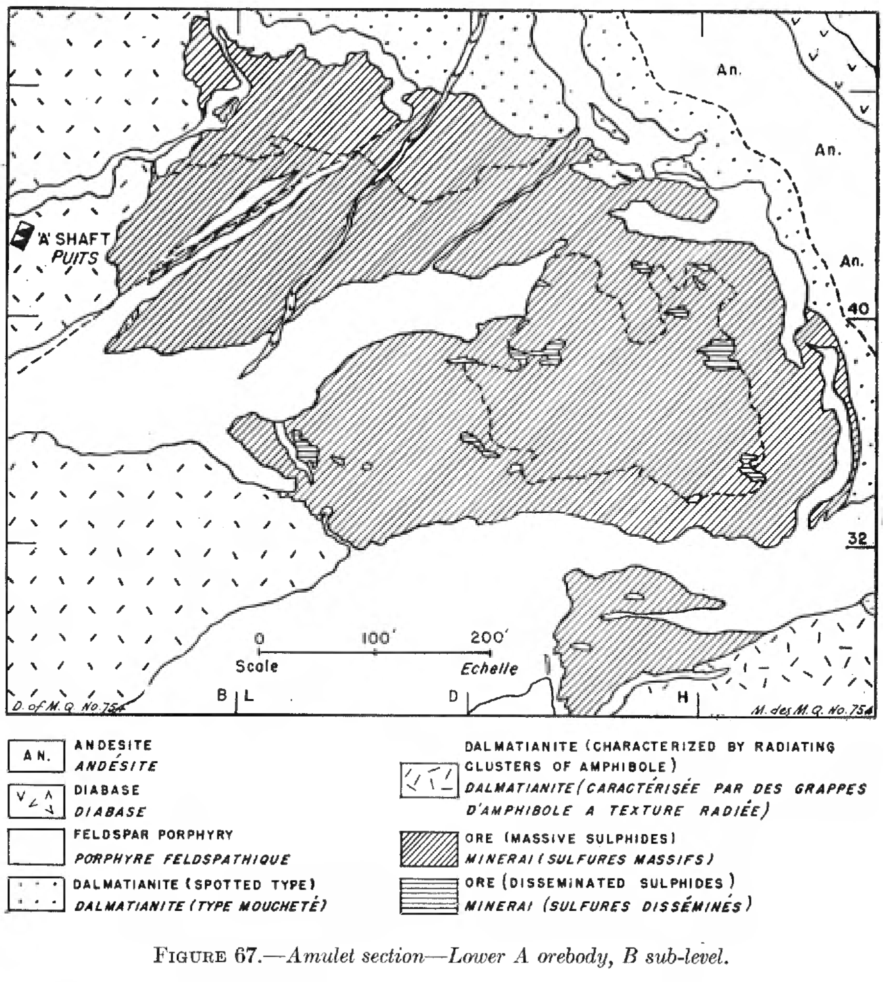

FIGURE 67.—*Amulet section—Lower A orebody, B sub-level.*

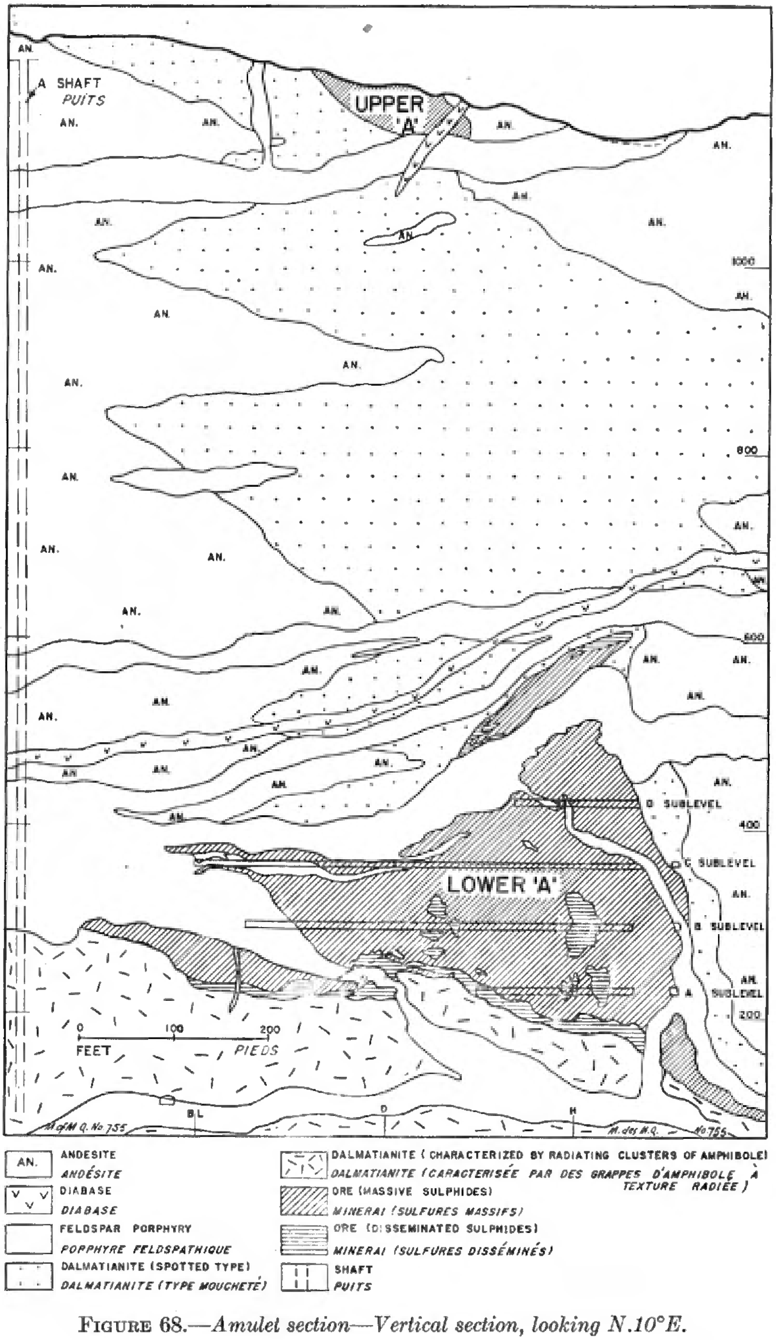

FIGURE 68.—*Amulet section—Vertical section, looking N.10°E.*

the development of deep, persistent fracture zones. These zones need not necessarily have been the result of violent movement. The main requirement was that they were slightly opened and reopened at the critical periods.

(7) What caused these fracture zones? It has been suggested that they were formed in a roughly simicircular pattern by the intrusion of the Dufault granodiorite batholith. This theory derives from the fact that the orebodies so far discovered are all at almost exactly the same distance from the western margin of this intrusive. Recent work, however, has shown that this granite mass approaches very close to (within 400 feet of) *F* orebody at no great depth (500 feet), and, if its present plunge is continued, may even underlie it. Hence it is believed that, while the intrusion of the Dufault mass produced considerable fracturing, the actual openings that were available for channel-ways were mainly the result of later minor movements. It is further probable that the intrusive responsible for the orebodies has not been encountered anywhere in the mine workings, and that it does not approach within a considerable distance of the present surface.

Relation of Orebodies to Rock Alteration

In the preceding pages, a description was given of the types of alteration that the rocks in this area have undergone. The relation of the orebodies to the alteration in general, and the structure of the altered zones themselves, are of considerable scientific interest, besides serving as guides to future prospecting. The following remarks are of general application, throughout the area:

(1) All orebodies are accompanied by more or less silicification and sericitization of the surrounding rocks. The bleaching and generally small pyrite mineralization which accompany these processes form quite extensive 'halos' horizontally. Selective attack on certain of the flat-lying flows tends to complicate the picture, especially in surface outcrop, but, in a general way, the above is true.

(2) Chloritization, as noted previously, is more local, and is generally close to, and quite often beneath, the orebodies. There is also a tendency for the central part of an orebody, even where barren, to be more chloritic than the borders. The same is true with regard to the amount of biotite present.

(3) The formation of epidote appears to have little relation to the mineralized zones.

(4) The relation of the orebodies to the dalmatianite is highly important, but somewhat complex. Certainly, both are closely connected in time and structure. On the other hand, all four groups of orebodies exhibit considerable variation in the intensity, extent, and structure of the accompanying dalmatianite alteration.

At the *A* group, the dalmatianite alteration is intense, forms a continuous 'pipe' from at least 1,800 feet in depth to the surface, throws out large, flat 'fins' along favourable flow contacts, shows a fairly constant diminution away from the centre of the 'pipe', and is, or tends to be, roughly proportional in intensity to the amount of ore in the vicinity (see Figure 68).

In the area in which the *C* group of deposits occur, however, there are no such definite relations between the orebodies and the dalmatianite. In fact, the most intense dalmatianite alteration occurs, not below or around the orebodies, but to the west of them on the surface, and to the east of them below the 600-foot level. Similarly, there is an entire absence of *intense* dalmatianite alteration in the immediate vicinity of *F* orebody. The nearest such alteration is 800 feet to the west (see Figure 62). It might be argued that the lack of close relationship with the dalmatianite shown by these two groups of orebodies is a consequence of their relatively small size. Such a theory, however, would still not account for the very minor dalmatianite alteration at the Waite, where there is no dalmatianite of the 'spotted' type and only comparatively minor zones of the 'rosette' type have been seen.

Hence it would appear that, while there is no doubt that the connection between ore and dalmatianite is fairly close, some separation in time and structural control is evident. Stated in another way, the presence of dalmatianite is not an infallible guide to ore.

Certain types of dalmatianite have been locally termed 'dry', the belief being that they were accompanied by only negligible mineralization. It was thought that recognition of these would aid in the delineation of the more promising areas to prospect. Unfortunately for this hope, it has been found that dalmatianite of the so-called 'dry' type occurs in the known mineralized zones.

(5) The relation of 'grid structure' to ore appears to be plain above *C* and *F* orebodies. In these areas, the andesite overlying the ore shows an intense development of this type of alteration. It is not certain yet whether grid structure indicates a relatively weak phase of mineralization or, as has been suggested, may occur above, and around, the borders of dalmatianite cores, especially along flow contacts.

It will be evident from the foregoing discussion that the ore areas present considerable variety in the size, structure, and type of their accompanying alteration zones. No one feature is prerequisite, nor does the size of the alteration zones reflect the amount of ore contained in them. The old theory, that dalmatianite occurs in quantity only under ore, is not tenable in the light of present knowledge (see Figure 68).

The Mineralization: Its Sequence and Distribution

The chief sulphide minerals forming the Waite Amulet orebodies are pyrite, pyrrhotite, sphalerite, and chalcopyrite. Minor amounts of cubanite (chalmersite) are present. Besides the sulphides, there is a considerable spotty development of magnetite.

These minerals are present in all orebodies, but their distribution, sequence, and mutual relationships have been influenced and controlled by both structure and distinct mineralization periods.

Apparently, pyrite and sphalerite were the first sulphides deposited. Microscopic and field evidence both show that pyrite formed first and that the sphalerite is closely associated with it but somewhat later. This mineralization probably deposited small amounts of chalcopyrite and minor gold and silver minerals.

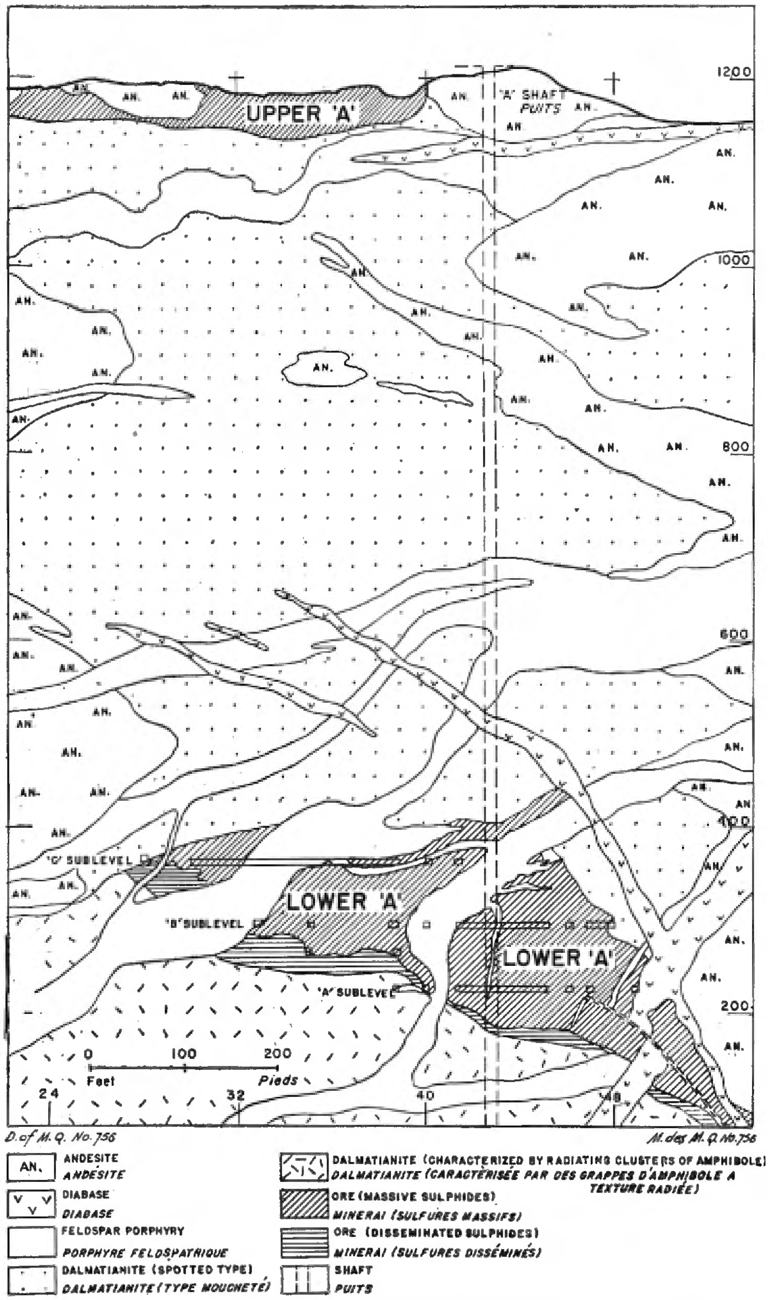

FIGURE 69.—*Amulet section—vertical section, looking N.80°W.*

The distribution of the pyrite-zinc mineralization shows a number of interesting features. It was undoubtedly the most widespread. While the bulk of the ore-bearing solutions travelled upward in vertical channels, they also, to some extent, sought out flat-lying, favourable flow contacts, tuff beds, and dyke contacts, and along these deposited pyrite and sphalerite. They spread themselves over a considerably greater area than was reached by later mineralization. It is probable that a certain amount of sealing of these early channels was thus effected. This would explain the frequency with which orebodies in the Waite Amulet area die out in thin (6-ft. to 2-ft.), flat, pyrite-zinc 'fins'. It also throws some light on the observed tendency for the central portions of these orebodies to be relatively rich in chalcopyrite, with the border zones frequently consisting of pyrite and sphalerite.

The formation of the *Surface* (zinc) orebody at the Waite mine must have been effected in a similar manner. Here, in the only orebody at the Waite which might be classed as zinc ore, a flat-lying lens, estimated to contain 300,000 tons of ore, shows a peculiar concentration of chalcopyrite in one place. This concentration is directly above a group of other sulphide lenses which carry only negligible zinc.

Thus, the conditions under which the sulphide minerals were deposited were similar to those at the Horne mine (see p. 350). Certain channels were open during the early mineralization. Some of these then became sealed off permanently (especially the outlying ones). Others were reopened and mineralization proceeded along these and through the same areas as in the earlier stage.

The ensuing pyrrhotite-chalcopyrite mineralization apparently followed the older channels, except, of course, those that remained sealed. Only in one case was there any appreciable extension out from, or below, the earlier mineralization. This was at the Waite, and it must have been at this period that the copper-bearing lenses with low zinc, and the copper-rich portion of the *Surface* orebody, were formed. In all the other orebodies in the district, this pyrrhotite-chalcopyrite mineralization adhered closely to the older channels.

Evidence regarding the time of formation of the magnetite is not so clear here as it is at the Horne mine, but it is probable that it was formed at this stage.

Similarly, there is uncertainty as to the relative age of the bulk of the dalmatianite alteration. As possibly throwing some light on this problem, it is of interest to note that, traversing and lying within most of the dalmatianite bodies are irregular veinlets and small masses of chalcopyrite and pyrrhotite. This would suggest that the dalmatianite alteration was closely related in time to the second period of mineralization, but it would be unwise to attach undue weight to this possibility in view of what has been said on an earlier page concerning the relation of the dalmatianite to the orebodies. Actually, it is probable that the formation of this alteration product proceeded throughout the entire period of mineralization.

The last minerals to be formed were those carrying the gold and silver or with which the native gold is closely associated. The average gold and silver content of the Waite Amulet ores is low as compared with the Horne ores, and consequently the mode of occurrence of these metals is less well known. Another point of difference is the ratio of gold to silver, which in the Horne ores is about 1 to 2, whereas at the Waite Amulet it is about 1 to 30.

The gold is found replacing all the sulphides and as minute veinlets and 'pipes' in pyrite. It has also been observed replacing magnetite. Generally, the gold is highly argentiferous (electrum). Seen in polished section, it is very pale, with a faint pinkish tinge in some specimens, and usually it is accompanied by minute crystals of a pale blue telluride. This mineral is difficultly soluble. Its composition has not yet been fully determined, but it contains some lead. Other associated minerals are cosalite ($2PbS.Bi_2S_3$), and a selenide, probably klockmannite, CuSe.

It has not been found possible to trace distinct high-grade gold or silver zones through the orebodies, as has been done at the Horne mine. This is probably due, in large part, to the comparatively low content of these metals in the ore, but it also leads one to doubt if there was, here, a distinct late gold mineralization such as there undoubtedly was at the Horne property. It is more likely that, at the Waite Amulet, some precious metals were introduced in each of the periods of mineralization.

Age and Source of the Mineralization

No orebodies have yet been found on the property in contact with the Powell diabase dyke or with the Dufault granodiorite. The age relation of the ore to these intrusives is therefore still in doubt. Indirect evidence, however, suggests that the orebodies are later than, and have little connection *genetically* with, the Dufault granodiorite. Their parent body is probably some deep intrusive nowhere seen on the surface.

From this postulated body, the ore-bearing solutions ascended in at least six pipe-like, vertical, fractured zones. In their upward travel, they passed through a complex assemblage of flows and intrusives. Their passage was retarded not only by the main andesite-rhyolite contact, but by the numerous small intrusive bodies in this general horizon. Conditions of temperature and pressure being suitable, the sulphide minerals were deposited in the favourable top horizons of the rhyolite or just above it. Masses of ore were formed singly; in clusters; in tiers of lenses stacked one above the other; a large lens at or near the main andesite-rhyolite contact; and a smaller 'satellitic' body in the andesite 600 feet above the contact (probably in a relatively favourable flow). This latter raises the question as to whether other favourable horizons may exist at greater depths below the contact. Work has only just started toward settling this important point, but it is believed that such horizons will be found.

Copper Deposits in the Eastern Townships

Historical

The earliest official report giving some account of the occurrence of copper mineralization in the Province of Quebec was published by the Geological Survey of Canada under the date 1847-48. In that report, the Director, W. E. Logan, described several occurrences of copper ores, all of which he regarded as too small for profitable operation, but some of which he thought indicated areas favourable for prospecting. All were in the disturbed rocks of the Eastern Townships.

At that date, the Grand Trunk railway was under construction across the folded country between Montreal and the Atlantic seaboard at Portland, Maine; also, a branch line was projected to run southwesterly from Quebec city along the northwest margin of the disturbed belt for a distance of about one hundred miles. The time for prospecting the new region was opportune.

Three localities that Logan recommended for further trial were in the townships of Inverness, Upton, and Ascot. None of the prospects thus opened became mines. Yet the localities proved to be well chosen. The Inverness prospect, range II, lot 4, proved too small to be useful, but more and better ore was found along the strike of this occurrence, in the township of Leeds. The latter discovery became known as the *Harvey Hill mine*, an enterprise that produced some ore, much of it of high grade, during a checkered period of operation of some thirty years, under unfavourable conditions of working and transport. The opening of this property, however, did much to make the possibilities of the region known to mining interests outside of, as well as within, Canada. At various times, mining interests from Great Britain and the United States, as well as local concerns, embarked upon this venture, and their engineers gave authoritative information of the prospective resources of the country which later facilitated the development of related districts in the Province.

The locality in Upton recommended by Logan, range XII, lot 51, did not advance beyond a prospect. Yet, a few years later, in 1858, corresponding strata, six miles away on the opposite side of a syncline, were found to contain the very rich ores of the *Acton mine*, which were mined actively and very profitably for some ten years.

The third prospect recommended by Logan for investigation was in lot 17, range VII, of Ascot township, near the town of Lennoxville. This, too, proved insignificant in itself, but it led to the discovery, some years later, of the deposits of the *Capelton* and *Eustis mines*, four miles southwest, which furnished a large part of all copper and sulphur ores that were mined in the Province during the following sixty years.

Disregarding numerous prospects, from some of which there was a small, sporadic production, the first mines from which there was an appreciable, sustained output were the Harvey Hill and Acton, both of which started production shortly before the period of high copper prices that prevailed during the civil war in the United States, between 1860 and 1864. Depletion of ore from these two sources was followed by the opening of the Capelton (1863), Eustis (1865), and Huntingdon (1865) deposits. Falling copper prices were later reflected in a decline in production from 1,882,491 pounds, in 1876, to 408,860 pounds in 1879.

In the years next following, the utilization of sulphide ores in the manufacture of sulphuric acid was begun. This led to a renewed production of ore, which, in the year 1888, reached 63,479 tons with an estimated content of 5,562,864 pounds of copper. A gradual decline ensued. The

Capelton mine was closed in 1907, but production began at the Weedon in 1910, and, during the Great War, 1914-18, the yearly output averaged five million pounds of copper and 125,000 tons of pyrite concentrates. An abrupt decline followed the close of that war and there was no production during the years 1922 and 1923.

After this period, the Eustis mine was reopened. In 1927, the Capelton mines were merged with the Eustis, and a new Company, the *Consolidated Copper and Sulphur Company, Limited,* was organized to explore and operate both properties. Production continued in the Eustis until 1939, when the mine was finally closed after seventy years of operation. With the closing of the Eustis, there was no production of copper from the Eastern Townships until 1944, when shipments were made from the Moulton Hill mine of the *Aldermac Copper Corporation, Limited* (see p. 388).

A comprehensive report on *The Copper Deposits of the Eastern Townships,* by J. Austen Bancroft, was published by the Mines Branch, Department of Colonization, Mines and Fisheries, in 1915.

Production

Records of copper production from this district are incomplete. It is known that the output from all mines in the Province for the period 1886 to 1939 amounted to 1,038,505,200 pounds (Dom. Bur. Statistics, 1938 and 1939). and that production from the mines of Western Quebec, from its inception in 1927 to 1939, was 868,876,093 pounds (Que. Bur. Mines, 1939). Since the whole of Quebec's copper production has come from mines in Western Quebec and the Eastern Townships, it would appear that the output of the latter mines during the period 1886 to 1939 was approximately 170,000,000 pounds.

Earlier records, that is, for the thirty years 1855-85, are so fragmentary and indefinite that little can be learned from them of the volume of the industry. It was evidently small by comparison with modern operations, but, due to high prices for copper for a time after 1860 and also to the high grade of some of the ore, the industry must have been an important factor under the financial conditions of the times.

Types of Deposits

The copper deposits of the region south of the St. Lawrence are of four different types. These are distributed, broadly, in four more or less definite bands that run parallel to the structure of the area. All are situated east of the St. Lawrence-Champlain fault and are thus within the disturbed belt. Individual occurrences of each type are often quite widely separated from one another, but, nevertheless, they occur in groups or belts, which, as a whole, have a generally northeasterly trend.

(1) The most easterly belt contains the deposits of Ascot and Weedon townships and minor occurrences between these townships. It furnished the main output of the region, chiefly from the Eustis and Capelton mines. The typical ore is chalcopyrite and pyrite in a country rock of quartz porphyry which is largely altered to sericite schist. The orebodies are in the shape of lenses a few hundred feet in length and rarely 100 feet in breadth.

In the Eustis mine, in Ascot township, at least, the depth greatly exceeds the length.

(2) The next series on the northwest occurs along the Serpentine belt, in the townships of Bolton and Garthby. These ores are in, or directly associated with, intrusions of basic rocks into sedimentaries or earlier volcanics. The ore is chalcopyrite with associated pyrite and pyrrhotite. Of this class of deposit, the *Huntingdon mine*, in the township of Bolton, was a small but rather constant producer of copper for some fifteen years; in its later operations, sulphur also was recovered. The *Ives mine*, at Eastman, is another of the same class. In lot 22, range I, Garthby township, pyrite alone was exposed by development work during several years. Trial shipments have been made from the Lake Memphremagog deposit in lot 8, range IX, Potton township, which also is in this belt.

(3) Occurrences of chalcopyrite and pyrite are numerous in the Sutton range. Many have been opened by pits, or small shafts, The ores are generally chalcopyrite with pyrite. The occurrences are either in volcanic rocks, generally basic, or in dolomite adjacent to such rocks. Shipments of ore have been made at times from several of these deposits, but the only appreciable output has been from the *Harvey Hill mine*, in Leeds township, which for a time yielded some high-grade ore.

(4) In the fourth type of occurrence, the mineralization is associated with sedimentary rocks of Lower Ordovician age in the vicinity of bodies of igneous rock. Some of the latter are undoubtedly intrusive, others seem as surely to be interbedded volcanics, and still others remain in the doubtful class. Native copper occurs in places as specks or narrow stringers in the igneous rocks. Sulphide mineralization in the sedimentary rocks consists of chalcopyrite (chiefly), pyrite, bornite, and, in places, minor amounts of chalcocite. Numerous occurrences of this type are known and have been investigated, but only one producing mine was developed, the *Acton*, which, early in the history of copper mining in the Province, proved one of the most profitable operations of its time.

Principal Deposits

The Eustis-Capelton Mines

Situated seven miles south of the city of Sherbrooke, on lots 2 and 3, ranges VIII and IX, Ascot township, the Eustis-Capelton properties occupy an area two miles long, northeast, by two-thirds of a mile wide.

Snow and Brownbill (p.73) point out that "in the case of the Eustis mine, [the ore] is found in one of the minor folds at right angles to the axis of the main anticline". They describe the ore occurrence as follows (p. 76):

"There are four distinct lenses of ore, arranged *en échelon*. Three of them are classified as pyrite lenses, assays of the ore ranging from 0.05 to 1.25 per cent copper and 36 to 44 per cent iron. The fourth lens, designated the copper lens, lies in the hanging-wall of, and to the southwest of, the pyrite lenses. The copper lens assays from 1.5 per cent copper and 40 per cent iron. in the southwest end, to as high as 16 per cent copper (and 26 per cent iron) in the northeast end. The mine-run for the past few years has averaged 4.11 per cent copper and 30 per cent iron.

"The walls of the orebodies are seldom sharply defined, the massive sulphide generally passing into schist or 'green rock' containing only disseminated pyrite and chalcopyrite.

"From the surface down to the 3,200-foot level, the orebodies, both copper and pyrite, have been completely mined out. In this section of the mine, the copper values in the pyrite ore were sufficiently high to warrant the mining of the pyrite orebodies. Below this level, the copper values have been largely segregated in the copper lens, apparently at the expense of values in the pyrite lenses, so that in reality there are two distinct orebodies in the lower part of the mine, a copper orebody and a pyrite orebody.

"It is interesting to note that the three pyrite lenses and the copper lens, separated by bands of schist or green rock, from two to ten feet thick, are continuous, never crossing the separating band of rock, from the 3,200-foot level to the 6,500-foot level, which is the bottom level at present (1936).

"The pyrite lenses are from 2 to 25 feet wide, normal to the dip and strike, and, where fully developed, show a length along the strike of about 250 feet. Very little mining of these lenses has been done below the 3,200-foot level. A conservative estimate of the pyrite ore reserve in the Eustis mine is 1,500,000 tons. The copper lens varies in width from 6 feet to 40 feet, normal to the dip and strike, and averages about 110 feet in length along the strike. It has been mined out down to the 5,900-foot level".

The description quoted above was written in 1936. Mining was continued to the 7,900-foot level, or to a vertical depth of 5,200 feet, the shaft having an average inclination of 41 degrees with the horizontal. The mine was finally closed and abandoned in June, 1939; the mining plant was dismantled and sold. It is estimated that, between 1881 and 1939, some 2,500,000 tons of ore was taken from the mine (F. W. Snow, personal communication). Production of copper during the final year of operation (1939) was 1,849,061 pounds (Que. Bur. Mines, *The Mining Industry in 1939*, p. 14).

Both Stevenson and Douglas, who carried out geological investigations at the mine in 1936 and 1937, concluded that the orebody was a result of hydrothermal replacement of schistose porphyry, and that the massive carbonate rock, locally termed 'green rock,' which is closely associated with the orebody, also was produced by replacement of the schist by the solutions that brought in the ores. The source of these solutions is not known. Both of these observers emphazised the lack of foliation or any mechanical deformation of the orebodies, unless locally by certain post-ore lamprophyre dykes.

The Weedon Mine

This mine, in lot 22, range II of Weedon township, ranks third as a copper producer among the mines in the Ascot-Stoke belt, It is five miles east of Weedon station, on the Quebec Central branch of the Canadian Pacific railway, and forty miles northeast of Sherbrooke. It is of interest to note that this deposit was not discovered until 1908, more than forty years later than the Capelton, Eustis, and other orebodies of the belt. Operation of the mine was continuous from 1909 until 1921, and from the workings, which reached a depth of 1,150 feet, the total ore extracted was

581,245 tons. The description that follows is taken from Bancroft's report (pp. 272-275):

"The schists, which enclose the orebody, strike N.35°E. with an average dip of about 45° toward the southeast. With depth, the dip varies from 25° to 60°, the orebody conforming to the 'rolls' of the schists. The hanging-wall is of sericite schists, the metamorphic equivalent of a quartz porphyry. They are identical in every respect with the schists that enclose the bodies of ore at the Eustis, the Capelton, and some other mines in the district. The footwall is of chlorite schists, derived from the metamorphism of either a hypabyssal or volcanic rock of the character of either a diabase or porphyrite . . . . . .

"Of lenticular form, the main orebody has been proved to have a length of somewhat more than 570 feet, and a maximum width of about fifty feet.

"The ore is granular pyrite, with chalcopyrite, some pyrrhotite, scattered grains of zinc blende, and a little galena. The last three minerals are of very subordinate importance in that they form but a relatively small percentage of the whole mass. Up to January, 1915, the ore shipped had averaged copper, 3.62 per cent; sulphur, 40.74 per cent; iron, 35.86 per cent; zinc, 0.77 per cent; lead, trace; insoluble, 12.25 per cent; (alumina, 4.08 per cent); gold, 0.01 ounce; and silver, 0.46 ounce".

Following the discovery of the Weedon orebody, prospecting was active in the surrounding country, but pyrite mineralization only was found (Burton pp. 133-142).

Moulton Hill Mine

The Ascot-Stoke-Weedon belt of schistose quartz porphyry in which these orebodies occur is some seventy miles long in a northeasterly direction and is commonly from one to two miles wide. The three productive mines—the Eustis and Capelton, within a mile of each other, and the Weedon, fifty miles northeast of them — are near the southern edge of the belt. In the vicinity of the Eustis-Capelton mines, there are numerous occurrences of copper mineralization, a few of which have yielded small amounts of ore, some of very favourable grade. All are southwest of St-Francis river. One important producer of pyrite for a few years, the *Moulton Hill mine*, on lot 23, range III, Ascot township, which is four miles northeast of that river, may have yielded a little copper.

Aldermac Moulton Hill Mine

In 1942, a geophysical survey carried out on lot 20, range III of Ascot township, about a mile and a quarter south of the Moulton Hill mine, indicated the presence of a zone of sulphide mineralization, on property owned by the *Aldermac Copper Corporation, Limited.* Trenching and diamond drilling showed that the zone extended for a length of 600 feet and to a depth of at least 1,000 feet, but that it was relatively narrow. Assays, however, were encouraging, and a vertical shaft was sunk to a depth of 244 feet to develop and mine the ore. In the following year, an inclined (40°) shaft was raised to the surface from the 200-foot level, and was sunk from that horizon to 486 feet. Workings were opened on three levels. A concentrator was installed, and production commenced in 1944. Stoping, however, disclosed that, between the levels, the ore width and area were greatly reduced by folding, which, also, has so weakened the rock that mining was both dangerous and costly. As a consequence, the operation was abandoned in 1945. During 1944, 35,175 tons of ore was milled, and the grade was 1.4 per cent copper, 5.28 per cent zinc, and 1.95 per cent lead, with a low tenor in gold and silver.

The ore occurs in a shear zone along or near the contact between highly schistose rhyolite and sedimentary schists. These strike northeast and dip 40° southeast. The sulphides have for the most part replaced the hanging-wall rhyolite schist, in which they appear as fine, disseminated grains and as discontinuous bands of massive ore from a few inches up to eight feet wide. From one to three bands of such massive ore were encountered along the drifts. Pyrite is the predominant sulphide, and with it are variable amounts of chalcopyrite, sphalerite, and galena (Hawley *et al.*).

Geological conditions along the fifty-mile belt from the Eustis to the Weedon mine are broadly uniform. The discovery by geophysical prospecting of the unexposed Aldermac deposit, about midway between these older mines, encourages the hope that future investigations along the belt may reveal the presence of other deposits of commercial size and grade.

Deposits in the Serpentine Belt

While the serpentine series is best known for its deposits of asbestos, talc, and chromite, it contains also bodies of copper and iron sulphides in a few places. The rocks of the belt are intrusive into the stratified series of the district (see Volume II, pp. 413-415). They are chiefly peridotite and pyroxenite, both serpentinized, but include also gabbro-diorite and a gabbroid diabase, the latter often altered to chlorite schist. Mining operations on a small scale have been carried on at fourteen or more localities along the belt. In most of the deposits, the ore consists of pyrite and chalcopyrite, but in some of those in the diabase schist, pyrrhotite is abundant. Assays of the ores usually show the presence of nickel, though seldom more than a 'trace'; but in one locality in Orford township, a vein contains the somewhat rare nickel sulphide, millerite.

The largest deposits of copper ore yet found in this belt were those of the *Huntingdon mine*, in lot 8, range VIII, and the *Ives mine*, in lot 2, range IX, both in Bolton township, Brome county. The Huntingdon mine was operated vigorously from 1865 until 1873, and intermittently during the ten years following. Since 1883, the property has been idle, except for short periods about 1890 and 1917.

Writing in 1872, Charles Robb, mining engineer, says: "At the Huntingdon mine, two parallel copper-bearing lodes or beds have been opened up and extensively developed, one on either side of, and both closely contiguous to, the serpentine and steatite bands. That lying to the west of this band and in immediate contact therewith has proved the richer and more important of the two".

Fragmentary records indicate an appreciable output of good grade ore at various times. The workings do not seem to have exceeded 600 feet in depth.

The deposit at the *Ives mine* is similar to that at the Huntingdon, from which it is distant about two and half miles. Shipments of ore from this mine appear to have been relatively small.

The stretch of country between these two mines would be favourable for exploration by diamond drilling. Structural conditions are well exposed.

Lake Memphremagog mine, on lot 28, range IX of Potton township, is seven miles south of the Huntingdon mine. This deposit consists of pyrrhotite with thin seams of chalcopyrite, a little pyrite, and occasional specks of sphalerite. The orebody lies at the contact between clay slates and an intrusion of diabase, which forms an adjacent hill known as Hog's Back mountain. The sulphide body dips northwesterly, down the slope of the hill, and extends for 100 feet or more along its flank, with a width up to thirty feet. Small trial shipments of ore, totalling about 1,000 tons, have been made from the mine at various times This deposit differs from those at the Huntingdon and Ives mines in its large content of pyrrhotite and lower tenor in copper. Also, it does not occur in a well defined shear zone.

The *Garthby*, or *Lac Coulombe mine*, in lot 22, ranges I North and I South, Garthby township, was opened in 1860. The ore is massive pyrite, with only very little chalcopyrite. It occurs in chlorite schists that have been formed through metamorphism of diabase. The extent of the deposit is not known. It is estimated that the ore would average below 0.5 per cent copper, with about 45 per cent sulphur.

Deposits in the Sutton Range

Spaced along the Sutton range over a distance of 140 miles between the State of Vermont and Chaudière river are numerous occurrences of copper ore. Richardson (1866) listed several hundreds. On forty-two of these, a limited amount of underground work was done, and from some of them a hundred tons or more of useful ore was mined. The ore was chalcopyrite with or without minor amounts of other copper sulphides, associated with pyrite. The only operation worthy of being termed a mine in this area of some 2,500 square miles was the *Harvey Hill mine*, on lot 17, range XV of Leeds township. The mine workings are on a dome shaped hill of sedimentary schists of the Sutton series, which contain much sericite and, in some beds, ottrelite (chloritoid). The ore, which consists of chalcopyrite, bornite, and chalcocite, associated with pyrite, occurs in lenticular beds or bands which parallel the schistosity, and also in transverse veins.

A feature of this deposit, and one which has not been at all fully studied, is the presence of an intrusion of pyroxenite, now altered to talc (soapstone). It appears near the southwest margin of the property and passes into or beneath the main workings. This would seem to indicate that the Harvey Hill deposit originated much in the same manner as those of the Serpentine series, previously mentioned.

An interesting history of operations at the property is given in a paper — cited on p. 393 under *References* — by the late Dr. James Douglas, who was associated with the enterprise throughout much of its early activity.

Deposits in the Acton-St. Flavien Belt

The copper occurrences of this belt all lie on the northwest side of the Sutton Mountain axis and east of the Champlain fault (see Vol. II, pp. 351-353). They are often associated with a belt of limestone that can be traced from Acton township to Wickham, a distance of eight miles. As early as 1863, Logan wrote (p. 717): 'The sulphurets of copper have been found in a great number of places in the intermediate distance and they are rarely absent from the limestone".

In ten or more localities in Acton, Durham, Roxton, Upton, and Wickham townships, some serious effort has been made to mine the copper. From perhaps half a dozen of these occurrences, a few tons of ore were shipped from exploratory workings, but only one profitable mine was developed. This was the *Acton mine*, in lot 32, range III of Acton township, half a mile from Acton Vale station on the Canadian National railway. This mine was in continuous operation from 1859 until 1864, during which period production amounted to 16,300 tons of ore containing 12 per cent copper. Although the price of copper throughout the years 1865-70 was high, the mine seems to have made only a very reduced production after 1864, and all work was suspended in 1870.

The rocks exposed, and encountered underground, on the property are magnesian limestones, underlying slates or shales of the Farnham (Lower Ordovician) series, and some dykes or sills, of 'greenstone' (originally diabase or related rock). The copper minerals, which are chalcopyrite, bornite, and lesser chalcocite, are confined almost entirely to the limestone, and, in this, to the vicinity of the 'greenstone'. They form the matrix in irregular, brecciated zones of the limestone, and adjacent to these the rock is impregnated, in places heavily, with the sulphides. In addition, there were on the property three relatively large sulphide masses, one of them sixty feet wide, within a length of 720 feet, and the ore that was mined came chiefly from these. At a depth varying between 100 and 300 feet, the limestone is underlain by Farnham shales. Some stringers of rich ore were found along the upper surface of the shales, but they persisted to a very limited depth within the latter.

From his examination of specimens of the ore, Bancroft (p. 90) concluded that the ore-bearing solutions were genetically related to the 'greenstone' intrusions. They deposited chalcopyrite, which replaced the limestone, particularly along and adjacent to the brecciated zones. Later, meteoric waters produced secondary enrichment by solution of some of the chalcopyrite and re-deposition of the sulphides at lower levels as bornite and lesser chalcocite. This would account for the general lack of mineralization in the underlying shales, which were impervious to the descending solutions.

Lower St-Lawrence and Gaspé Peninsula

Matane County and Vicinity

Some surface work has been done on occurrences of copper mineralization in Matane and neighbouring counties to the west, adjacent to the south shore of the lower St-Lawrence river. These counties are underlain chiefly by Lower Ordovician sediments which in places, as in the adjoining townships of Tessier and Saint-Denis, at several points along the north shore of Matapédia lake, and farther west, in Cabot township, include interbedded basaltic flows. Much of the work has been along a zone adjacent to Gagnon brook, extending from lot 1 to lot 5, range V, Saint-Denis, and from lot 36 to lot 40, range V, Tessier. Copper mineralization occurs in both the sediments and the volcanics: chalcopyrite with some bornite in the former, and native copper and cuprite, with malachite and azurite staining, in the flows. Shallow prospect shafts have been put down to explore some of these occurrences (Aubert de la Rue, pp. 25-28).

In several places for about twenty-five miles northward from the village of Matapédia, along the valley of Matapédia river, there are strong quartz veins, some of which carry small amounts of chalcopyrite, galena, and sphalerite.

Headwaters of York River, Gaspé

Copper mineralization was discovered at the headwaters of York river, in Holland township, Gaspé, in 1921, and has been explored by a considerable amount of trenching, chiefly on the Miller claims (Denis, pp. 34-37). In 1937-38, a motor road was built to the claims from Gaspé village, sixty miles to the east, and early in the summer of 1938 Noranda Mines, Limited, investigated the deposits by further trenching and some diamond drilling (Jones, pp. 60-74).

The rocks underlying Holland township are Lower Devonian sediments except for a hilly area of about three and a half square miles at the headwaters of York river, where they are silicified tuffs, rhyolites, and altered sediments, with some porphyry which may be intrusive or a facies of the rhyolite. The copper mineralization occurs in the volcanics and in the porphyry. It consists of chalcopyrite, for the most part disseminated through the rock but occurring also as seams up to three-quarters of an inch wide along joint planes, and in quartz veins, some as much as four inches wide. Accompanying the sulphide are its alteration products, malachite, and lesser azurite and chrysocolla, which cause a conspicuous staining of the rocks in the vicinity. Pyrite is present in some places, and molybdenite has been reported (Jones, p. 68).

Reference is made on page 450 to the occurrence of chalcopyrite in some of the zinc-lead deposits in Lemieux township, on Marsoui river, and in the vicinity of Gaspé bay.

Copper Occurrences in Grenville Rocks

Petite Nation Seigniory, Papineau County

In 1923, occurrences of chalcopyrite and bornite were discovered in the valley of Sweezy creek, a tributary of Kinonge (Salmon) river, in Petite Nation seigniory, Papineau county. The locality is about five miles north of Fassett, a station on the North Shore branch of the Canadian Pacific railway, seventy-six miles west of Montreal.

The rocks underlying the district are crystalline limestones and quartzites of the Grenville series, and pyroxenic gneiss of the Buckingham series.

The deposit occurs on a ridge of the gneiss that projects eastward as a spur from the side of the valley. The gneiss, which is much injected by pegmatite, contains disseminated grains and aggregates of grains of chalcocite with, in places, some bornite. The rock surface has been opened by blasting over a length of about thirty feet, and throughout this opening the mineralization is continuous, but the average copper content is probably below one per cent Similar occurrences are reported to north and south (M. E. Wilson, pp. 74-75).

North Shore, Lower St-Lawrence River

Longley (pp. 8-10) has described several occurrences of chalcopyrite mineralization, and one of bornite, in sedimentary schists of Grenville type and associated intrusive rocks along the North shore of the Lower St. Lawrence, at points about 400 miles below Quebec city. These are in Appititatte bay and, eastward from there, near Johan Beetz bay and Watshishou river.

The sharp bend in the course of Romaine river from southward to westward is about ten miles west of Appititatte bay, the river finally entering the St. Lawrence some thirty-three miles west of the bay and ten miles east of Mingan. Paragneisses and schists of the Grenville series outcrop intermittently, and in some places over long stretches, along the southward flowing part of the river, with intrusive granites and gneisses along the intervening stretches. At several points, and particularly in the vicinity of Simon, Forget, and Cimon lakes, some forty-five miles north of the St. Lawrence shore, chalcopyrite has been observed in the Grenville rocks or in associated gabbroic intrusives (Retty, pp. 27-28).

Although, in themselves, these occurrences appear to be of no importance, they are of interest as indicating that copper mineralization is widely distributed in these areas of Grenville rocks, which, in the opinion of both Longley and Retty, merit careful prospecting.

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IRON

HISTORICAL

Although, up to the present, production of iron from Quebec deposits has been relatively small, it is of interest, historically, that by far the earliest metal mining operations in the Province, or for that matter in Canada, were on deposits of bog iron ore in the vicinity of Trois-Rivières, Saint-Maurice county. These deposits were known before 1670 and a blast furnace for reduction of the ore was built in 1737. Other furnaces, or 'forges', were built in subsequent years, and it was not until 1910 that the last of these, the Radnor forges, were finally dismantled. During that period these operations supplied iron for many local needs, especially in the early days of the colony and, at times, there were small exports of iron products*.

Bog ores were also mined south of the St. Lawrence river, especially in the latter half of the 19th century. At about the same time, lode ores were mined in the Ottawa River valley. Since 1908 there has been no serious production of iron ore, except in the form of hydrous iron oxides and ochres for use in the manufacture of pigments and for the purification of illuminating gas.

Records of production are fragmentary and omit altogether the first 150 years' operation. In the annual report on the mineral production of

*Musket and cannon balls, and one or more cast-iron cannon, were exported to France during the years 1749-56; *Relations des Jésuites* and official correspondence of the time, translated by the late Sir Stopford Brunton, Bt. (personal communication).

Canada issued by the Dominion Bureau of Statistics in the year 1938 (page 26), the production of iron ore in the Province of Quebec during the years 1887 to 1938 is given as 433,697 tons.

South Shore of the St. Lawrence

Lode Ore

During the early settlement of the Eastern Townships along the United States border, small quantities of iron ore, chiefly lenses of magnetite in the Sutton schists, were mined in the townships of Sutton and Bolton. This ore was hauled to North Troy, Vermont, where a small furnace was operated for the treatment of similar ores occurring in that State. With the advance of means of transportation from the St. Lawrence, these Quebec ores were replaced by ores from better sources of supply and the deposits passed into disuse. Small bodies of similar ores have received attention at times in the townships of Leeds (lots 7*a* and 7*b*, range V), Megantic county, and Spalding (lots 6 to 14, ranges VIII and IX), Frontenac county, and in the counties of Sherbrooke and Wolfe.

No commercial production has been made from these deposits, or from a series of small high-grade hematite bodies that occur at intervals near a belt of Early Volcanic rocks that extends from the county of Missisquoi to Arthabaska.

In Gaspé peninsula, Jones (1933, p. 31) has noted that siderite is interbanded with Ordovician slates along Madeleine river in Deslandes township, and he also observed loose blocks of massive magnetite just south of the granite mass of Tabletop mountains, a few miles west of the river.

Bog Iron Ore (Limonite)

Bog iron ore occurs at numerous places south of the St. Lawrence river, both in the vicinity of the shore and in the valleys of several tributaries. Logan (pp. 683-685) refers to the widespread occurrence of such deposits in a tract some twenty-five miles east and west by five to six miles in width in "the Seigniories of Isle Verte, Villeray, Cacouna, and Rivière-du-Loup, as well as in the townships of Viger and Wentworth". He adds, "whether the ore occurs here in sufficient quantities to warrant establishment of a smelting furnace is perhaps doubtful". There is no record of any serious investigation of these deposits.

The only localities south of the St. Lawrence in which bog iron ores have been mined are near St. Francis river, where furnaces for the reduction of the ore were built at Drummondville and at Rivière-aux-Vases; near the mouth of Nicolet river; and in Stanbridge. From Stanbridge, ore was shipped to Alburg, Vermont, for smelting.

The furnace at Rivière-aux-Vases, according to Ells (p. 24), was built by the *St. Francis River Mining Company*, in 1869 and was "worked by the Company till 1873, making in that time 5,520 tons of charcoal pig iron". The plant was then sold to John McDougall & Company, of Montreal, who operated it until 1880, when it was closed owing to the exhaustion of ores in the vicinity.

The works at Drummondville were erected in 1880-81 by *John McDougall & Company* and continued in operation until 1911, the final three or four years under the ownership of the *Canada Iron Corporation.* The plant consisted of two blast furnaces, with a combined capacity of about 4,000 tons of pig iron per year. This was principally used for car wheels, which were made at the Company's foundry in Montreal. The ore was obtained in part from deposits in the vicinity and in part from Vaudreuil, near the St. Lawrence river a short distance above Montreal. It contained from 40 to 44 per cent iron.

The furnaces treated 11,067 tons of ore in 1908, but only 1,043 tons in 1911. Throughout the period of operation, charcoal was used to reduce the ore. The pig iron produced, being of high quality, commanded a superior price. Economical local supplies of ore and of charcoal are now probably exhausted.

North Shore of the St. Lawrence

Bog Iron Ores near St. Maurice River

(See also under *Ochre,* p. 488)

Lac-à-la-Tortue was the chief source of the bog iron ores used in the Radnor furnaces, near Trois-Rivières, from late in the French régime to the early part of this century, when these operations ceased. The lake is twenty miles north of the city of Trois-Rivières, two miles east of St. Maurice river. It is about three miles long from northeast to southwest and averages one mile in width. It occupies the lowest depression of a great swamp (the Grand Pré swamp) that extends north and south from the lake. Formerly, it had a depth at its centre of nearly twenty feet, shallowing gradually toward the shore, but, by the removal of an obstruction at the discharge, the water was lowered six to eight feet and a wide marginal zone of the lake bed was exposed.

A. P. Low, who examined the deposits in the early 'nineties', describes them as follows (p. 275):

"The lake is fed by a number of small streams flowing from the surrounding swamp; these are highly charged with salts of iron, giving the water of the lake a very ferruginous taste and colouring it a rusty yellow. The ore is found in the form of concretions scattered through the soft greenish mud, for several feet below the surface of the bottom. It appears to be formed by the precipitation of the protosalts in solution, which take up oxygen from the surface and, becoming insoluble, sink to the bottom, where they collect about various particles of foreign matter and form flat, porous concretions of various sizes, the largest being often six or eight inches in diameter by over an inch in thickness, and show distinct rings of growth. The growth of the ore in the lake bottom is quite rapid, it having been found that paying quantities of ore can be obtained from areas completely exhausted some eight or ten years ago".

Magnetite-Bearing Sands

At a number of places along the north shore of the gulf of St. Lawrence there are accumulations of black sands containing magnetite and, in places, appreciable amounts of ilmenite as well, Between 1867 and 1875, the *Moisie Iron Company* smelted concentrates of the iron sands with charcoal in furnaces near the mouth of Moisie river, 330 miles below Quebec city. The blooms produced were marketed in Montreal, chiefly for export to the United States. At that time the Canadian demand was small and, the American tariff having been raised to a prohibitive figure, the operation finally became uneconomical and ceased. At various times since, these sands have been under investigation as a source of iron ore. The conclusions reached have been that no large amount of this iron-bearing material is present at any one locality or in such concentration as to assure a continuous and profitable supply of ore. The most attractive of these black sand deposits occur along the shore at intervals from a point 200 miles below Quebec city to Natashquan on the gulf of St. Lawrence, 530 miles below Quebec city

Along the gulf are tidal flats of varying widths, but not of great extent, and inland from them in many places, above high tide level, are relatively narrow widths of the sands, a few feet to some tens of feet in thickness. Locally they have been re-worked by winds.

The sands composing the tidal flats and the benches back of them are the accumulations of material brought down by the southerly-flowing rivers draining into the gulf of St. Lawrence and re-sorted by wave and current action along the shore. The re-working of parts of these deposits along the successively lower shore lines that were formed as the area rose, and, probably, especially in the vicinity of the present shore line, has resulted locally in a pronounced concentration of the heavy, iron-bearing minerals. Regular and cross bedding is pronounced in these sands, and relatively rich concentrations of magnetite, or of magnetite and ilmenite, are not uncommon, but the thickness of the rich beds is often only a few inches at most, and even though the length of a deposit of such material may be considerable, its width is usually narrow. The result is that, even including the very low grade parts of these sands, the total iron-ore tonnage present in any district is rarely impressively large.

Some typical deposits are described below.

Betsiamites (Bersimis), 200 miles below Quebec city

The largest deposit of black sand in this locality is between the church at Betsiamites and Little river, two miles below. It forms a band along the sea shore at the foot of sand banks and terraces, from which its magnetite content has been washed out and concentrated by the action of waves which reach them only at high tides. The iron sands form a rather continuous band about five feet wide with a maximum thickness of two and a half feet. The thickness is always greatest at the highest point of the beach and diminishes rapidly toward the sea.

Faessler (1933, p. 129) estimated the volume of iron-rich sand along one and a half miles of beach at about 20,000 cubic feet, a commercially insignificant quantity. He gives the average composition of the sand as 54.27 per cent magnetite, 16.36 per cent ilmenite, and 29.37 per cent quartz, garnet, etc.

Moisie, 330 miles below Quebec city

The magnetite-bearing sands at this locality were worked on a fairly large scale from 1867 to 1875 by the *Moisie Iron Company.* The sand was gathered by hand shoveling, concentrated by a process of magnetic separation, and compressed into briquettes. Charcoal was used as fuel and the furnace product was cast into pigs on the spot.

The black sands extend along the beach for four or five miles eastward from the mouth of Moisie river, and also for about two miles from a point three miles west of the estuary. In the estuary itself, along the concave shore, there is a band several hundred feet long. Back from the beaches, the shore terraces contain magnetic sand beds over unknown distances. These beds are generally horizontal but not continuous.

In 1911, E. Dulieux (pp. 135-151) systematically sampled the deposit for a distance of two miles east of the mouth of the river. The average width of the band of black sand was estimated to be 35 feet, and the average thickness 1.6 feet. Samples were taken at twenty-nine points, and a composite of these, weighted according to the number of cubic feet represented by the individual samples, gave, on analysis, 36.42 per cent iron and 7.48 per cent titanium. From this composite sample, a magnet removed 26.23 per cent, by weight, and analysis of the magnetic fraction gave 67.17 per cent iron and 1.46 per cent titanium. This deposit was estimated to contain 40,000 tons and would average 17 to 18 per cent of metallic iron recoverable in the magnetic concentrate.

Dulieux also sampled part of the terrace sands to a distance of 500 feet back from the sea. He estimated that a concentrate could be made, amounting to 6.8 per cent of the weight of the original sands, containing 65.67 per cent iron. A strip one mile long, 500 feet wide, and six feet deep, would yield 57,000 tons of such concentrate.

Natashquan, 530 miles below Quebec city

The main deposits of iron-bearing sands in this district commence at the mouth of Natashquan river and continue eastward to English point (mount Joli), a distance of three miles. They are chiefly in an area of grass-covered dunes which extend back from the shore of the gulf an average distance of 500 feet. After extensive sampling of the deposits, G. C. MacKenzie (pp. 41-43) estimated there was available here 5,800,000 tons of sand containing 8 to 9 per cent iron, with the depth of the material averaging fifteen feet. From this, he thought it might be possible to produce 500,000 tons of magnetite concentrates averaging 67 per cent iron.

Lode Magnetite Deposits

The most important known deposits of magnetite low in, or devoid of, titanium are in the Ottawa Valley district, where they occur along the southern margin of the Precambrian shield at numerous points between Fort Coulonge, sixty miles northwest of Ottawa, and St. Jérôme, thirty miles northwest of Montreal. Most of these deposits are quite small and only a very few have produced any appreciable amount of ore. These latter are all within a short distance of Ottawa, most of them in the townships of Bristol, Hull, and Templeton.

Production of ore, which in some cases was smelted at the mine, began as early as 1845 in the case of the Forsyth mine, in Hull township. The last mining operation was at the Bristol mine, in Bristol township, which closed in 1894, although ore was shipped from its stock piles as late as 1917 (Mining Operations in Prov. of Que. in 1917, Que. Bur. Mines, p 23).

Bristol Mine

The Bristol mine is in lots 21 and 22, range II of Bristol township, Pontiac county, about thirty-five miles north of west of Ottawa, and three miles north of Chat lake, an expansion of the Ottawa river. It is a mile and three-quarters north of Pontiac station, on the Canadian National railway, and was formerly connected by a branch line, four miles long, with the Waltham branch of the Canadian Pacific railway at Wyman, which is northeast of the deposit.

History

Mining operations commenced in the winter of 1872-73 and continued intermittently until 1894. In 1896 and again in 1917, some ore was sorted and shipped from the stock piles remaining on the property. In 1909, E. Lindeman, of the Mines Branch, Ottawa, made a magnetometric survey of the property (Map 443), and in the following years the owners trenched some of the areas which had given high magnetic 'anomalies', but found only relatively small, scattered lenses of ore.

Mining operations were carried on from two shafts, the deeper of which was inclined and reached a vertical depth of about 150 feet, and from at least four open pits, the largest 50 ft. by 30 ft. by 70 ft. deep. Owing to the high pyrite content of the ore, roasting was resorted to prior to shipment. The plant had a capacity of 100 tons per day.

Geology

The bulk of the bed-rock exposed within a radius of a thousand feet of No. 1 shaft is granite or granite gneiss. In the vicinity of the workings there are numerous small outcrops of metamorphosed sediments — with possibly some volcanics — of the Grenville series, chiefly amphibolite, amphibolitic limestone, and chlorite and mica schists. It is with these rocks — designated by Wilson (p. 23) the Bristol phase of the Grenville — that the magnetite deposits are associated. To the northwest there are outcrops of quartzite, and similarly to the southeast, where, also, there is a small body of pyroxene diorite, probably Buckingham series. The Grenville rocks have a northwesterly strike and dip about 60 degrees northeast. The granite intrudes both the pyroxene diorite and the Grenville rocks.

Orebodies

From the information available, Wilson (pp. 107-112) considers that the ore occurs in lenses, from a fraction of an inch to twenty feet or more in width, intercalated in amphibolite and amphibolitic limestones. The lenses conform to the structure of the sediments in which they occur.

The ore, as seen in the ore piles remaining on the property and in the faces of the pits, consists of granular magnetite with varying amounts of associated hematite, pyrite, mica, amphibole, calcite, and orthoclase. The hematite occurs as a marginal fringe around the magnetite grains, or in fractures traversing them, and is probably secondary. Pyrite is relatively abundant, forming from 0.58 to 5.47 per cent of the ore. It occurs partly in aggregates and partly in seams traversing the magnetite.

Published analyses of the ore, most of them made from selected specimens and thus not necessarily representative of the run-of-mine ore, show the following range: iron, 43 to 62 per cent; sulphur, 0.31 to 2.47 per cent; phosphorus, *trace* to 0.015 per cent.

The ore reserves in the neighbourhood of the workings are a matter of speculation. The ore so far encountered occurred in scattered lenses whose maximum width seldom, if ever, exceeded twenty feet. Thus, while the total tonnage of ore on the property may be considerable, the amount in any one lens is small. In Lindeman's magnetometric survey of the property, the most extensive area of magnetic attraction was on lot 22, to the southeast of the mine workings. Up to the present, no mining has been done in this part of the property.

Forsyth, Baldwin, and Lawless Mines, Hull Township

The Forsyth mine is on lot 11, range VII, Hull township, about five miles northwest of the city of Hull. West of it are the Baldwin and Lawless mines, the former near the northeast corner of lot 13, range VI (Lindeman and Bolton, Vol. II, p. 146, and Map No. 439), and the latter northwest of the Baldwin on the south part of lot 14, range VII. In all three mines, the ore is predominantly magnetite, occurring as lenses in limestones and other rocks of the Grenville series.

The *Forsyth* deposit was first mentioned in the report of the Geological Survey for 1845-46, and mining operations date back to that period, when some ore was shipped to Cleveland by way of the Rideau canal. It is reported that, in 1855, about 5,000 tons of ore was shipped, and in 1858 a further 8,000 tons, the latter averaging 60.70 per cent iron. In 1867, a blast furnace was built at the mine, which was in operation that year and for a part of 1868. The daily production was 6.5 tons of iron, which was about 54.5 per cent of the weight of the ore charged. The fuel used was a mixture of wood, charcoal, coke, and peat. The quality of the iron produced was pronounced excellent, but the operation was not economically successful.

The remains of the workings now visible are a large, benched, open cut trending slightly north of west for about 700 feet, having a width of 40 to 70 feet and a depth of 25 to 50 feet, a shaft having a reported depth of 100 feet, and some other, minor openings.

Diamond drilling on the property is reported to have indicated orebodies that would yield 430,000 tons of concentrates containing 57.29 per cent iron, with 0.62 per cent sulphur, 0.017 per cent phosphorus, and 10.67 per cent silica (Lindeman and Bolton, Vol. II, p. 147).

The *Baldwin* workings consist of a series of small pits that have been opened on pockets and lenses of ore over a length of about 1,100 feet. This work was presumably done during the time of activity at the adjacent Forsyth mine. A later magnetometric survey (Lindeman and Bolton, Vol. II, p. 146, and Map No. 439) gave a strong 'anomaly' just southwest of the northeast corner of lot 13, range VI, and another 500 feet to the southwest. Cuts and pits were made to investigate these, but they revealed only very small pockets of ore.

The principal opening on the *Lawless* property is a pit 15 feet square and 30 feet deep. On the adjacent surface, only small pockets, lenses, and disseminations of magnetite in limestone can be seen.

Cirkel (p. 59) considered these deposits as occurring in a belt, which he called the 'Hull Iron Range', having a length of about 6,800 feet and a width of 40 to 100 feet. He saw no geological reason why lenses of ore similar to those encountered in the shallow workings of the several mines along the 'range' should not be found at greater depth. Dulieux (1913, pp. 114-120), however, emphasises the small size of the lenses so far discovered, their rather widely scattered distribution, and the fact that, in many of the lenses he examined, the magnetite occurs in relatively narrow bands separated by bands of barren, or nearly barren, rock.

The present state of the old workings gives little opportunity for a detailed study of the ore occurrence. The rocks exposed at the surface and in the workings, and with which the ore is associated, are chiefly crystalline limestone (Grenville) with some interbedded amphibolite and, in places, feldspathic gneiss. The ore, consisting of fine grained magnetite with minor amounts of hematite, occurs as more or less massive lenses, 'pockets', and bands, and as densely to widely disseminated grains. Analyses of the ore show a range in composition about as follows: iron, 53 to 60 per cent; silica, 11 to 20 per cent; sulphur, 0.085 to 0.44 per cent; phosphorus, 0.014 to 0.027 per cent.

Haycock Mine

This property lies on either side of the Hull-Templeton township line, about nine miles from the city of Hull. A small tonnage of ore was mined here in 1873 and 1874, most of it coming from two excavations in the northeast corner of the south half of lot 28, range VI of Templeton township. From one of these, 70 ft. by 20 ft. by 20 to 25 feet deep, upwards of 2,000 tons of ore was taken, and nearby is another pit, 50 ft. by 30 ft. Some, at least, of the ore was smelted at the property in a charcoal-fired furnace, but although the quality of the ore was excellent, the quantity necessary to keep the furnace in operation was apparently lacking.

The ore, which is hematite with a considerable amount of associated magnetite, occurs in amphibolite (Grenville) and gneiss. The results of assays of fifteen samples, as given by Cirkel, indicate that the magnetite is a titaniferous variety or that some ilmenite is present. They show a range for iron of 47.23 to 68.49 per cent, and for titanium dioxide, 0.25 to 16.8 per cent (Cirkel, pp. 61-73; Dulieux, 1913, pp. 119-120).

Banded Iron Ores

Western Quebec

Banded 'iron formation' is found interbedded with lavas in Western Quebec as in other areas underlain by assemblages of Early Precambrian rocks. However, none of the known occurrences holds promise of being of economic importance. Most of them are quite 'lean' and, wherever any rich bands are present, they are narrow. Some of these occurrences are in Desmeloizes township (Mawdsley, pp. 44-45) and Bousquet and Cadillac townships (Gunning, pp. 8-9). Others are in Laverlochère, Gaboury, and Blondeau townships (Henderson, p. 11).

Territory of New Quebec

(See also pp. 2-11)

The iron formations on the east coast of Hudson bay, in the Richmond Gulf area, and those mapped by A. P. Low along and in the vicinity of Kaniapiskau and Koksoak rivers, have been discussed in Volume II of *Geology of Quebec* (pp. 227-249). Also, mention is made there of the exploration work in progress on the little known, but very extensive, iron ore deposits in the region on both sides of the height-of-land separating the headwaters of the Kaniapiskau from the basin of the Hamilton river. The centre of this general area is at about the intersection of longitude 67°W. and latitude 55°N., some 350 miles north of the village of Seven Islands, on the gulf of St. Lawrence.

In 1942, the *Hollinger North Shore Exploration Company, Limited,* a subsidiary of Hollinger Consolidated Gold Mines, Limited, was incorporated for the purpose of exploring a large block of ground in New Quebec in the region of Attikamagen-Wakuach lakes. The territory covered by the Company's exploration license embraces approximately 3,900 square miles of country lying to the north of the height-of-land in the central part of Ungava peninsula. Extreme measurements are 100 miles east-west and 40 miles north-south.

An extensive programme of systematic exploration was commenced immediately, and is continuing. This work, which has included much rock-trenching, test-pitting, diamond drilling, and geological mapping, has revealed the presence of large deposits of high-grade hematitic iron ores, but much further work will be necessary to establish their full economic value. Some large sulphide bodies have also been tested by diamond drilling and in numerous places have been found to carry copper, zinc, and nickel, with minor gold and silver. Geologically, therefore, it appears evident that the area explored is favourable for the occurrence of non-ferrous metals as well as iron ores, although, so far, no base-metal deposits of commercial grade have been discovered.

The activities of the Company are briefly touched upon in the Quebec Department of Mines' annual report on *The Mining Industry of the Province of Quebec* for each of the years 1944, 1945, and 1946. The conditions under which the license was granted the Company are set forth in the *Report of the Minister of Mines* for the fiscal year ending March 31st, 1946.

The favourable results of the Hollinger exploration have attracted widespread attention to the potentialities of the iron ore resources of the district and in 1946 exploration licenses covering concessions northward from the Hollinger block were granted — in conformity with Section 228 (amended) of the Quebec Mining Act — to the following organizations:

Norancon Exploration (Quebec), Limited, subsidiary of Noranda Mines, Limited, 1,500 square miles.

Fort Chimo Mines, Limited, subsidiary of Frobisher, Limited, 1,000 square miles.

Quebec Labrador Development Company, Limited, 1,000 square miles.

All these concessions, including that of Hollinger, lie along the north-northwesterly trending 'Labrador trough', which is underlain by formations of Late Precambrian age.

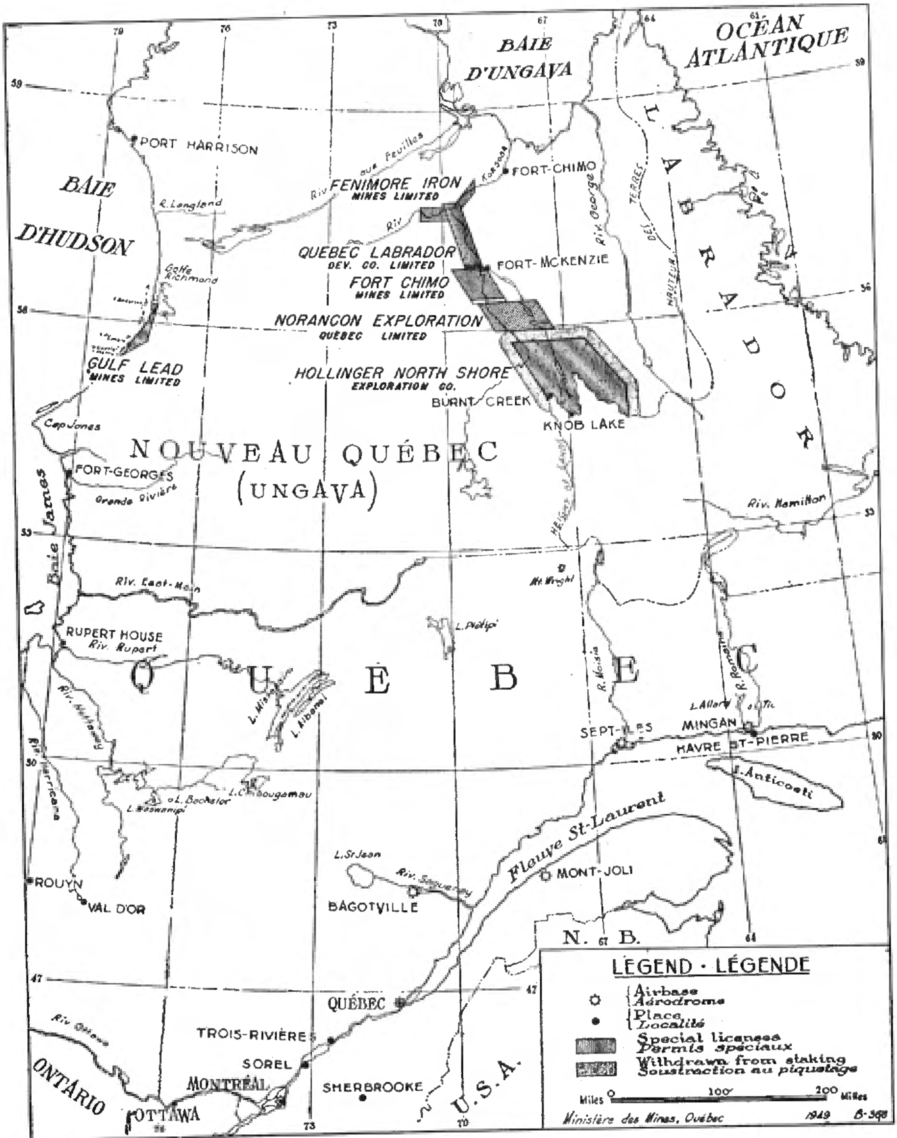

FIGURE 70.—*Sketch-map of New Quebec Territory (Ungava) showing location of special exploration licenses, mainly for iron ore.*

During 1946, reconnaissance surveys were made for construction of a railway from the village of Seven Islands to the permanent camp of the Hollinger company, a distance of 350 miles. A site was also selected by technicians of the Federal Department of Transport for construction of an airport in the vicinity of longitude 66°40′, latitude 54°50′.

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LEAD

See Zinc and Lead (pp. 438-452)

MAGNESIUM

See Magnesitic-Dolomite (pp. 469-475)

MANGANESE

MAGDALEN ISLANDS

(See Volume II, pp. 333-335)

Occurrences of manganese ore on the Magdalen islands have been known since at least 1880, in which year Richardson (p. 10) recorded the presence of loose blocks containing pyrolusite on Amherst island and also found the mineral in place in the rocks on that and some of the other islands. At various times since then, exploration has been carried on in the hope of discovering deposits of commercial size and grade, but so far with little success. It is reported that, prior to 1903, several tons of ore were shipped from deposits on Grindstone island (Obalski, p. 70). At that time, mining rights on the island were held by the *Magdalen Islands Company*. The outbreak of war in 1939 led to a revival of interest in the deposits, and a considerable amount of work was done in that year and in 1940 by two syndicates, chiefly on Grindstone and Amherst islands. On Grindstone, *Magdalen Manganese Mines, Limited*, opened a large number of test-pits in the overburden and sank three shafts to depths of thirty to forty-six feet, with short drifts at the shaft bottoms. Most of this work was about a mile and a quarter northwest of the harbour. A small tonnage of ore was taken from the underground workings and was stockpiled (Dufresne, p. 15). Since that time, little if any work has been done on the islands.

These islands lie in the gulf of St. Lawrence, extending for a distance of some sixty miles in a northeasterly direction, with a width generally less than five miles. The south end of the group is fifty-four miles north of the east end of Prince Edward Island. The three largest islands, from south to north, are Amherst, Grindstone, and Alright, the two first named connected by a bar and the other two by a bridge. A mile or less west of Alright is the long and very narrow Wolf island, and beyond it to the northeast is a group of smaller islands.

The oldest rocks exposed on the islands are a series of interbedded sedimentary and volcanic rocks of the Windsor series (Mississipian or Lower Carboniferous). The sedimentary rocks are chiefly limestones, with some shale and gypsum beds, and the volcanics are of basaltic composition and largely fragmental. These are overlain, in some places at least conformably, by grey sandstones, also Mississipian. These rocks are all steeply folded, and they — and particularly the fragmental volcanics — form the hilly, central portions of the islands. Flanking these hills and occupying about three-quarters of the surface of the islands is an overlying series of generally flat-lying red sandstones, believed to be of Pennsylvanian age.

Where in place, the manganese ore, chiefly pyrolusite, occurs as a replacement of, and veining, the limestone. Some veins of manganite occur in the volcanic rocks, but they are not abundant and most of those observed are less than an inch wide. It is generally agreed that the manganese to form the deposits has been derived from the volcanic rocks, which contain the metal in appreciable amount. One published analysis gives 0.22 per cent manganese. Concerning the mode of formation of the deposits, Alcock (pp. 646-647) says: "The ore-bearing zone appears to occupy a definite stratigraphic position, occurring along the unconformity between the base of the red sandstone and the older complex of folded rocks. Its vuggy character and the association with it of low-temperature minerals, such as the carbonates calcite and dolomite, suggest that it was formed as the result of the action of meteoric waters. The original source of the manganese was undoubtedly the volcanic rocks, which, as has been already pointed out, have a relatively high content of manganese. It is believed that surface waters, descending from the hilly country where they had permeated fragmental volcanic material, carried manganese in solution and, when they reached the low slopes in front of the hills, deposition of the manganese took place. Where the surface rock was favourable for replacement, as for example limestone, deposits of that type were produced. Where depressions favourable for their production existed, it is possible that bog deposits may have been formed in front of the hills. Some manganese oxide material of residual origin formed as a result of the weathering of the volcanic rocks may even have been washed down to the base of the hills".

Four analyses of the ore, cited by Obalski in his report for the year 1904, show a manganese content ranging from 50.36 to 64.62 per cent. Presumably, these were selected, high-grade material.

Bog Manganese Ore

Bog manganese ore has been found in numerous localities in the Eastern Townships and in years gone by a few tons of ore were shipped from some of these occurrences. However, the known deposits are all of small extent or low grade and have little or no commercial value.

Hanson (pp. 96-100) lists nineteen occurrences of bog manganese ore in ten counties of the Province of Quebec, most of them in the Eastern Townships. Particulars relating to seven of the most interesting of these are tabulated below. In the last occurrence listed, the material is not a bog ore but a manganiferous dolomite.

Locality	Character and Extent
St-Maurice Co., near St-Maurice	Bog iron and bog manganese intermixed.
Quebec Co., near Quebec city, south of St-Louis road, Ste-Foye parish	Bed of black, porous masses of manganese in sand. Area is 60 by 5 yards. Bed is one foot thick in the centre and thin at the edges.
Kamouraska Co., Seigniory of Kamouraska	Deposit of mixed bog iron and manganese. Area is 30 by 300 paces and thickness is 6 to 8 inches.
Beauce Co., Seigniory of St-Joseph, one mile west of Chaudière river	Earthy oxide of manganese occurs with copper, quartz, and chlorite in small fissures in slate.
Stanstead Co., Stanstead Tp., lot 9, range X	Patches or bodies 6 to 9 feet in diameter and one foot thick in the centre, consisting of nodular masses of manganese in sand. Patches extend over 20 acres. Analysis gives 37 per cent MnO_2.
Brome Co., Bolton Tp., in lot 20 or 22, range XII	Earthy manganese resting on clay slate and filling interstices in the slate. Analysis gives 26 per cent MnO_2. Deposit is several hundred square yards in area and 3 to 6 inches thick.
Brome Co., Sutton Tp.	Specimen of ferruginous dolomite contained 7.65 per cent manganese carbonate.

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MOLYBDENUM

There are well over a hundred known occurrences of molybdenite in the Province of Quebec. Eardley-Wilmot, in a report on *Molybdenum* published in 1925 by the Mines Branch, Department of Mines, Ottawa, lists (pp. 157-161), with brief descriptive notes, sixty-one localities at which a certain amount of trenching and test-pitting has been done. Most of these are in the Ottawa River valley between Hull and Waltham and northward from there, near Maniwaki, and have been described in some detail by Wilson (pp. 63-95, 129-133), but several are in Western Quebec and there are others in the Eastern Townships and elsewhere. Numerous additional occurrences have been discovered since Eardley-Wilmot's report was published. Substantial production, however, has come from only three deposits.

Up to the present, the mining of molybdenite in Quebec — and in Canada as a whole — has been essentially a wartime industry. The deposits that have been developed to the producing stage are all of relatively low grade, making mining and concentration costs high. As a consequence, it has been possible to operate profitably only at times when the market price of the metal has been abnormally high or when production has been essential at almost any cost.

Thus it was that 1916 was the first year in which molybdenite was produced from any Quebec mine, and the output continued, first at a rising, and then at a very rapidly declining, rate until 1919, when it ceased. Production during this period amounted to 781,312 pounds of molybdenite concentrates, and virtually the whole of it came from one mine — the Moss mine, in Onslow township, near the north shore of the Ottawa river about thirty miles west of Hull. In each of the three years 1924-26, there was a small production, again from the Moss mine, and in 1929 a new producer, the La Corne mine, in La Corne township, Western Quebec, made its appearance with an output of 16,000 pounds. Following that, there was no production until the outbreak of the second World War in 1939, and, in the years that followed, annual shipments mounted by leaps and bounds to reach 2,124,693 pounds in 1944. In this period there were three producers, the Moss, La Corne, and Indian Molybdenum mines, the last in Preissac, two townships west of La Corne. A small contributor in 1942-43 was the Farley mine, near Maniwaki, in Egan township. From 1939 until the end of 1944, shipments of concentrates totalled 3,352,775 pounds. Up to that time, from the initial production in 1916, Quebec mines had produced some 4,215,000 pounds of molybdenite concentrates. Thus, the 1944 output equalled the total for all preceding years. Despite the relatively small scale of production, however, Quebec has easily led all other provinces.

Ottawa Valley and Maniwaki Districts

The numerous molybdenite occurrences in these districts are associated with Grenville rocks or with bodies of quartz syenite or granite gneiss that have intruded them. Wilson (p. 63) distinguished four types of occurrence: (1) Segregations in quartz syenite (Moss mine orebodies); (2) veins in granite gneiss; (3) in pegmatite dykes and feldspathic quartz veins; (4) contact metamorphic deposits, the most abundant type.

Segregations in Quartz Syenite

The Moss Mine

The Moss mine is in lots 9 and 10, range VII, Onslow township, about three miles north of Quyon station on the Canadian Pacific railway and thrity-three miles west of Ottawa. The name is an anagram on the formula of molybdenite—MoS_2. Ownership of the property has changed several times since the first years of production, in 1916, but in its most active years, during the first and second World Wars, it was operated by, respectively, the *Dominion Molybdenite Company, Limited*, and the *Quyon Molybdenite Company, Limited.* There are five orebodies on the property, but almost the whole of the production has come from a deposit in the south half of lot 9. In the early years of operation this was worked as an open pit, which attained dimensions of 150 feet by 65 feet by 125 feet deep at its north end, but in 1918 the mining system was changed to the 'glory hole' method. A 70° incline shaft was sunk to a depth of 200 feet and a raise from a cross-cut at that level was put up to the bottom of the pit. A shaft, 85 feet deep, was sunk on a much smaller body of ore some 500 feet to the west. The other deposits, all relatively small, were worked as open pits. In 1940, a new concentrator with a capacity of 100 tons per day was placed in operation and also a roasting plant. In the latter, the concentrates were converted to molybdenum trioxide, in which form the output was shipped.

The molybdenite occurs in quartz syenite, a stock-like body of which, two miles long (east-west) and up to one mile wide, is exposed in lots 9 to 13, range VII. This body, named by Wilson the Onslow syenite, is bounded on the north by granitic gneiss and on the east by porphyritic syenite, both older than the stock. Nearby are patches of Grenville limestone.

The country to the south of the stock is low and drift covered, but some 800 feet to the south, in the south part of lot 9, a small outlier of the Onslow syenite is exposed. The main orebody and two of the smaller ones are in this outlier. The others are to the north and east, near the south margin of the stock.

The molybdenite occurs partly in disseminated form and partly in aggregates which consist, in addition to the rock-forming minerals, of molybdenite, pyrite, and fluorite, with lesser amounts of pyrrhotite, magnetite, titanite, and other minerals.

From his study of the deposits, Wilson concluded that these aggregates were formed by segregation of the ore minerals in the quartz syenite magma during its consolidation. Some of the smaller aggregates have obviously originated in this manner, and development has shown that some, at least, of the large ore masses are completely isolated, with gradation outward through disseminated, lean ore to normal quartz syenite. Also, analyses indicate a very close correspondance in composition between the ore masses and the syenite, apart from the much higher content of MoS_2, FeS_2, and F in the former. Wilson decided that the absence of any extensive system of pre-ore fractures in the syenite precluded the possibility of the ore masses having been formed by emanations from an outside source metasomatically replacing the rock. There has been some such replacement, however, of blocks of the older porphyritic syenite which are included in the Onslow stock.

The orebody mined in the main pit is by far the largest found on the property. Diamond drilling has indicated that it is 500 feet long, 60 feet wide, and extends to a depth of 250 feet. The body some 2,500 feet to the northwest, on the margin of the main stock, from which there was some production, consists of two ore zones separated by ten feet of barren rock. As exposed in pits, the larger of these is five to fifteen feet wide and 150 feet long. Within both zones there are scattered lenticular masses of high-grade ore. The three other deposits are apparently small.

The ore is grey to greenish in colour, in contrast to the normal quartz syenite, which is pink. The molybdenite is present as flakes, or is in aggregates of flakes, which range in diameter from half a millimeter in sparsely disseminated ore to an inch or more in the larger aggregates.

Shipments totalling more than four million pounds of ore sent to the Ore Testing Laboratory of the Department of Mines, Ottawa, in 1916 for concentration contained 1.83 per cent molybdenite, and two lots of ore, each more than a million pounds, shipped to the laboratory in 1917 contained 1.01 and 0.91 per cent.

Wilson (pp. 77-80) gives brief descriptions of the following additional occurrences of molybdenite in the Onslow syenite stock. All of them have been investigated by a limited amount of stripping and test-pitting:

Range VII: lot 7; north half, lot 10 (Moyle property); lot 11.

Range VIII: lot 9 (Pontiac Development Company); lot 10; lot 12.

In 1917, 25,004 pounds of ore containing 1.54 per cent molybdenite was shipped from the Moyle property to the Ore Testing Laboratory, Ottawa.

Veins in Granitic Gneiss

Daley Molybdenite Company, Limited

The only deposit of this type described by Wilson (pp. 81-82) is in lot 5, range I, of Thorne township, Pontiac county. It is near the northeast end of Philip lake, about ten miles north of Shawville, on the Canadian Pacific railway.

Some development work was done here by the Daley Molybdenite Company during the years 1919-21. It consisted of the opening of a pit some thirty feet long and ten feet deep, and a small amount of lateral work from a shaft fifty feet deep. Very little ore was extracted.

The molybdenite, with quartz, scapolite, pyrite, and pyrrhotite, occurs in veins cutting biotite granite gneiss and also in irregular masses which have probably developed by replacement of the gneiss. The veins range up to two feet in diameter and in general are less than six feet long. One vein, however, was exposed continuously for a length of thirty feet and was reported to have a known length of fifty feet.

In Pegmatite Dykes and Feldspathic Quartz Veins

Molybdenite occurrences of this type are rare in the Ottawa Valley district. Only two were seen by Wilson (pp. 80-81). One of these is in a pegmatite dyke cutting metamorphic pyroxenite on lot 17, range VII, Onslow township; the other in a mass of quartzose pegmatite, about thirty-five feet long and ten feet wide, on lot 27*B*, range XII, Eardley township. Neither of these occurrences is of economic interest.

Contact Metamorphic Deposits

Apart from the magmatic segregation deposits occurring within the Onslow quartz syenite stock, the molybdenite deposits of the Ottawa Valley and Gatineau districts are practically all of the contact metamorphic type. Although very numerous, however, and despite the fact that many of them have been explored by test-pitting, and some by a limited amount of underground work from shafts, no large orebodies of commercial grade have been discovered, and their combined production has been negligible.

These deposits occur in bands or irregular masses of metamorphic pyroxenite lying along contacts between Grenville limestone and bodies of granite or syenite, or within such bodies. Typical ore consists chiefly of pyrite, pyrrhotite, molybdenite, diopside, scapolite, and other lime silicates. It has unquestionably been formed by the interaction of siliceous and molybdenum-bearing emanations, derived from the intrusives, with limestone.

Reference is made below to some of the deposits from which there has been a small production, or on which fairly extensive development work has been done. More detailed descriptions of these, and numerous other, occurrences may be found in the reports by Eardley-Wilmot (pp. 132-156) and Wilson (pp. 82-95, 129-133) and in a report by W. N. Ingham which appears in *The Mining Industry of the Province of Quebec in 1943* (pp. 33-40).

Indian Lake Property (Lots 54 to 58, range X, Masham township, Gatineau county).

This property is in the northwest corner of Masham township, about forty miles northwest of Ottawa. The rocks exposed around the north shore of the small Indian lake, adjacent to which the molybdenite deposits occur, are granite gneiss, within which, in places, there are small included masses of metamorphic pyroxenite. There are four principal deposits, and at two of them very small patches of limestone appear between the pyroxenite and gneiss.

No. 1 deposit, on the northeast shore of the lake, is about 100 feet long and five feet wide. Wilson estimated it contains not less than one per cent of molybdenite. No. 2, also close to the lake shore, is 100 feet north of No. 1. It has an exposed width of more than 60 feet and is nearly 100 feet long. The molybdenite content appears to be rather lower than in the No. 1 body. No. 3, about 175 feet east of No. 2, is 175 feet long with very irregular width, from 5 to 35 feet. The pyroxenite and gneiss are very intimately mixed, with molybdenite disseminated through both, but probably in amount less than one per cent. The No. 4 deposit is 400 feet northwest of the lake. The vicinity is largely covered with glacial débris but the pyroxenite zone has been exposed at intervals, by stripping and in test-pits, over a length of nearly 200 feet for a width of 5 to 25 feet. At the time of Wilson's visit, some fifty tons of selected ore, carrying not less than 2 to 3 per cent molybdenite, had been piled near the pits. A sample of about one ton of ore from this deposit was shipped to the Ore Testing Laboratory at Ottawa. It contained 1.97 per cent molybdenite.

Ingham, in 1943, reported that a shaft 30 feet deep had been put down on the deposit in lot 55 and that diamond drilling was in progress. A small flotation mill was also under construction. These operations were being carried on by *Vic-Ore Molybdenite Mines, Limited,* subsidiary of Goodrock Mines, Limited.

Chaput Property (Lot 1, ranges VII and VIII, Eardley township, Gatineau county.

This property is fifteen miles northwest of Ottawa, a short distance north of the village of Breckenridge.

The deposits here are of two types. Near the southwest corner of lot 1, range VII, and on the adjacent parts of lots 1 and 2, range VI, molybdenite occurs in a fine, granular, banded pyroxenic gneiss, believed to have been formed by interaction of granite gneiss and crystalline limestone. A mass of the latter, now transformed into metamorphic pyroxenite, is exposed nearby. The molybdenite is associated with pyrite and occurs in the gneiss in seams, small aggregates, and as disseminated flakes, in amount probably less than 0.5 per cent. The total length of the zone in which molybdenite is known to occur is about 500 feet.

In the other type, which occurs on lots 1 and 2, range VII, to the northwest of the last, the molybdenite is in metamorphic pyroxenite. The principal deposit is exposed in a pit 30 feet long, 25 feet wide, and 10 to 25 feet deep. Centrally along this pit for a width of 20 feet is a zone of breccia, along which masses of the pyroxenite are cemented by pink calcite containing crystals of pyroxene and phlogopite and disseminated pyrite and pyrrhotite. Molybdenite, in crystals up to three inches in diameter, is scattered through the calcite and adjacent pyroxenite.

In 1917, a shipment of 65,301 pounds of selected ore from this property was concentrated in the Ore Testing Laboratory, Ottawa. It contained 0.771 per cent molybdenite and from it 503 pounds of concentrates were recovered.

In 1941, four tons of selected ore (1.67 per cent MoS_2) was shipped to Ottawa, from which 106 pounds of concentrate were obtained. Following his visit to the property in 1942-43, Ingham estimated that 2,500 tons of rock had been taken from the four main pits. Presumably the shipments to Ottawa of some forty tons of ore were hand-picked from this. Operators of the property at that time were *Norwin Molybdenite Mines, Limited.*

Some shipments have been made from at least two other properties in Gatineau county. During the first World War, the *Standard Molybdenite Company* produced 750 pounds of pure flake molybdenite, and made shipments of ore, believed to have totalled thirty tons, from deposits on lots 6 and 7, range III, Egan township; and in 1942 and 1943 there was a substantial production by the *Farley Mining Company* from its property on lot 69, range IV of the same township.

During the years 1916-18, small shipments of ore to the Ore Testing Laboratory, Ottawa, were made from a number of properties in Pontiac county. These included:

Ross Property, lots 1 and 2, range III, Aldfield township
Kirkham Property, lots 1, 2, and 3, ranges IV and V, Aldfield township
Tippin Prospect, lots 4 and 5, range XII, Clarendon township
Chabot Mine, lots 20, 21, and 22, range V, Huddersfield township
Squaw Lake, lots 19 to 26, range VIII, Huddersfield township

Large quantities of excellent museum specimens of molybdenite were obtained from the Ross property in 1894 by the Foote Mineral Company, of Philadelphia.

Western Quebec

Molybdenite has been reported at numerous localities in the mining region of Western Quebec (for references to occurrences, see *Index* at end of volume), but up to the present commercial concentrations of the mineral have been found only in the three adjoining townships of (from west to east) Preissac, La Motte, and La Corne, which are occupied almost wholly by a composite granite or granodiorite batholith — the La Motte-La Corne batholith (see Volume II, pp. 99-101). The molybdenite occurs chiefly in quartz veins cutting the granite and associated pegmatite, and in these rocks adjacent to the veins, and practically all of the veins yet found are in the marginal zones of the batholith, or batholiths. In some of the occurrences, native bismuth and bismuthinite are present with the molybdenite, and some of the veins, and also pegmatite dykes, of the district contain other minerals of interest, as, for example, tantalite, scheelite, beryl, and spodumene (see page 418).

Molybdenite was first discovered in these townships in 1901, on the east side of Indian peninsula, which projects from the north into Preissac (Kewagama) lake, in west-central Preissac township. Other discoveries followed, and in 1906 claims were staked on deposits on the west side of Kewagama (Kinojévis) river at the north boundary of Preissac township. There was a small production of molybdenite from the Height of Land mine opened in these deposits. At about this time, also, what appear to be more extensive orebodies were found on the west side of Indian peninsula, and in 1943-44 there was a considerable production from the mine developed here by Indian Molybdenum, Limited. In 1916, important deposits were discovered at the southwest corner of La Corne township, and the mine opened here by the Molybdenite Corporation of Canada, Limited, has been producing since 1943.

The La Motte-La Corne batholith consists actually of three more or less distinct masses, adjacent to which in places are small outlying stocks or sill-like bodies. The rock ranges in composition from granodiorite to granite, and in a general way hornblendic types predominate in the eastern part (La Corne township) and biotite and muscovite granite in the central and western parts. Pegmatitic facies and pegmatite dykes and quartz veins are particularly abundant in the mica granite and in places form as much as 50 per cent of the rock, at least in the marginal zones of the masses. The molybdenite deposits have been found chiefly at and near the margins of the main, or small, bodies of the muscovite or biotite granite.

A noteworthy feature of all these granitic rocks is that they contain much more potash than soda, in marked contrast to the high-soda types found in the gold-producing districts of Western Quebec. No important gold mineralization has been reported within, or in the vicinity of, this batholith.

La Corne Mine

La Corne mine is near the southwest corner of La Corne township, in lots 1 and 2, range I. It is about twenty-two miles northwest of Val d'Or, the highway from which town to Amos passes through the property.

The claims were first staked in 1916. In 1922 they were acquired by the *Molybdenum Reduction Company, Limited,* who developed the property (which they named the Eureka mine) from an inclined shaft, and in 1929 installed a flotation plant. In the following year, this Company suspended operations.

The *Molybdenite Corporation of Canada, Limited,* purchased the property in 1937 and operated the mine and mill on a small scale in that and the following year. Production in these two periods amounted to only a few thousand pounds of molybdenite concentrates.

Following the outbreak of the war, in 1939, the property was optioned on behalf of the Government by *Wartime Metals Corporation,* with Siscoe Metals, Limited, subsidiary of Siscoe Gold Mines, Limited, as manager. The shaft was deepened to 275 feet, with workings on two levels, at 150 and 250 feet. A 200-ton mill was installed, and production commenced in 1943. In July, 1945, the Crown returned the property to Molybdenite Corporation. During this period, 3,066,800 pounds of concentrates were produced, containing 2,663,600 pounds of molybdenite.

The concentrate, as produced at that time, contained 2.5 to 3.5 per cent bismuth, an amount which would have rendered it unsalable in normal times or at least subject to a penalty. Recently, however, a flotation process has been developed by F. K. McKean, of the Bureau of Mines, Ottawa, whereby practically the whole of the bismuth minerals (native bismuth and bismuthinite) can be eliminated and recovered as a valuable by-product.

A wide sand plain in the vicinity of the deposit conceals bed-rock except at four small and widely spaced outcrops, but a very considerable amount of diamond drilling has indicated that the ore zone has a length of at least 1,150 feet.

The western margin of the La Corne granite batholith parallels, and is less than two miles distant from, the western boundary of the township. Flanking it on the west are biotite schists which are believed to be highly metamorphosed sedimentary rocks. Within the biotite schists are several small bosses or sills, and dykes, of biotite granite, outliers of, or offshoots from, the main mass. One of these occurs immediately at the southwest corner of the township, and others crop out through the sand plain to north and south. The molybdenite-bearing quartz veins are associated with the sill or boss at the township corner, lying near the granite-schist contact, in both granite and schist.

The shaft is close to the northwest margin of a mass which is at least 1,500 feet wide and is exposed for a length, east of north, of 3,000 feet. In common with all the granite of the La Motte-La Corne batholith, this rock contains much more potash than soda.

Hawley (p. 109)) found that there are quartz veins of four ages, but that only those of the two intermediate ages carry molybdenite. The earlier of these trend N.70°-75°E. and maintain a fairly regular width, from one to seven feet, throughout their length, which is from several tens of feet to upwards of three hundred feet. Usually they consist of quartz with marginal zones a few inches to a foot wide in which there is much white plagioclase (where they are in schist) or muscovite (where they are in quartz). The molybdenite is concentrated in these marginal zones and also in aggregates of muscovite that are sparsely distributed through the veins. With the molybdenite are variable amounts of pyrite and, more rarely, native bismuth, bismuthinite, chalcopyrite, and tantalite or columbite. Some veins contain conspicuous amounts of tourmaline and beryl, and the presence of scheelite, also, has been noted.

The later molybdenite-bearing quartz veins strike west of north. They pinch and swell, from quite narrow veinlets to widths of fourteen feet, and only very rarely do they occur in the schists or pass from granite to schist. They contain red feldspar and muscovite, and it is with these minerals that the highest concentrations of molybdenite are found. In general, these veins contain a higher percentage of molybdenite than the earlier ones. Fluorite is a noteworthy constituent of the youngest veins.

As indicating the close spacing of the veins, a vertical section of the workings shows, at the 150-foot level, twelve molybdenite-bearing veins, eight of which are from two to five feet wide, in a cross-cut length of 500 feet (Hawley, p. 117). Several of these veins, however, do not appear on the 300-foot level.

Hawley (p. 118) states that practically every fissure in which a vein occurs in the granite is a fault plane. The fracturing and faulting of the granite evidently continued over a long period of time and was accompanied by the injection of the quartz and pegmatite veins, with molybdenite. Still later faulting has so shattered some of the veins as to render them of little value. Norman (p. 16) thinks it probable that "some local structure, either a warping of the granite contact or a fault zone, as at Indian Molybdenum mine, controls the local concentration of molybdenite-bearing veins at the La Corne deposit."

Indian Molybdenum Mine

This property is in ranges III, IV, and V of Indian Peninsula, about twenty miles southwest of Amos, on the Canadian National railway. The peninsula is a spur ten miles in length projecting into Kewagama (Preissac) lake from the north, and the property is on its west side. Following the discovery of molybdenite here in the early years of the century, surface exploration was carried on by various interests and was particularly active under the direction of the *St. Maurice Mines Company, Limited,* during the period 1916 to 1921. In addition to much test-pitting, a shaft was sunk to a depth of 970 feet, and a concentrating mill was installed. There were, however, no shipments of ore. Little further work was done until 1942, when the *Dome Exploration (Quebec) Company, Limited,* subsidiary of Dome Mines, Limited, acquired the property and carried out a programme of diamond drilling which outlined an important body of ore. In 1943, *Indian Molybdenum, Limited,* was organized to develop this discovery. Much additional drilling was done, a shaft, inclined at 20 degrees, was sunk 493 feet on the incline, and a mill with a capacity of 700 tons a day was installed. Production commenced in September of that year, but all operations were suspended at the end of April, 1944, when the Company's wartime sales contract with the Department of Munitions and Supply was cancelled. During

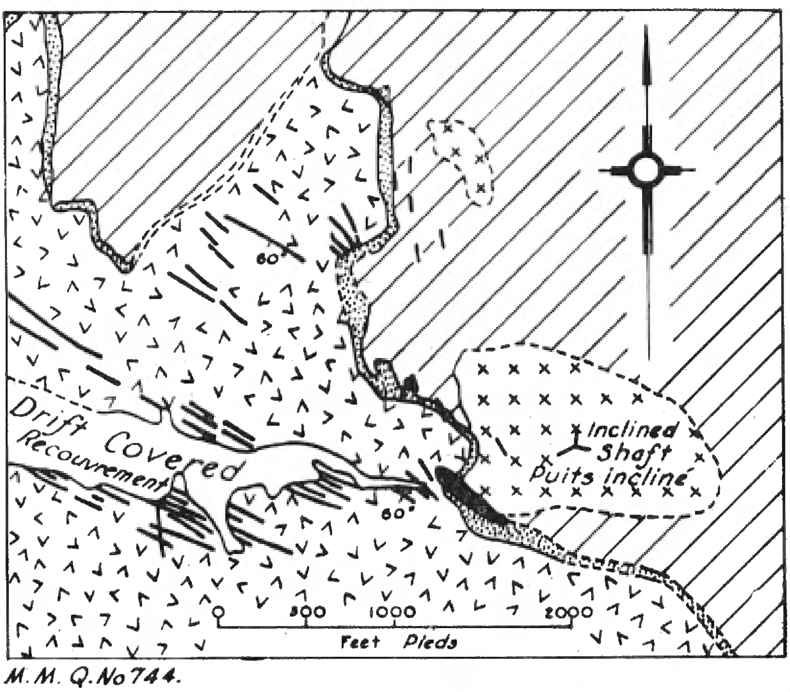

FIGURE 71.—*Geology of vicinity of Indian Molybdenum mine.* (Economic Geology, Vol. XL, No. 1, p. 6).

the seven months of operation, the mine produced 91,489 tons of ore, from which the mill recovered 766,912 pounds of concentrates containing 88 to 93.8 per cent molybdenite.

The broad, southern part of Indian peninsula is occupied by granite, marking the western end of the La Motte-La Corne batholith. Bounding the granite on the north and underlying the neck of the peninsula are biotite and hornblende schists, probably altered tuff beds. This marginal zone of the batholith is a muscovite granite which in places grades into biotite granite with segregated masses or dykes of coarse muscovite pegmatite.

In the vicinity of the mine, the granite is traversed by numerous quartz veins, from a few inches to twelve feet and more wide, some of which contain molybdenite, and it is cut by two parallel faults (Figure 71). Both the veins and the faults strike northwest and dip at 40° to 60° to the northeast. The distance between the faults varies between thirty and sixty feet.

The orebody lies between these faults and has been traced, by workings and diamond drilling, for a length of 450 feet, with ore indicated to a depth of some 400 feet. The footwall fault has sharply defined walls of relatively massive rock, but in places along the hanging-wall fault there is a zone several feet wide of intensely crushed and altered granite cut by molybdenite-bearing gouge-filled slips. In both faults, a horizontal movement of the northeast side to the southeast is indicated.

From the hanging-wall fault southwestward across the greater part of the orebody, gently dipping quartz veins, six inches to a foot wide, occur at intervals in the granite and are connected by steeply dipping quartz stringers. These veins increase in number toward the footwall fault, along which they coalesce to form a solid vein of quartz, in places twelve feet wide. The vein contains about 5 per cent of red feldspar and is evidently of pegmatitic type. Deformation following the introduction of the quartz has caused fracturing of both granite and quartz, and the fracture planes are

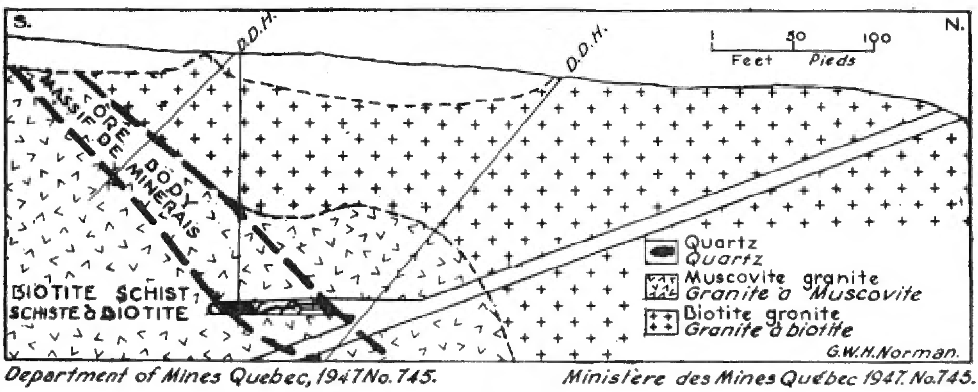

FIGURE 72.—*Indian Molybdenum mine, vertical cross-section.* (Economic Geology, Vol. XL, No. 1, p. 12).

lined with muscovite and finely crystalline molybdenite, the latter very conspicuous in places. Molybdenite also occurs sparingly in the granite distant from any veins.

Norman, who has made a detailed study of these and other molybdenite deposits in the Preissac-La Corne area, and whose paper forms the basis of the foregoing description of the ore occurrence, summarizes his conclusions as follows (p. 14): "The general succession of events appears to have been: (1) faulting, and fracturing of granite between the two faults; (2) infiltration of quartz with minor microcline, molybdenite, and pyrite along the footwall fault and progressively upwards along fractures from this fault; (3) deformation of the orebody, producing slip surfaces, accompanied by the development of muscovite and molybdenite along these surfaces, and alteration of much of the original microcline to muscovite; (4) final deformation after cessation of molybdenite mineralization, resulting in slight slippage along the footwall fault and further movement along the hanging-wall fault, producing gouge-filled seams darkened by a little molybdenite caught up during movements along this fault".

Some quartz veins beyond the confines of the faults contain appreciable, though very unevenly distributed, amounts of molybdenite, with coarse pyrite and very minor amounts of bismuthinite, fluorite, and (though very rarely) tantalite or columbite.

Height of Land Mine

The Height of Land mine is at the northern boundary of Preissac township, about five miles west of north of the Indian Molybdenum mine. It is on the west bank of Kewagama (Kenojévis) river, two miles below (north of) Preissac (Kewagama) lake.

The rocks exposed on the west side of the river are hornblende and biotite schists, which are cut by dykes of granite, offshoots from a batholith of this rock that extends eastward from the river. The dykes of granite, and also of pegmatite, extend over a zone up to ninety feet wide, paralleling the river, and in places they are in such number as to exceed in bulk the schists they intrude. They are traversed by veins of quartz containing molybdenite and also bismuthinite.

A considerable amount of work was done here by the *Height of Land Mining Company, Limited.* This included stripping and test-pitting, one pit being seventy feet long and twelve feet deep, and the sinking of a shaft to a depth of eighty feet. At the shaft bottom, a cross-cut was driven for eighty-seven feet at right angles to the strike of the schists and dykes, but although it intersected three or four pegmatite dykes and quartz veins, these contained very little molybdenite. In the surface workings, some 'pockets' of rich ore were encountered, and from one of these it is reported that 500 pounds of large crystals of molybdenite were taken. One of the principal veins is fifteen feet wide. Along its walls is a selvage of muscovite up to several inches wide in which there are large — up to 2-inch — crystals of molybdenite. Within the vein there is some bismuthinite, but very little molybdenite. Beryl occurs in some of the quartz veins and pegmatite dykes, and crystals of phenacite, Be_2SiO_4, were found in a specimen from one of the pits. This is the only known occurrence of phenacite in Canada. Some interesting pseudomorphs, in which molybdenite is completely replaced by bismuthinite, indicate that, in part at least, the latter mineral was deposited later than the molybdenite (Bancroft, 1912, pp. 192-195; Eardley-Wilmot, pp. 129-131).

It is reported that about 1,200 pounds of molybdenite (98 per cent grade) was taken from the workings on this property.

Beryl, Tantalite, and Spodumene

It is of interest to note that beryl is associated with the molybdenite in all occurrences of this mineral in the Preissac-La Corne area that have been mined or investigated. Also, tantalite occurs in the quartz veins and pegmatite dykes at the La Corne and Indian Molybdenum mines. Both minerals have been found elsewhere in pegmatites near the margins of the granite batholiths (Norman, pp. 7-10).

Beryl.—Beryl occurs in many of the pegmatite dykes and masses near the north margin of the granite mass that extends westward from La Motte lake across the southern part of Figuery township, which adjoins La Motte on the north. The crystals, which are pale green and clouded, range from a quarter of an inch to an inch and a half in diameter and from one to four inches in length. They are particularly common in dykes containing central bands of quartz bordered by muscovite, in which they are associated with, or close to, the muscovite bands. The dykes are from a few inches to more than twenty feet in width, but the beryl crystals are sparsely and irregularly distributed and, so far as observed, the total amount of the mineral in the numerous dykes is very small.

Tantalite.—The most important discovery of tantalite in the area is in Preissac township, about three and a half miles south and half a mile west of its northeast corner, a mile and a half northeast of the northeast corner of Preissac lake. Cutting the granite here, about 1,000 feet north of, and parallel to, its southern border is a pegmatite dyke, about twenty feet wide, which can be traced for a length of 500 feet. The greatest concentration of tantalite is at the east end of the dyke, over a length of sixty feet and width of ten inches. The mineral occurs in isolated crystals, up to three-quarters of an inch by three inches in size, and also in radiating clusters of small crystals replacing albite and quartz.. Associated with it are crystals of red garnet and smaller amounts of chrome spinel and beryl. A sample sent to the Ore Dressing and Metallurgical Laboratories of the Bureau of Mines, Ottawa, for a concentration test contained 0.65 per cent tantalite, or 13 lb. per ton. Analysis of the mineral gave 54.17 per cent Ta_2O_5 and 26.37 per cent Cb_2O_5.

Another occurrence on which some trenching has been done is near the southwest corner of Figuery township. This is in a pegmatite dyke, five feet wide, which cuts peridotite about 1,000 feet north of the granite batholith. Tantalite occurs as conspicuous crystals in places along the dyke, but the majority of the crystals are very small and the percentage of tantalite low.

Spodumene.—Spodumene-bearing pegmatites have been found in an area extending eastward for at least thirteen miles, and southeastward for ten miles, from the east side of Preissac lake, in Preissac township. The dykes have sharp walls and do not exhibit the banding characteristic of those carrying tantalite and beryl. They range from a few feet to thirty feet in width and can be traced for hundreds of feet. Many of the spodumene crystals have dimensions of the order two inches by eighteen inches, and one crystal four feet long has been reported. In some dykes, feldspar, quartz, and spodumene are in about equal amount, but in others the spodumene is restricted to local concentrations. An analysis of the mineral by R. J. C. Fabry, of the Section of Mineralogy, Geological Survey, Ottawa, gave 5.77 per cent Li_2O.

Other Occurrences of Molybdenite in Western Quebec

La Reine Township (lots 48 to 53, range IV)

On this property, which is three and a half miles south of Dupuy, some six miles from the Quebec-Ontario boundary, a small body of granite intruding Keewatin-type volcanics is cut by several east-west trending quartz veins, from one to five feet wide, which contain pyrite and molybdenite. One of the veins, three and a half feet wide and bordered by a width of nineteen inches of mineralized rock, has been exposed by stripping and trenching for a length of 135 feet.

Between 1936 and the end of 1938, *La Reine Gold Mines, Limited*, did a considerable amount of work on the property, chiefly on lots 51 and 52. In addition to very extensive stripping and trenching, they completed 5,800 feet of diamond drilling in seventeen holes and put down a shaft to a depth of 118 feet, with 185 feet of lateral work on the 100-foot level. In 1940, the property was taken over by *La Reine Molybdenum Mines, Limited* (Ross *et al.*, pp. 3-4).

Privat Township (parts of lots 54 to 59, ranges IX and X)

This property is at the northeast corner of Privat township, two and a half miles north of Taschereau. The claims are underlain by granite of the Robertson Lake batholith which, one mile to the east, is in contact with Keewatin-type volcanics. Quartz veins occur along joint planes striking northeast and northwest — but chiefly along those with the former trend — and some of them, and particularly those with bordering walls of strongly sheared granite, contain molybdenite, pyrite, chalcopyrite, and tourmaline. One vein has been traced by trenching for a length of 1,400 feet, over the greater part of which it is eight feet wide. A two-foot width of the vein as exposed in one of the trenches was reported to carry 3 per cent molybdenite — presumably a visual estimate (Ross *et al.*, p. 6).

Launay Township (lot 4, range VII)

A lobe of the Robertson Lake granite batholith occupies the western part of Launay township, which adjoins Privat on the south. On the Bergeron claims, on lot 4, range VII, the granite is cut by a quartz vein, striking N.12°E., which is exposed for a length of about 200 feet and is said to have been traced farther in other outcrops. It averages twenty feet in width and contains small amounts of disseminated pyrite and molybdenite (Lang, pp. 34-35).

SOUTHEASTERN QUEBEC

Gayhurst Township, Frontenac County (lots 18-23, range IX; Dostie property)

On this property, in the extreme southeast corner of the Province, molybdenite-bearing quartz veins occur in slates of the St-Francis series, regarded as Ordovician. Nearby is the northeast margin of a granite batholith (probably Devonian) which extends for six miles to the southwest.

Vein quartz is exposed intermittently over a distance of about 2,000 feet in lots 17, 18 and 19, and there are several veins also in lots 22 and 23. The molybdenite occurs in the quartz as disseminated specks, as thin seams coating fracture planes, and as occasional 'pockets' of coarse flakes. Most of the mineralized zones consist of a system of veins, two inches to two feet wide, which form a stockwork ten to fifteen feet wide in which about two-fifths of the material is quartz. In the wider veins, the molybdenite is usually concentrated over a width of two to three inches at each margin, with the central part not well mineralized. Enrichment occurs where veins meet, and in such places chalcopyrite and pyrite are commonly found in close association with the molybdenite.

Development work has included some stripping, the opening of about a dozen small pits and trenches, and the driving of an adit for twenty feet into a hillside. One car-load (probably about forty tons) of ore has been shipped from the property (Ingham, pp. 36-37).

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NICKEL

Analyses of many of the basic igneous rocks occurring in various parts of the Province, and particularly in Western Quebec and in the Serpentine belt of the Eastern Townships, show the presence of nickel, but seldom in amount exceeding a quarter of one per cent. A small amount of nickeliferous pyrrhotite in these rocks doubtless accounts for their nickel content. Some of the copper and other base-metal sulphide orebodies in Western Quebec and elsewhere in the Province contain pyrrhotite in considerable volume, but in these the mineral contains no more than a 'trace' of nickel.

However, in two places in Quebec, attempts have been made to mine ores containing nickel. At some time prior to 1898, a shaft was sunk on a steeply dipping band of pyrrhotite on lot 12, range IX of *Grand Calumet Township* (Calumet island). Some lateral work was done at a depth of forty feet, but no marketable nickel ore was found (Geol. Surv. Can., Ann. Rep't, Vol. XI, Pt. *A*, 1898, p. 119).

The other operation, which was at an earlier date — some time prior to 1880 — was in lot 6, range XII of *Orford township*, Sherbrooke county, about three-quarters of a mile east of Brompton lake. Here, a vein of calcite contains small crystals of emerald-green chrome garnet (uvarovite), long prismatic crystals of pale cream diopside, and slender prisms of brass-yellow millerite, NiS. Two shallow shafts were sunk here, and a smelting plant was installed. It was found, however, that millerite did not form more than one per cent of the vein material and the operation did not prove profitable. The dump at the Orford nickel mine has long been a place of interest for mineralogists on account of the excellent specimens of the relatively rare mineral millerite, and also of uvarovite and diopside, that may be collected there (Geol. Surv. Can., Ann. Rept., Vol. IV, Pt. *K*, 1888-89, pp. 81-82; Vol. XIV, Pt. *H*, 1901, p. 150).

References to nickel-bearing minerals and rocks in the Province, including many chemical analyses, may be found in the following reports:

Geol. Surv. Can.: Report of Progress, 1853-54-55-56, p. 388; 1863, pp. 505-507, 738; 1871-72, pp. 115-119. Annual Report, Vol. IV, Pt. *K*, 1888-89, pp. 81-82; Vol. V, 1890-91, Pt. *R*, p. 40, Pt. *SS*, p. 114; Vol. VI, Pt. *R*, 1892-93, p. 36; Vol. VII, Pt. *J*, 1894, p. 80; Vol. XI, 1898, Pt. *A*, p. 119, Pt. *R*, pp. 39-40; Vol. XIV, Pt. *H*, 1901, pp. 149-150, 154-155, 160-161; Vol. XV, Pt. *A*, 1902, p. 430.

Que. Bur. Mines: Ann. Rep't, 1931, Pt. *D*, p. 40.

Que. Dept. Mines, The Mining Industry in the Province of Quebec in 1943, p. 32.

SELENIUM AND TELLURIUM

Selenium and tellurium occur in small amount in the complex copper sulphide ores of the Horne and some other mines of Western Quebec (see p. 357), and are recovered in the course of refining the copper anodes produced at the Noranda smelter. The anodes are shipped from the smelter to the plant of *Canadian Copper Refiners, Limited*, subsidiary of Noranda Mines, Limited, at Montreal East.

In the process of electrolytically refining the copper, the selenium and tellurium, as well as the gold and silver, present in the anodes fall to the bottom of the tank as a sludge or mud. The whole of the gold and silver are recovered, but only enough of the selenium and tellurium are saved as may be required to meet the probable demand for these metals. That the output can be greatly increased at any time the demand arises is indicated in the following table of production for the years 1933-45. The abrupt changes from high to low, and *vice versa*, merely reflect periodic fluctuations of the demand.

PRODUCTION OF SELENIUM AND TELLURIUM IN THE PROVINCE OF QUEBEC

YEAR	Selenium		Tellurium	
	Pounds	Value	Pounds	Value
1933	22,131	$ 16,600	.....	.....
1934	48,764	73,146	.....	.....
1935	206,421	396,328	1,708	$ 3,416
1936	168,417	298,078	19,502	34,519
1937	208,531	360,759	26,439	45,739
1938	217,952	378,147	41,577	71,512
1939	23,841	42,175	2,940	4,769
1940	43,510	83,104	.....	.....
1941	203,162	388,039	.....	.....
1942	326,208	626,319	.....	.....
1943	216,491	378,872	.....	.....
1944	146,352	263,434	.....	.....
1945	160,720	308,582	.....	.....
Total	1,992,507	$3,613,603	92,166	$159,955

SILVER

An appreciable amount of silver is produced each year from Quebec ores, and has been produced regularly for the past eighty years or so, but the whole of it has been by-product silver recovered in the treatment of ores that are mined primarily for their content of some other metal or metals. Doubtless some silver was recovered from the small amount of argentiferous galena taken from Quebec's — and Canada's — earliest metalliferous mine, the Wright mine, on the east shore of lake Témiscamingue (see p. 307).

Until 1927, the production came from two main sources: the copper and pyrite (sulphur) ores of the Eastern Townships (see pp. 383-391), all of which had closed by 1945; and the zinc-lead ores of the old Calumet Island mine, a small producer between 1898 and 1912, and the Tétreault mine, in Montauban township, Portneuf county (see p. 446). From 1887, the first year for which official records of production are available, until the end of 1927, Quebec's total output of silver amounted to 19,059,344 ounces, which would give an average for the forty-one years of about 83,000 ounces per year.

Since 1927, when production started from some of the gold, copper, and other base-metal mines of Western Quebec, the ores of this district have furnished the major part of the silver, Thus, in 1944, the thirty-one mines active in that district furnished nearly 75 per cent of the total output. The native gold in all Western Quebec mines contains silver, and the metal occurs also in the base-metal ores. Some silver continued to come from mines in the Eastern Townships, from the Tétreault mine, and from the Calumet mine. The Calumet Island property had been acquired by Calumet Mines, Limited (now New Calumet Mines, Limited) in 1937, and the New Calumet mine started production in 1943 (see p. 443). The zinc-lead sulphide ore carries silver in appreciable amount, and some gold. For the seventeen years 1928 to 1944, silver production in the Province amounted to 19,059,344 ounces, the average per year for the period being about 1,121,000 ounces.

In 1885-87, attempts were made in ranges XIV, XV, and XVI of Risborough township, Frontenac county, and also in the adjacent township of Marlow, to mine argentiferous galena primarily for its silver content. The galena occurs in veins, a foot or less in width, which cut schists of sedimentary origin in the vicinity of augite prophyrite dykes. These were investigated in numerous shallow pits, but the silver content of the ore was too low for profitable mining (Ells, p. 77). Faessler, who examined the occurrence in 1937, found that the veins are mineralized for only a part of their length and width, and that the galena is by no means highly argentiferous.

Alcock (p. 178) has described an occurrence of silver-bearing galena, with associated sphalerite, at Cross Point in Mann township on Chaleur bay. The mineralization occurs along a series of cross-fractures in volcanic rocks, which, adjacent to the fractures, are replaced by the sulphides. Only a small amount of work had been done here at the time of Alcock's visit, but he considered the occurrence merited further investigation.

Numerous veins containing argentiferous galena, and also sphalerite, have been found cutting calcareous slates and limestones along and near the west branch of Marsoui river, in the contiguous townships of Christie and Boisbuisson, Gaspé Nord county, about eleven miles south of the village of Marsoui, where this stream empties into the gulf of St. Lawrence. Some surface work has been done on claims here. These occurrences were examined by Jones (pp. 44-51), who concluded that the general area was favourable for prospecting.

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TITANIUM

Ilmenite and Ilmenite-Bearing Magnetite

Deposits of ilmenite, or of magnetite with variable amounts of associated ilmenite, some of them very extensive, are known at several localities in the Province. Those that have been investigated in some detail, and from which there has been a small production, are near Ivry, about fifty-five miles northwest of Montreal; at and in the vicinity of lake St. John, in the Saguenay River area; and at several points adjacent to the north shore of the lower St. Lawrence river, notably at St. Urbain-de-Charlevoix, also near the bay of Seven Islands, and along Romaine river, which last three localities are, respectively, 60, 320, and 430 miles below Quebec city. Some of the St. Urbain ore contains an appreciable amount of rutile, included as small grains in the ilmenite. All of these deposits occur within bodies of anorthosite or related basic rock.

Although for many years there has been regular production of ore from the St. Urbain deposit, and in past years some was shipped from Ivry, the total output has been small (see accompanying table of production). In the thirty years from 1911 to 1940 it amounted to less than 55,000 tons, or an average of only about 1,800 tons a year. Since 1940, shipments have increased sharply, with an average of 31,500 tons per year for the period 1941-44. World production of titanium ore in 1944 was about 400,000 tons of ilmenite and 20,000 tons of rutile.

Almost the whole of the Quebec production has been exported to the United States for use in the manufacture of ferrotitanium and titanium oxide paints. The latter industry is by far the largest consumer of titanium. Thus, in 1944, about 98 per cent of the ilmenite produced in, and imported into, the United States was used in titanium pigments (*Minerals Yearbook*, 1945, U.S. Bur. Mines). Consumption of these pigments in the Canadian paint industry is increasing rapidly, as is shown in the accompanying tables. Up to the present, however, little or no titanium oxide for the manufacture of such paints has been made in Canada. Titanium oxide is used also in the dyeing and ceramic industries.

To be marketable, titanium ore must contain at least 40 per cent TiO_2. The theoretical percentage in ilmenite of composition $FeO.TiO_2$ is 52.7. If the ore contains enclosed grains of rutile, the percentage of TiO_2 may, of course, be higher than this. Actually, the percentage is usually below the theoretical value, due to intergrowth of hematite with the ilmenite.

Deposits in Morin Anorthosite Mass

The Morin anorthosite mass lies a few miles within the Canadian shield, its southeast margin being about twenty-five miles northwest of Montreal. Its surface dimensions are about thirty-five miles east-west and twenty-four to thirty-five miles north-south, the greater length being in its eastern part. It thus occupies an area of rather more than 900 square miles. The Mont Laurier branch of the Canadian Pacific railway passes northwest across the southwestern part of the mass. Ivry station is near the ilmenite deposits.

Except at its southern margin, where there are patches of limestone and other rocks of the Grenville series, the anorthosite mass is surrounded by granitic rocks, for the most part fine grained, gneissic types, some of which are older than, and are intruded by, the anorthosite, whereas others, at least in places on the south side of the mass, are younger than, and are genetically related to, the anorthosite. These latter and the anorthosite

Table of Production of Ilmenite
in the Province of Quebec, 1910-1944
(Dominion Bureau of Statistics)

Year	Tons (2,000 lb.)	Value $	Year	Tons (2,000 lb.)	Value $
1910..........	3,528	5,292	1929.........	2,748	7,359
1911..........	3,789	5,684	1930.........	412	1,239
1912..........	1,127	4,024	1931.........	1,509	10,261
1913..........	4,981	9,824	1932-33......	none	none
1914-15-16.....	none	none	1934.........	2,023	14,161
1917..........	4,435	22,770	1935.........	2,288	16,400
1918..........	5,032	22,417	1936.........	2,566	18,318
1919..........	none	none	1937.........	4,229	26,432
1920..........	960	2,999	1938.........	207	1,449
1921-22.......	none	none	1939.........	3,694	21,267
1923..........	68	180	1940.........	4,535	24,510
1924..........	1,408	3,771	1941.........	12,651	49,110
1925..........	3,978	11,934	1942.........	10,031	50,906
1926..........	200	600	1943.........	69,437	308,290
1927..........	2,029	8,980	1944.........	33,973	165,195
1928..........	2,244	6,732			

Consumption of Titanium Pigments in the
Canadian Paint Industry, 1936-1944
(Dominion Bureau of Statistics)

Year	Total Titanium Pigments		Pure Titanium-White Pigments	
	Quantity, lb.	Cost at Works $	Quantity, lb.	Cost at Works $
1936.........	2,456,265	269,130	1,396,337	193,638
1937.........	3,748,341	362,869	1,299,857	193,107
1938.........	3,903,337	378,548	1,341,359	200,552
1939.........	5,088,234	494,914	1,855,288	275,103
1940.........	6,138,760	616,360	2,297,248	344,945
1941.........	8,971,865	1,004,591	3,076,490	560,621
1942.........	11,202,473	1,399,884	4,168,097	820,990
1943.........	13,994,999	1,580,995	4,436,382	811,086
1944.........	13,176,631	1,061,614	4,600,654	933,199

Imports into Canada of Antimony Oxide, Titanium Oxide, and White Pigments
Containing Not Less Than 14 Per Cent of Titanium*

Year Ending March 31st	From United Kingdom		From United States	
	Quantity lb.	Value $	Quantity lb.	Value $
1936.............	1,157,773	141,783	2,190,886	204,014
1937.............	2,081,767	235,593	2,763,407	251,562
1938.............	1,926,857	227,573	3,611,232	268,636
1939.............	1,741,699	217,102	4,475,924	333,945
1940.............	1,451,402	199,998	7,645,254	616,355

*Compiled from *Reports of the Trade of Canada*, Department of Trade and Commerce, External Trade Branch, Ottawa.

mass are together designated the Morin series. In some places, the acidic, marginal facies, which is quite high in potash feldspar and quartz, may be seen grading into normal anorthosite; in others, it cuts across the latter.

The typical anorthosite consists of plagioclase (labradorite to basic andesine) almost to the exclusion of other minerals, but hypersthene, augite, biotite, ilmenite, apatite, orthoclase, and quartz are common accessories and may make up from 5 to 10 per cent of the rock. For the most part it is a coarse grained, or very coarse grained, rock, but fine grained types occur, and in these a foliated structure is common. Such rock has a green colour, whereas that with normal or coarse grain is deep mauve. At two localities, large bodies of ilmenite have been found within the anorthosite (Adams, Osborne).

Ivry Mine

The Ivry ilmenite deposit is mainly in lot 38, range V, Beresford township, five miles west of Ste-Agathe. The first shipment of ore was made in 1912 and between that year and 1918 there was intermittent production totalling about 1,600 tons. This ore was shipped to the *Titanium Alloy Company*, at Niagara Falls, N.Y., for the manufacture of ferrotitanium. Between 1927 and 1935, a further 500 tons was mined. The workings are in the face of a hill and the ore was mined by hand and hauled by truck to the railway, about one mile distant. The following analyses indicate the composition of the ore (Robinson, 1922, p. 54):

ANALYSES OF IVRY ILMENITE

	I	II	III	IV
Ti	18.18	19.00	19.92	19.84
Fe	48.05	47.86	42.75	42.98
SiO_2			7.54	....
P			0.036	0.076
S			0.010	0.144
V_2O_3				0.04
Cr_2O_3				0.08

The rock in the vicinity of the deposit is typical dark mauve anorthosite. For the most part, contacts between ore and rock are sharp, and in places dyke-like masses of ilmenite penetrate the anorthosite wall-rock. These and other considerations have led Osborne (1936, pp. 77-78) to conclude that the deposits are not magmatic segregations, as was formerly supposed, but that they are dyke-like injections into the anorthosite of a high-titanium magna with only a moderate content of mineralizers. The ore minerals, however, were deposited before the magmatic period of the anorthosite was complete, for, in places, dykes of anorthositic type cut the ore. The anorthosite is cut by many shear zones, and it may be that these were responsible for the localization of the orebodies. Contacts of gradational nature are explained by Osborne as the result of injection of ilmenite magma between grains of feldspar.

The ore is a medium to coarse textured aggregate of grains of ilmenite which enclose minute intergrowths of hematite. Associated with the ilmenite are sparsely scattered grains of pyrrhotite, chalcopyrite, pyrite, and marcasite which, near the margins of the orebody, appear as veins of these minerals. They are evidently later than the anorthosite and ilmenite.

It is difficult to form an estimate of the size of the orebody because exposures are scattered. The largest of the workings from which ore was extracted is 100 feet wide and up to 30 feet high. A geophysical survey carried out by Professor D. A. Keys, of McGill University, using an Askania variometer, indicated that the deposit consists of two bodies, striking northwest, and a few small neighbouring masses. The survey indicated that the more northerly body, in which the quarry was opened, is a lens-like mass, 75 feet wide and upwards of 800 feet long, extending to a depth 93 feet below the quarry floor. The other body, 75 feet to the southwest, apparently has similar dimensions but is a vertical, tabular mass. The tonnage of available ore is obviously considerable (Osborne, 1936, pp. 79-85).

Desgrosbois Deposit

The Desgrosbois deposit is a little more than a mile north of the Ivry mine, in lots 39 to 41, range VI of Beresford township, close to the railway. The ore is quite different from that of the Ivry deposit, consisting of ilmenite mixed with magnetite which contains intergrown ilmenite. Also, according to Robinson (1922, p. 68), it occurs in a gabbroic facies of the anorthosite.

Very little work has been done here. Dulieux (1913, pp. 72-78) visited the locality in 1912 and found that test-pitting on lot 39 had exposed ore over a length of 22 feet and to a depth of 5 feet, and by stripping to the west of this he found ore at intervals over a length of 70 feet and a width of 27 feet. Much of the ore, however, was not compact but was mixed with country rock. On the western part of lot 40 and extending onto lot 41, ore was found in a number of outcrops distributed over an area 47 feet by 27 feet. He concluded that the ore occurs as a series of relatively small segregations in the midst of the anorthosite. In 1935, Professor Keys made a dip-needle survey of the ground westward from the outcrops on lot 40. This indicated a zone of high magnetic attraction over a length of about 1,300 feet and a width of 400 feet (Osborne, 1936, p. 88).

Dulieux (1913, p. 75) gives the following four analyses of the ore, No. I from lot 40 and the other three from lot 39;

	I	II	III	IV
Iron..............	46.59	40.76	42.85	44.04
Titanium..........	18.09	4.49	6.73	5.09

According to Osborne (1936, p. 87), textural relationships of the ore minerals indicate that it might be possible to separate the ilmenite from the magnetite, including that which is intergrown with the latter. The analyses given by Dulieux, however, suggest that the ore is of too low grade to be considered as a possible source of titanium.

St. Charles Deposit, Saguenay River

The St. Charles, or Bourget, deposit of titaniferous magnetite lies mainly in lots 44 and 45, range I of Bourget township, Chicoutimi county.

It is about a mile and a half west of St. Charles village, which may be reached by an automobile road of seventeen miles from Jonquières or Kénogami station on the Quebec-St. John branch of the Canadian National railway.

The deposit, which is on the north side of the Saguenay river, is in anorthosite, a large body of which extends eastward to this area from St. Jean lake. Robinson (1926, p. 49), who made a magnetometric survey of the ground in 1924, found that "closely spaced outcrops extending over a breadth of some 1,200 feet can be followed almost from the water's edge to points on the top of the plateau over 2,000 feet inland and between 300 to 400 feet above the river", and that the surficial area underlain by these outcrops is 358,000 square feet. However, the ore exposed is not all solid titaniferous magnetite. There are two types: one coarse grained in which there is comparatively little foreign matter, the other fine grained and containing up to 50 per cent of rock material. It was not possible to form an estimate of the relative amount of each type. Robinson describes the ore as occurring in dyke-like bodies, contacts with massive anorthosite being clean and sharp. In this respect the deposits appear similar to those at Ivry, as described by Osborne. The ore is magnetic, and is generally designated 'titaniferous magnetite'. As the following analyses show, considered either as an iron ore or as a possible source of titanium, it is low-grade. It is of interest to note that the ore contains a minute quantity of vanadium.

Analyses of Ilmenite from St. Charles Deposit

	I	II	III	IV Coarse	V Fine Grained
Fe	52.97	50.50	52.10	48.18	33.77
Ti	9.32	10.08	12.60	13.45	7.44
S	0.02	0.492	0.034	0.007	0.038
P	0.21	0.046	0.079	0.404	3.85
V_2O_5			0.10	0.36	0.36

I.—Dulieux, 1913, p. 89 (20 to 40 mesh material after crushing and screening).
II and III.—Robinson, 1922, p. 58 (analyses by H. R. Leverin)
IV and V.—Robinson, 1926

Stansfield (pp. 52-73) has discussed the commercial feasibility of smelting these ores in the electric furnace.

St. Urbain Ilmenite Deposits

The village of St. Urbain, Charlevoix county, is eight miles north of Baie St-Paul, on the north shore of the St. Lawrence river sixty miles below Quebec city. Ilmenite was discovered here in or about 1666, but the occurrence appears to have attracted little serious attention until 1872, when the *Canadian Titanic Iron Company* erected charcoal blast furnaces near the deposits and, in the following year, produced a small amount of white pig iron. However, fuel consumption was so high that the undertaking did not prove profitable and the operation was abandoned in 1874. Following development of the process for making ferrotitanium from ilmenite in the electric furnace, some small lots of the St. Urbain ore were shipped out for

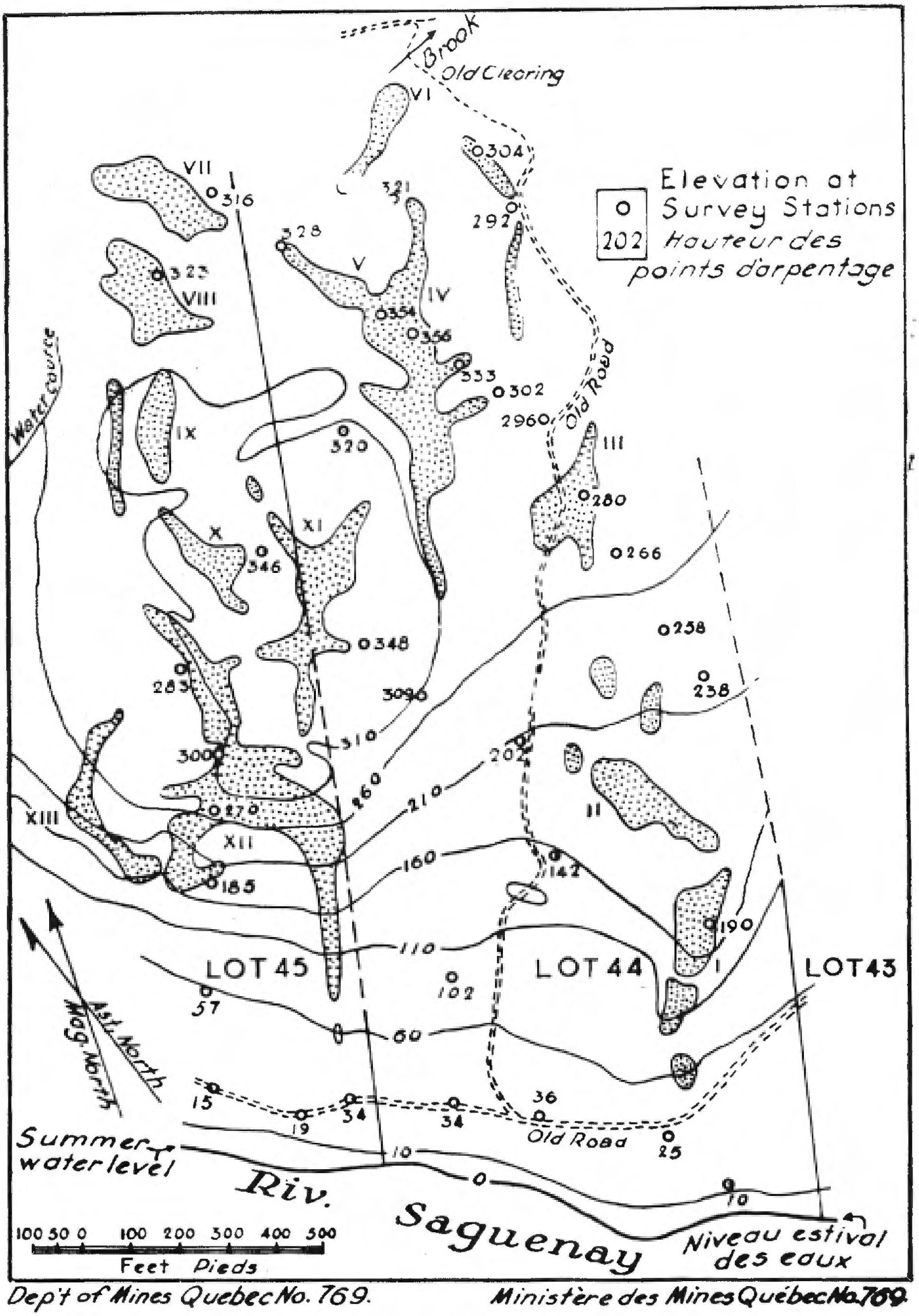

FIGURE 73.—*St. Charles titaniferous magnetite deposit, lots 44 and 45, Bourget township, Chicoutimi district.* Mining Operations 1925, p. 48.

testing purposes and, the ore having proved satisfactory, there has been a small production from various properties in the district since 1908. The district was mapped, and the ilmenite deposits were investigated, in 1923 by J. B. Mawdsley, of the Geological Survey, on whose report the following description is chiefly based.

The deposits occur within a body of anorthosite which is rudely elliptical in outcrop with dimensions twenty miles (north-south) by nine miles. The southern margin is about four and a half miles north of Baie St-Paul and three miles south of St. Urbain. This body is surrounded by rocks ranging in composition from granite to diorite which extend far to the west, north, and east, but on the south are followed, after a width of some two miles, by an assemblage of schists and gneisses of sedimentary origin (Grenville) and intrusive granitic gneisses, the former definitely, and the latter probably, older than the granite-diorite. The age relationship of the anorthosite to the granite and diorite is not clear. Mawdsley found no dykes or offshoots of the one penetrating the other, but in two places small blocks of anorthosite were seen lying within the granite or diorite. He concluded that the two are genetically related, and suggested (p. 30) that "the granite-diorite series and the anorthosite were developed *in situ* in stratiform fashion, with the granite-diorite rocks overlying the anorthosite, and that the stratiform arrangement was in part obliterated by movements of the two rock groups while still at least only partly crystallized".

The anorthosite is a white to mauve, medium to coarse grained rock, consisting of plagioclase with composition range from andesine to labradorite. Minor constituents include hypersthene, hornblende, biotite, ilmenite, apatite, and, in the less basic facies, orthoclase. The rock is generally massive, but the marginal zone for a width of 1,000 to 3,000 feet is foliated, as also is the adjacent granite or syenite over a somewhat lesser width.

The most important ilmenite deposits of this region lie within an area of about one square mile whose centre is two miles south of St. Urbain and less than one mile from the southern margin of the anorthosite body, but others have been found ten or more miles to the north of here, in the vicinity of Ontario lake. Between the several deposits exposed in the area near St. Urbain there are very few outcrops, but dip-needle traverses made by Mawdsley indicated that some at least of the deposits extend beyond the limits of exposure, beneath the cover of sand and drift. In 1930-31, a much more detailed magnetometric survey was made, using a Hotchkiss superdip instrument. This indicated that the ilmenite bodies lie along two structural lines, or planes, one striking N.75°W., the other N.40°E. (Gillson).

There is difference of opinion as to the origin of the deposits. Gillson (p. 572) considers they were formed by replacement of the anorthosite by ore-bearing vapours or solutions, whereas Mawdsley (p. 46) is of opinion that the ilmenite was injected as an essentially water-free magma into fractures in the rock. In support of this view he emphasizes that the deposits have dyke-like form, that their contacts with the anorthosite are sharp, and that in all of them there are engulfed 'horses' of the rock.

The ore consists almost wholly of grains of ilmenite, but these grains invariably contain intergrowths of fine hematite lamellæ, which make up an average of 20 per cent of the volume of the ore. This is true also of the ilmenite occurring in the anorthosite and in the diorite or granite adjacent to it. In some, but apparently not in all, of the deposits, the ore contains an appreciable amount of rutile. Pyrite, pyrrhotite, and chalcopyrite are present, but generally in very small amount; they appear to be later than the ilmenite.

Apart from some 2,000 tons from the deposits at Ivry, the whole of the Quebec production of ilmenite has come from the St. Urbain deposits (see *Table of Production*, p. 542). The first shipments were made in 1908.

The accompanying table of analyses shows the composition of typical samples of the ilmenite from four of the deposits.

Analyses of Ilmenite from St-Urbain Deposits

	I	II	III	IV	V
TiO_2	53.35	40.46	41.61	41.00	35.46
SiO_2	2.24		1.10	2.64	3.12
Fe_2O_3	13.61				
FeO	24.49				
MnO	0.30				
MgO	4.04				
CaO	0.30				
P		0.058	Trace	0.040	0.044
S		0.148	Trace	0.041	0.040
V_2O_5		0.09			
Cr_2O_3		0.25			
Ni		nil			
Iron	28.54	45.49	44.52	40.09	42.89
Titanium	32.01	24.82	24.98	24.62	21.30

I.—Rutile-rich specimen; Warren, U.S. Geol. Surv., Bull. 580, 1915, p. 407
II.—Furnace deposit; Robinson, 1922, p. 52 (analysis by H. A. Leverin)
III.—General Electric deposit; Dulieux, 1912, p. 94
IV.—West Coulombe deposit; Dulieux, 1912, p. 91
V.—East Coulombe deposit; Dulieux, 1912, p. 91

Principal Deposits

Furnace Deposit.—A mile and a quarter southwest of St. Urbain. Four dyke-like bodies of ilmenite, striking northeast, are exposed in three quarry faces and two adjacent strippings. The distance between the first and the last dyke, across the strike, is 250 feet. As exposed, the width of ore is from eight to thirty feet, but only one of the dykes has its full width exposed.

Bignell Deposit.—Half a mile west of the Furnace workings. Ilmenite was exposed here many years ago, by trenching, but cannot be seen now owing to caving. However, the dip needle indicates the presence of an orebody.

General Electric Deposit.—About 3,000 feet south of the Furnace orebodies. This deposit, notable for its content of rutile, has furnished the bulk of the ilmenite shipped from St. Urbain. Quarrying and stripping have exposed ore, within which are some 'horses' of anorthosite, over a length of 300 feet and a width of as much as 150 feet, or an area of at least 15,000 square feet. The orebody is known to extend beyond the limits of the stripping.

West and East Coulombe Deposits.—About 800 feet south of the General Electric quarries. A body of ilmenite has been exposed by stripping for a length, east-west, of 180 feet and a width of 80 to more than 120 feet, widening eastward, and it evidently extends beyond these limits, concealed by overburden. About 350 feet to the east, ore has been uncovered for a length of 200 feet. At the western end of this stripping it has an exposed width of 70 feet, with no walls in sight, and toward the eastern end it narrows to 25 feet, bordered on both sides by walls of anorthosite. The area of ilmenite as actually exposed in the two strippings is about 18,000 square feet. It appears highly probable that the orebody is continuous from the west to the east workings.

Joseph Bouchard (or *Glen*) *Deposit.*—Half a mile east of the Coulombe orebody. This is a dyke-like body of ilmenite, 30 feet wide, between walls of anorthosite. It has an easterly strike and has been quarried for a length of 80 feet.

Deposits near Bay of Seven Islands

The bay of Seven Islands is on the north shore of the St. Lawrence river about 320 miles below Quebec city. Des Rapides river enters the bay at its head, and Ste-Marguerite river empties into the St. Lawrence four miles west of the bay. The occurrence of deposits of magnetite and titaniferous iron ore along and near the lower reaches of these rivers was mentioned by Sterry Hunt in the *Report of Progress* of the Geological Survey for 1866-69. During the period 1867-75, the Moisie Iron Company shipped ore from the Molson mine, at Cran de Fer falls on des Rapides river, to their furnaces at Moisie, some ten miles east of Seven Islands bay, where it was smelted with the magnetite-bearing sands occurring at the mouth of Moisie river (see p. 398). Dulieux (1912, pp. 103-125) made a detailed examination of the deposits in 1911.

A body of anorthosite extends northeasterly from near Ste-Marguerite river, past the head of Seven Islands bay, to several miles beyond des Rapides river. It is bounded on the north by older granitic rocks, largely gneissoid, and on the south by marine sand and clay deposits. The anorthosite shows gradation to gabbroic types and also to granitic types. In some places there is gradation from anorthosite to granite, but in others the latter is in sharp contact with the anorthosite, particularly where this is the gabbroic type. There appears no doubt, however, that it is an acidic facies of these rocks. Actually, in this mass, the gabbroic facies is much more abundant than the true, mono-mineral anorthosite and it invariably contains grains of magnetite or ilmenite. Locally, these are heavily disseminated through the rock or appear as segregations with little or no rock material. Such occurrences are found chiefly in the marginal zone of the anorthosite mass. Segregations of solid ore, however, are few in number and of relatively small size. They presumably consist chiefly of magnetite and ilmenite and are commonly referred to as titaniferous magnetite.

The following analyses, reproduced from the report by Dulieux (1912, pp. 110-113), indicate the composition of typical samples of magnetite-rich gabbro (I to IV) and compact ore (V to VIII). The samples were taken on the west side of des Rapides river at various points below Cran de Fer falls.

ANALYSES OF GABBRO AND ORE FROM DES RAPIDES RIVER

	Magnetite-Rich Gabbro				Compact Ore			
	I	II	III	IV	V	VI	VII	VIII
Fe	28.60	22.06	21.82	16.15	45.70	52.84	49.75	51.85
Ti	0.225	0.71	4.15	5.60	14.73	13.46	12.85	15.51
SiO_2	26.85	....	14.26	14.60	6.72			1.16
Al_2O_3	17.30	20.00	11.67	12.13	3.16			1.50
CaO	9.48	8.84			0.29			0.32
MgO	2.16	1.28			3.28			3.42
S	0.25	0.21				0.13		
P	1.20	1.68				0.02		

Molson Mine.—The largest of the known deposits of ore are at Cran de Fer falls, about half a mile from the mouth of des Rapides river. This is the site of the Molson mine, from which ore shipments were made to Moisie. Much of the rock exposed here on both banks of the river is magnetite-rich gabbro. Within this, for a distance of 650 feet along the west bank of the river immediately below the falls, are several masses of solid ore, from 25 to 35 feet wide. There are some, also, along the east bank. In 1911, Dulieux shipped 3,000 pounds of ore from piles at the workings on the east bank to the Ore Testing Laboratories at Ottawa. The results of tests by passing the very finely ground material through Grôndal separators indicated that it was not possible by this method to obtain a substantially titanium-free product, but that an almost pure ilmenite concentrate could be made (Robinson, 1922, pp. 63-64).

Gagnon Deposit.—This is about 200 feet east of Cran de Fer falls. The rock here, which is well exposed, is gabbro and in some places it is so charged with magnetite and ilmenite that it has the appearance of solid ore. Analyses, however, show that, at the best, it is very low grade, containing only 25 to 30 per cent iron and 8 to 11 per cent titanium.

Outarde Falls.—These falls are one mile above Cran de Fer falls. An outcrop sixty feet long on the west bank of the river contains all gradations from gabbro to practically solid ore, but the latter constitutes but a small proportion of the whole.

ILMENITE DEPOSITS, LOWER ROMAINE RIVER AREA

Numerous occurrences of ilmenite were discovered by Retty in 1941 in the course of mapping the geology of the lower Romaine River area for the Quebec Department of Mines. The southward flowing Romaine river turns abruptly westward about five miles before it reaches the St. Lawrence and, after continuing in that direction for twenty-four miles, enters the St. Lawrence some ten miles west of Havre St-Pierre. The mouth of the river is 430 miles below Quebec city.

The rocks along the lower Romaine are for the most part massive granite and Grenville schists and gneisses, the two alternating in zones of various widths. A few miles west of the sharp bend in the course of the river, the granite is in contact with anorthosite, which extends far to the west. Tributaries of the Romaine — Puyjalon, Allard, and Bat-le-Diable — traverse this mass, but along the main Romaine river itself anorthosite does not appear until a point about fifty-five miles north of the St. Lawrence, and from there it continues northward to the limit of the area mapped by Retty. What may be the northern margin of the same anorthosite mass was encountered by Low (pp. 234-238, 287) in 1894 at a point about seventy-five miles north of the St. Lawrence.

The anorthosite presents the several facies usual in masses of this rock. In most parts of the portion examined by Retty, the feldspar is andesine and such rock consists almost wholly of feldspar. Types in which the feldspar is labradorite contain in addition some 10 per cent or more of hypersthene, augite, biotite, and ilmenite, and small amounts of apatite and pyrite. In places, this labradorite-anorthosite contains as much as 25 per cent ilmenite. A narrow marginal zone along the east side of the mass has the composition of gabbro or norite. Retty found evidence that the granites to the east of the anorthosite are of two ages, and that the later of them is later also than the anorthosite.

Deposits of more or less solid ilmenite were seen by Retty in some twenty places around the shores of Allard, Puyjalon, and Bat-le-Diable lakes — widenings in the rivers having those names — and on Petit-Pas lake, off the north end of Allard. As exposed, they are all of relatively small size, of the order of fifty feet long and eight feet wide.

The ore is usually granular (4 to 5 mm.) and somewhat magnetic. When examined in polished section, the ilmenite grains are seen to contain discontinuous lamellæ of hematite which make up about 16 per cent of their volume. Pyrite, pyrrhotite, and plagioclase occur interstitially in small amount. Seven samples of the ore, taken from various localities by Retty (p. 24) and analyzed in the Quebec laboratories of the Department of Mines, gave ranges as follows for the main constituents:

Total iron as Fe	41.06—45.08	P	None—0.05
Total iron as FeO	52.82—58.00	S	0.01—0.47
TiO_2	32.24—38.14	V	0.02—0.19
SiO_2	0.87— 2.57		

Regarding the origin of the ore, Retty (p. 26) "favours the view that the ilmenite is an original constituent of the anorthosite magma and that, in some places, it has segregated to form masses of appreciable size, and, in others, it has remained scattered through the anorthosite in varying degrees of concentration".

A number of claims have been staked in the area since it was mapped by Retty. Surface work has been done on some of these and in 1943 Longley made a dip-needle survey of one group on the western side of Allard lake, two and a half miles from its south end. Passing through the claims in a north-south direction is a west-facing escarpment, 50 to 100 feet high.

Trenching at intervals along the west of the ridge has exposed a well defined zone of mineralization over a length of 2,800 feet. Longley (p. 10) reports that the work to date indicates that the ilmenite occurs along this zone as a series of discontinuous lenses of ore with large aggregate tonnage.

On another group of claims just north of Allard lake, a zone of ilmenite mineralization is exposed over a length of 330 feet.

In 1944, *Kennco Explorations, Limited*, a subsidiary of Kennecott Copper Corporation, became interested in the Allard Lake area and acquired options on the mining rights of claims covering some 6,000 acres. This organization began, in 1945, an extensive programme of geophysical exploration work and diamond drilling.

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TUNGSTEN

Scheelite, $CaWO_4$, one of the principal ores of tungsten, is present in the ore of many of the Western Quebec gold mines, but, so far as observed, only in such minute amount that, as a commercial operation, its recovery is not feasible (for references to occurrences, see *Index* at end of volume). In 1940, however, the war demand for tungsten became so insistent that both the Federal and the Quebec Departments of Mines conducted investigations of all mines in the Province where scheelite was known to occur, and steps were taken to have scheelite-bearing ore, or concentrate, shipped from these mines to the ore dressing laboratory of the Provincial Mine School at Val d'Or, where a plant was installed for recovering the scheelite in a concentrate containing 70 per cent tungsten trioxide. This was disposed of through the Metals Controller. The cost of recovery was, of course, quite prohibitive measured by normal, peacetime standards.

The Val d'Or plant operated until the end of 1943, when, the tungsten situation having become much easier, recovery of scheelite from Quebec ores was discontinued. During the three-year period, the Val d'Or laboratory received shipments from ten or a dozen Western Quebec gold mines and recovered 9,371 pounds of scheelite concentrate. The following mines contributed to this production of scheelite: *Lamaque, Perron, Sigma, Sullivan, Wood Cadillac, Central Cadillac, Canadian Malartic, McWatters,* and *Halliwell.*

Scheelite occurs in quartz veins cutting Ordovician schists on the north slope of Mine hill, in lot 1, range VII of Marlow township, Frontenac county. Several veins, the largest a foot wide, have been exposed in trenches and pits. On the dumps near these, Faessler (pp. 16-17) found a number of lumps of vein quartz carrying scheelite, but apparently the distribution of the mineral in the veins is very erratic.

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URANIUM

Uraninite and other minerals containing uranium have been found in pegmatite dykes in a number of localities in the Province. It should be pointed out, however, that the mineral occurring in these dykes is uraninite, and not pitchblende, names that have been used more or less synonymously in the past.

In modern usage, the name uraninite is restricted to the mineral species having the formula UO_2 (with some ThO_2) and occurring in crystals belonging to the cubic or isometric system, frequently dodecahedra. It occurs invariably in pegmatite dykes, and nowhere in the world has it been found in such dykes in sufficient concentration to be used as a commercial source of uranium or radium. On the other hand, pitchblende, the ore from which practically the whole of the world's supply of these metals is obtained, is a massive mineral, never occurring in crystals. It has approximately the composition U_3O_8 and is found in vein deposits associated with such minerals as native gold and silver, cassiterite, cobalt and nickel arsenides, and copper and other metallic sulphides. No occurrences of pitchblende have been reported in the Province of Quebec.

Uraninite has been found at three localities in Papineau county, and at one in Charlevoix county.

Villeneuve Mica Mine, lot 31, range I, Villeneuve township, Papineau county.

In 1886, Hoffman (p. 12) received from the Villeneuve muscovite mine a specimen weighing about one pound which he identified as uraninite with some 'gummite', the latter being the name given to various scarlet to yellow coloured alteration products frequently associated with uraninite. This specimen has since been analyzed and described by Ellsworth (p. 242).

The uraninite occurs in a pegmatite dyke composed of quartz, white microcline and albite, and muscovite, with fairly abundant black tourmaline and lesser apatite, zircon, fluorite, beryl, and, in addition to the uraninite, two other rare-element minerals, monazite and cerite, phosphate and silicate, respectively, of the cerium group metals with, in the case of monazite, some thorium.

Wallingford Feldspar Mine, lot 14, range II, Derry township, Papineau county.

Ellsworth (p. 244) states that N. B. Davis, then in charge of the Wallingford mine, discovered uraninite in small amount in the pegmatite dyke mined on this property for production of both feldspar and quartz. The feldspar is chiefly very pale to pure white microcline and the quartz also is white or, in places, smoky.

The uraninite occurs in nodules up to a quarter of an inch in diameter. Other rare-element minerals present are thucholite, a black, somewhat coal-like, material whose chemical constitution is unknown, and allanite, a silicate of cerium and related elements containing, in this occurrence, an unusually high percentage of thorium. Both are rather strongly radioactive.

Leduc Quarry, lot 25, range VII, Wakefield township, Papineau county.

On this property, a pegmatite dyke some forty feet wide, containing much tourmaline of various shades of green and pink, and more or less transparent, was investigated in 1908 with the idea of producing gem tourmaline, but the crystals were found to be too much shattered for use as gems. Hugh de Schmid (Spence) (p. 43) states that "small quantities of uraninite, gummite, fluorite, and spodumene are also recorded from this mine". It is of interest to note that the mica in this pegmatite is the lithia variety, lepidolite (see p. 479), about a ton of which is reported to have been taken from one small surface pit in 1885 (de Schmid, p. 42).

Lac Pied des Monts, De Sales township, Charlevoix county.

In his report on mining operations for 1903, Obalski (pp. 65-67) describes a specimen which had been found a few years previously at Pied des Monts lake and which he had identified as uraninite. This is an almost complete dodecahedron, two inches in diameter, having the usual black colour of uraninite and coated in places with deep orange to brown gummite. It has since been described by Ellsworth and Osborne (pp. 421-425), with a complete analysis by Ellsworth. The pegmatite dyke from which it came is on the north side of the lake, about eighteen miles northeast of Murray Bay. The dyke is fifteen to twenty feet wide and consists of pink microcline, white albite and quartz, much biotite, and somewhat less muscovite. Accessory minerals, present in very small amount, are zircon and monazite. Obalski states that, in addition to the large crystal of uraninite, he found several small pieces. In the same dyke there is (p. 66) "a coaly substance that burns pretty easily, leaving a considerable proportion of ash containing a marked quantity of oxide of uranium". From Obalski's description of this material, Ellsworth (p. 250) concludes it is thucholite.

Allanite occurs rather abundantly in a coarse granite near lac à Baude, in Norman township, Champlain county. Tabular crystals three inches long are common and some are as much as twice that length (Harvie). Similarly large crystals are found in a coarse grey pegmatite on lot 13, range III of Portland East township, Labelle county (Walker and Parsons, pp. 30-31). Analyses of the allanite from both localities are given by Ellsworth (p. 258).

Samarskite and *fergusonite* occur in a pegmatite dyke at the Maisonneuve mine on lots 1 and 2, range II, Maisonneuve township, Berthier county. These are somewhat similar minerals, both being tantalo-colombates of rare earths, thorium, uranium, and iron, with samarskite containing more uranium (10 per cent or more UO_3) than fergusonite. The samarskite was analysed in 1882 by Hoffmann (1883, p. 1). It contains 55.41 per cent $(Cb,Ta)_2O_5$; 10.75 per cent UO_3; 14.34 per cent $(Yt, Er)_2O_3$; 4.78 per cent $(Ce, La, Di)_2O_3$. It is quite strongly radioactive.

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ZINC AND LEAD

Ores of zinc occur in important amount in each of the geological sub-provinces of Quebec. In the Temiscamian sub-province there are three producing mines — the Normetal in Desmeloizes township, the Waite Amulet in Dufresnoy, and the Golden Manitou in Bourlamaque. The Normetal and Waite Amulet produce also copper, and the Golden Manitou produces lead. The ores of all three mines contain appreciable amounts of gold and silver. The Waite Amulet property is described on pages 361-383, in the section dealing with copper deposits.

In the Grenville sub-province, the New Calumet mine, on Calumet island, produces both zinc and lead, with, also, some gold and silver, and the Tétreault mine, in Montauban township, was, for a number of years prior to 1937, an important producer of both zinc and lead.

What appear to be large and important deposits containing sphalerite, with some galena and chalcopyrite, occurring in rocks of Lower Devonian age, have been under development in Lemieux township, Gaspé peninsula, for several years.

Minor zinc and lead mineralization has been reported in numerous localities in all three sub-provinces, and particularly in the Grenville area, thus indicating that the ores of these metals have wide distribution and encouraging the hope that intensive exploration will lead to the discovery of new deposits of commercial value. For references to occurrences, see *Index* at end of volume.

Western Quebec

Normetal Mining Corporation, Limited

The Normetal property is in range X of Desmeloizes township, about seven miles east of the Quebec-Ontario boundary. The village of Dupuy, on the Canadian National railway, is eleven and a half miles to the south. Zinc and copper mineralization was discovered here in 1925 and from then until 1930 development of the deposits was carried on by Abana Mines, Limited, who, in addition to surface exploration and diamond drilling, sank two shafts to depths of 300 feet (No. 1) and 565 feet (No. 2), and erected a flotation mill. Since 1931, operation of the property has been carried on by the Normetal Mining Corporation, subsidiary of the Mining Corporation of Canada. No. 2 shaft, which is 275 feet slightly east of north of No. 1, has been deepened to 950 feet, and a third shaft (No. 3), 210 feet west of No. 2, has been sunk to a depth of 3,200 feet. The ore, containing zinc and copper with minor gold and silver, is treated at the property to produce a zinc concentrate, which is shipped to the United States, and a copper concentrate, which goes to the Noranda smelter. The plant has a capacity to treat 800 tons of ore per day. Production commenced late in 1937 and to the end of 1944 some 1,300,000 tons of ore had been treated, yielding about 126,000 tons of zinc concentrate containing 134,000,000 lb. zinc, and 155,000 tons of copper concentrate containing 68,000,000 lb. copper with appreciable amounts of gold and silver. At that time, ore reserves above the 2,750-foot level were estimated at 1,380,800 tons carrying 6.77 per cent zinc, 3.56 per cent copper, and 0.032 oz. gold and 2.39 oz. silver per ton.

The property is underlain by Keewatin-type volcanic rocks which, in the vicinity of the orebodies, are chiefly rhyolites, siliceous agglomerates and tuffs, and sericite and chlorite schists, The deposits are largely confined to a band of sheared agglomerates and tuffs which, at the surface, has a width of about twenty-five feet, with strike N.60°W. and dip 80° northward. Cutting these rocks about forty feet southwest is a sill-like

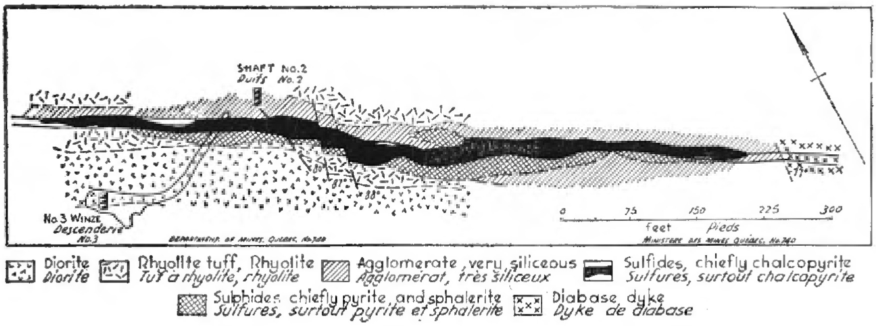


FIGURE 74.—*Normetal mine, plan of 1385-foot level*

body, twenty-five to sixty feet wide, of highly altered quartz diorite (Tolman) or albite granite (Mawdsley) whose strike about parallels that of the volcanics, and in the general vicinity there are a number of dykes and irregular masses of feldspar porphyry, older than the quartz diorite. Later than any of these intrusives, and also than the ore, is a dyke of quartz diabase which strikes north-south and dips eastward at about 80°. This dyke cuts across the ore zone. Exposures of similar quartz diabase intermittently to the south along the projected strike of this dyke indicate that it may have a length of at least fifty-five miles. About four miles southwest of the mine is the margin of a granitic batholith which extends for several miles southward and also westward across the provincial boundary, and a few miles to the north is the irregular southern margin of the extensive area of granite that here flanks the volcanic belt.

Although the volcanic rocks are highly sheared, faulting in the direction of the shearing has not been recognized in the mine workings except on the 935-foot level where, at a distance 700 to 900 feet east of No. 3 shaft, the ore is cut by a fault of undetermined but slight movement, which strikes N.80°W. There are, however, a number of north-south faults cutting the orebodies, but in general the displacement on them is only a few feet. An exception to this is a fault that parallels, and lies within the east part of, the quartz diabase dyke. This has displaced the ore zone for a horizontal distance of about 150 feet, with relative movement of the east side to the south.

The orebodies have been formed by replacement of the agglomerate and tuff band, chiefly along its footwall side, by pyrite, sphalerite, and chalcopyrite, and minor amounts of pyrrhotite and galena. The pyrrhotite appears as streaks in the chalcopyrite and seems to increase in amount with depth. No. 1 and No. 2 orebodies are on the west side of the diabase dyke. At the surface, they are about fifty feet apart, but they converge downward and unite to form a single body below the 550-foot level. Chalcopyrite predominates in the hanging-wall, and sphalerite and pyrite in the footwall. The orebody becomes both longer and wider with depth, at least to the 1,385-foot level, and at the same time it contains progressively less pyrite and sphalerite, and more chalcopyrite. Thus, on the 935-foot level, it is

416 feet long, 11.9 feet wide, and averages 1.79 per cent copper and 10.18 per cent zinc, whereas on the 1,385-foot level, the length and width are 653 feet and 14 feet, and the tenor 3.91 per cent copper and 2.41 per cent zinc.

No. 3 orebody is east of the dyke. As intimated above, it appears to be the faulted continuation of the ore zone on the west side. It consists chiefly of pyrite and sphalerite and has been under development as a source of zinc ore.

From the results of a study of polished sections of the ore, Mawdsley (pp. 69-71) concluded that all the sulphides were introduced during a single period of mineralization, with pyrite first and followed in turn, and with some overlapping, by sphalerite, chalcopyrite, and galena. The mineralization, he believes, is genetically related to the feldspar porphyry or to the albite granite (Mawdsley, pp. 64-71: Wilson, pp. 78-79; Tolman, pp. 7-9; Johnson, A. W., Mine Geologist, personal communication).

Golden Manitou Mines, Limited

The shaft of the Golden Manitou mine is a mile and a half west of the east boundary of Bourlamaque township and a mile and a quarter north of the centre line. The deposits mined are sulphide bodies containing zinc (chiefly), and copper, along with important amounts of gold and silver.

The property consists of the western part of a large group of claims, extending westward from the east boundary of the township, which had been held by various interests and from 1936 until 1941 by Quebec Manitou Mines, Limited, and on which a considerable amount of exploration work had been carried out, including trenching, diamond drilling, and the sinking of a shaft to a depth of 385 feet, with lateral work on two levels. Following incorporation in 1941, Golden Manitou Mines deepened the shaft to 1,130 feet and opened five new levels at intervals of about 150 feet. A concentrator and cyanide mill was erected and was placed in operation in 1942. To the end of 1944, it treated 702,197 tons of ore, producing concentrates which were shipped to outside points and from which were recovered 86,907,252 lb. zinc, 982,744 lb. lead, 99,545 lb. copper, 24,614.35 oz. gold, and 1,013,061.96 oz. silver.

At the end of 1944, ore reserves above the 960-foot level were estimated at 983,121 tons containing 7.74 per cent zinc and 0.045 oz. gold and 3.06 oz. silver per ton, with possibly one per cent lead and copper. Diamond drilling from the 1,100-foot level had proved the downward extension of the ore to a depth of at least 1,500 feet.

The shaft is sunk on an outcrop at the south margin of an extensive muskeg. The rock along the north side of this outcrop is sericite schist, striking east-west and dipping steeply to the north. It was in this schist that the initial discoveries were made, and diamond drilling and a geophysical survey indicated that the sulphide mineralization extended, beneath the muskeg, for an east-west length of at least, 1,800 feet. The ore occurs in a strong shear zone, some 80 feet wide, in the band of sericite schist, whose total width appears, from the drilling, to be 400 to 500 feet, beyond which, both to north and south, are fine grained chloritic rocks, presumably representing andesitic lavas although they may be altered tuffs.

The sericite schists are in places highly siliceous and to some extent brecciated. The sulphide orebodies occur within the shear zone as lenticular masses. No definitely intrusive rocks are reported in the vicinity of the orebodies, but the southern margin of the Bourlamaque granodiorite batholith is only about 3,000 feet north of the shaft.

At the end of 1939, it was reported that drilling, and underground work on the first and second levels of the mine, had revealed or indicated four orebodies, as follows: No. 1, about 400 feet long and averaging 30 feet in width; No. 2, near the north margin of the zone, about 400 feet long and 15 feet wide, and possibly apexing not far above the 200-foot level; Nos. 3 and 4, not at that time encountered in the mine workings but indicated by diamond drilling. Even up to the end of 1944, however, the full lateral extent of the ore zone had not been explored.

There is considerable variation in the mineralogical nature of the ore. In places, white quartz veins and stringers are important, as in No. 2 orebody. Some, at least, of this quartz is fine grained, and 'ghost like' structures indicate that it has replaced schist. Some of the orebodies, as No. 3, are essentially massive sulphides. Carbonate, probably dolomitic, may be present in varying amount as a gangue mineral. Sulphide minerals usually present are as follows, in order of decreasing abundance: pyrite, sphalerite (may exceed pyrite), arsenopyrite, chalcopyrite, tennantite, and galena. With these are minute amounts of native gold and pyrrhotite. The pyrite and arsenopyrite are believed to be the earliest of the sulphides and are in part contemporaneous with the early quartz; both are medium to fine grained*. Sphalerite occurs largely as veins and masses and encloses medium to small, irregular grains of chalcopyrite, galena, and tennantite, and corroded grains of pyrite and arsenopyrite. Most of the sphalerite includes also minute grains and rods of chalcopyrite which lie on cleavage or other internal structural planes of the host mineral. The larger grains of chalcopyrite and tennantite are possibly later than the sphalerite and of about the same age as the galena. Gold in visible particles has been noted, but generally it is in microscopic grains. The gold content of quartzose ore is at times above mine grade. However, the distribution of the gold is not uniform and local high assays are not uncommon; one of 15 ounces per ton is reported (Hawley, pp. 88-92, Denis, 1938, p. 4).

Deposits in Rocks of Grenville Series

Disseminated grains and small pockets of sphalerite and galena are of fairly common occurrence in the Grenville rocks of the Province, but up to the present deposits of these minerals of commercial size and grade have been found in only two localities: on Calumet island, in the Ottawa river some fifty miles west-northwest of the city of Hull, and on the Tétreault property, five miles west of Montauban and fifty-two miles west of Quebec

*The description of the ore is summarized from an unpublished report on an investigation carried out in the Ore Dressing and Metallurgical Laboratories of the Department of Mines and Resources, Ottawa, dated July 30th, 1938, and entitled *Microscopic Examination of Samples of Copper-Zinc Ores from the Quebec Manitou Mines, Limited.*

city. The latter deposit lies within a belt of Grenville rocks, four miles long, along which similar mineralization has been found in a number of places, but nowhere else in economically important amount.

With the sphalerite and galena in these deposits there is usually a minor amount of chalcopyrite, and the ores carry both gold and silver, the former in the native state and the latter as a constituent of the galena or some copper sulphide mineral or, more rarely, as silver sulphide (argentite).

New Calumet Mines, Limited

Calumet Island has a length, north-south, of eleven miles and a width averaging about four miles. It has been surveyed and is designated Grand Calumet township. Deposits of sphalerite and galena were discovered near the south end of the island in 1892, and between that year and 1926 a very considerable amount of development work and diamond drilling was carried out by various interests. A number of pits were opened in the ore, and five prospect shafts were sunk, one, the MacDonald, to a depth of eighty-five feet. A concentrating plant was erected at the MacDonald shaft, and from this and other workings there were small shipments of concentrates, totalling probably not more than 1,200 tons. These deposits are all in lots 9 to 12, range IV, and are within distances ranging from 1,800 feet to 3,600 feet from the west side of the island. In 1937, these properties were acquired by Calumet Mines, Limited (later reorganized as New Calumet Mines, Limited), who embarked on a systematic exploration of the ground, and particularly of lots 9 to 12. This included a geophysical survey and 97,000 feet of diamond drilling. A large tonnage of good grade ore having been indicated, a three-compartment shaft was sunk in the south part of lot 10, at a point about 3,000 feet from the island's western shore. Late in 1943, the shaft was 745 feet deep and levels had been opened at 100-foot intervals from the 200-foot to the 700-foot horizon. A concentrator with a capacity of 500 tons per day was erected and started operating late in 1943. To September, 1944, it treated 148,245 tons of ore with production of 24,161 tons of zinc concentrates containing 25,000,000 lb. zinc, and 7,376 tons of lead concentrates carrying about 6,600,000 lb. lead together with 445,000 oz. silver and 1,791 oz. gold. Estimated ore reserves reported at that time were, in round figures, 935,000 tons, carrying 9 per cent zinc, 3 per cent lead, and 6.0 oz. silver and 0.04 gold per ton. Rather more than half of this tonnage is in the MacDonald, Longstreet, and Bowie areas, where shafts had been sunk in earlier operations. These are, respectively, 1,000 feet northwest, 1,000 feet northeast ,and 450 feet south, of the new main shaft.

Except for a small area in the north, which is occupied by Ordovician strata, the island is underlain by rocks of the Grenville series (Figure 75). In the vicinity of the orebodies, they consist of a succession of relatively narrow bands, chiefly of gneiss and amphibolite, which trend N.15°-20°W. with dip to the east at 30°. Osborne (pp. 15-16) gives the section as follows, eastward from the river: crystalline limestone, amphibolite and hornblende gneiss, highly granitic migmatite containing relic sedimentary structures, biotite gneiss (in which the main ore shoots occur), and, overlying this, rather massive amphibolite. This is followed by a band of migmatite beyond

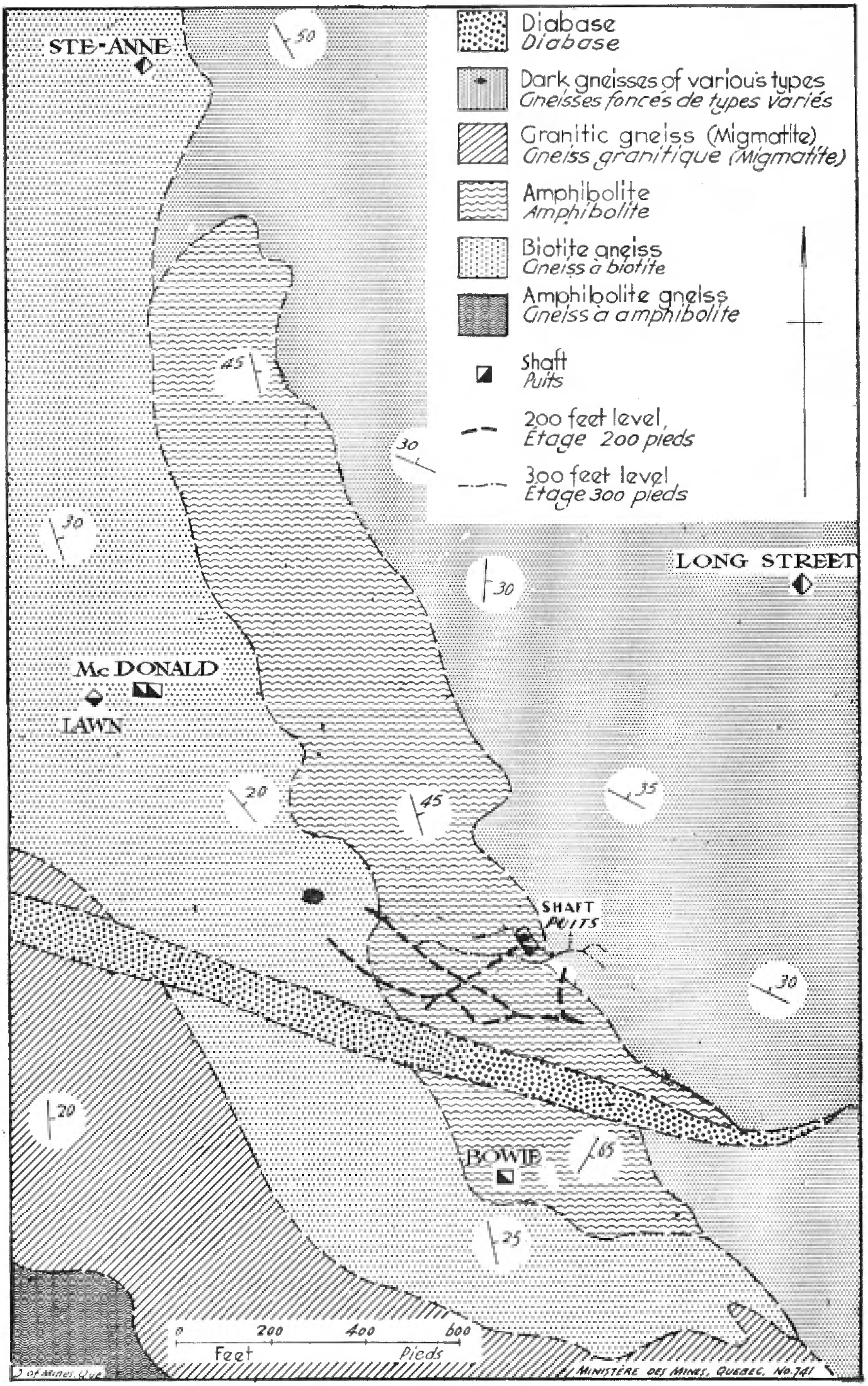


FIGURE 75.—*Geology in vicinity of Calumet Island lead and zinc mine.* (Dept. of Mines, Que. "Calumet Island Area", G.R. 18, after map 550).

which the surface is largely covered with overburden, with the underlying rocks chiefly amphibolite and hornblende gneiss. Some ore (*e.g.*, that at the Longstreet shaft) has been found in these amphibolites.

As shown on Osborne's map, the band of biotite gneiss is rudely lenticular in outline with a length of about three-quarters of a mile, extending from the north part of lot 9 to lot 13. The main shaft is sunk in the overlying massive amphibolite just east of the south end of the biotite schist. The latter here has a width of 400 feet but, northward, it widens gradually to 700 feet in lot 12. Beyond there it rapidly narrows and soon pinches out. Orebodies and ore shoots have been found at intervals along the belt over a length of 2,500 feet.

Cutting the Grenville rocks and also the orebodies is a diabase, or diorite porphyry, dyke, up to 100 feet wide. From the west side of the island it strikes south of east to just south of the main shaft, where it appears to die out. The ore is also cut by a number of lamprophyre dykes, one to two feet wide.

Osborne (p. 23) considers that the solutions responsible for forming the deposits originated at considerable depth. On reaching the biotite gneiss beneath the relatively impermeable layer of amphibolite, they spread laterally and formed the ore shoots in the gneiss. The source of the solutions is a matter of uncertainty. However, in lots 12 and 13, range III, a mile or so northeast of the main shaft, the Grenville rocks are intruded by two small bosses of pink granite, and there are larger bodies of this granite near the east side of the island. This granite may well have been the source of the ore-bearing solutions.

The ore minerals are sphalerite (the high-iron variety, marmatite) and galena, with very minor chalcopyrite, pyrite, pyrrhotite, native gold, and various silver-bearing minerals. The latter include argentite or polybasite, and freibergite (argentiferous tetrahedrite). These are closely associated with the galena and doubtless account for the high content of silver in the lead concentrates. The gold is in the native state, associated with all the sulphides and as minute grains in the gangue. In some polished sections of ore from which high gold assays have been reported, the metal has been observed along fractures in the sulphides, indicating that some, at least, of the gold was introduced at a late stage of the mineralization.

In the most common type of ore, the sulphide minerals occur as grains, blebs, and stringers disseminated through a gangue of altered feldspar and pyroxene, the latter veined by chlorite and sericite. Such ore is in places 'sweetened' by sections of massive or nearly massive sulphides. Usually, these occur near the top or bottom, or both, of the ore section. In the course of the diamond drilling, core lengths up to twenty-one feet of massive sulphides were obtained in many places. These consist of sphalerite and subordinate galena with, usually, some irregular grains of pyrite; or, more rarely, they are predominantly pyrrhotite with 'splashes' of sphalerite in which grains of galena are enclosed. A third, and much less common, type of ore is distinguished by its high gold content and the almost complete absence of any sulphides except sparsely disseminated, fine grained pyrite and a little pyrrhotite. The gangue is coarsely crystalline caclite, with, often, some feldspar and tremolite. Where encountered in the drilling, such ore was either contiguous to, or between sections of, massive sulphide ore containing only the small, normal amount of gold. As noted above, it is believed that this gold was introduced as an end phase of the mineralization (Goranson, pp. 116-122; Armstrong, pp. 386-412; Osborne, pp. 12-24).

Tétreault Mine

The Tétreault zinc-lead mine is in lot 40, range I, of Montauban township (Portneuf county), four miles west of the village of Montauban (formerly Notre-Dame-des-Anges) and forty-five miles west of Quebec city. The north shore of the Saint-Lawrence river is about twenty miles southeast of the mine.

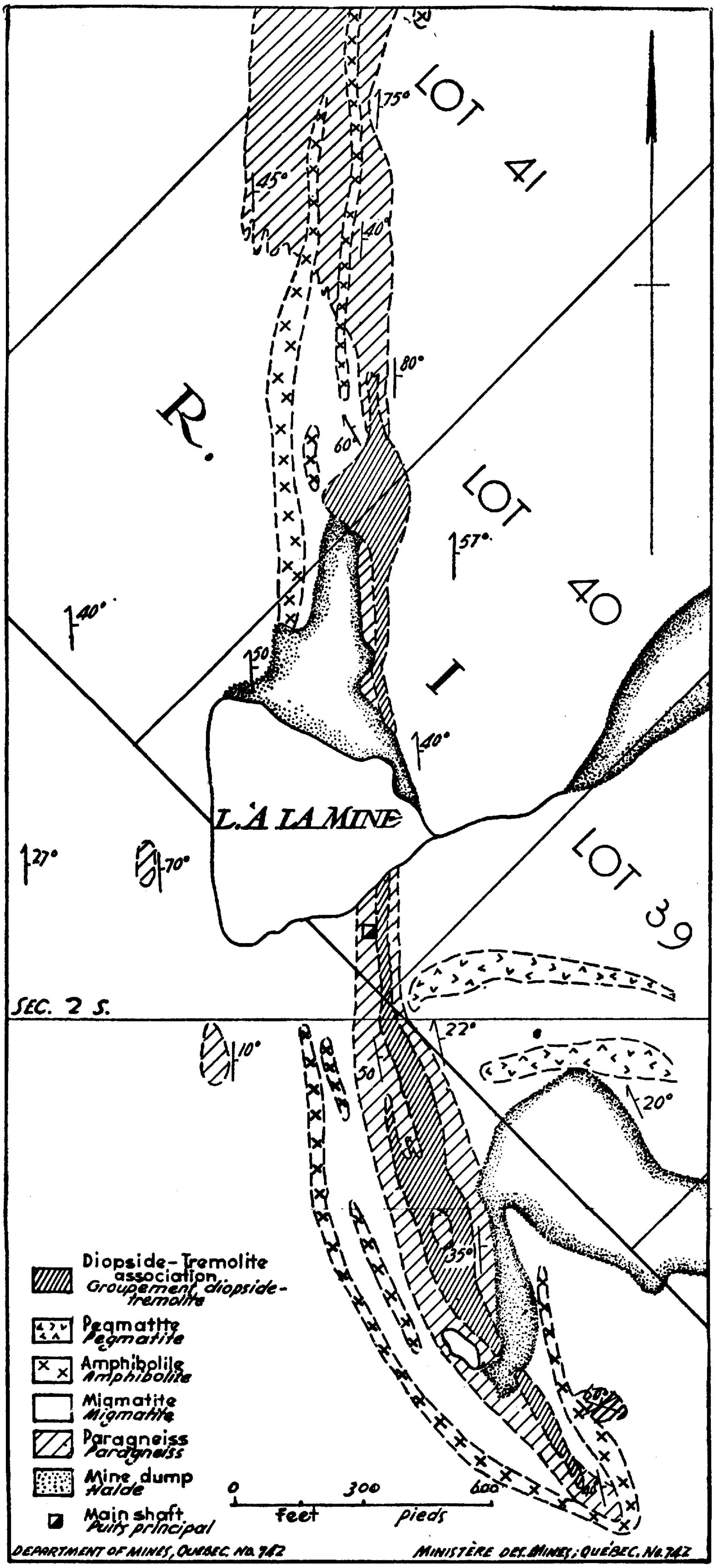
Following the discovery of zinc-lead mineralization here in 1910, the property was acquired by Pierre Tétreault. With some interruptions, mining was carried on by Mr. Tétreault (or by the Pierre Tétreault Estate) and by lessors until 1937. Lessors were the Zinc Company, Limited, subsidiary of the Weedon Mining Company, Limited, who operated the mine, a 200-ton concentrating mill, and a roasting plant at Notre-Dame-des-Anges for production of zinc oxide, from 1914 until 1921; and the British Metal Corporation (Canada), Limited, who held a lease on the property from 1924 until the end of 1929. The latter Company was successful in developing a large tonnage of ore northward from previous workings at the main shaft. Also, the mill was enlarged, and the flow-sheet was changed from gravity concentration, employed up to that time, to differential flotation. In 1927, it was reported that the mill was treating 450 to 500 tons per day of run-of-mine ore carrying approximately 9 per cent zinc, 3 per cent lead, and 0.09 oz. gold and 8.3 oz. silver per ton (Staff, B. M. Corp'n, p. 278).

It has been estimated that, from the commencement of operations until their suspension in 1937, production of ore totalled 1,100,000 tons, and that the concentrates shipped contained 120,000,000 lb. zinc and 40,000,000 lb. lead.

In 1942, the mine was re-opened by Siscoe Metals, Limited, subsidiary of Siscoe Gold Mines, Limited, and was operated as a war measure under the supervision of Wartime Metals Corporation until May, 1944. The property was then returned to the Pierre Tétreault Estate.

The deposits have been developed and mined from two shafts. The main shaft, which is about midway along the length of the ore zone, has a depth of 600 feet, with workings on six levels. The other, 1,000 feet to the north, is 100 feet deep.

The property is underlain by rocks of the Grenville series (Figure 76). The orebodies occur in a narrow, northerly trending, lens-like band of crystalline limestone, now metamorphosed largely to tremolite. Actually, at the surface, there are two lenses of this rock, separated along their line of strike by a lake (Mine lake), about 600 feet wide. The overall length of the band is 3,000 feet. At the surface, the south lens has a width of some 130 feet over much of its length and tapers both to north and south. The north lens is in general narrower, but it widens to 200 feet in its central part. Flanking this band on both sides and bounding it on the north and south



Geology in vicinity of TÉTREAULT MINE.

Géologie au voisinage de la MINE TÉTREAULT.

Fig. 76

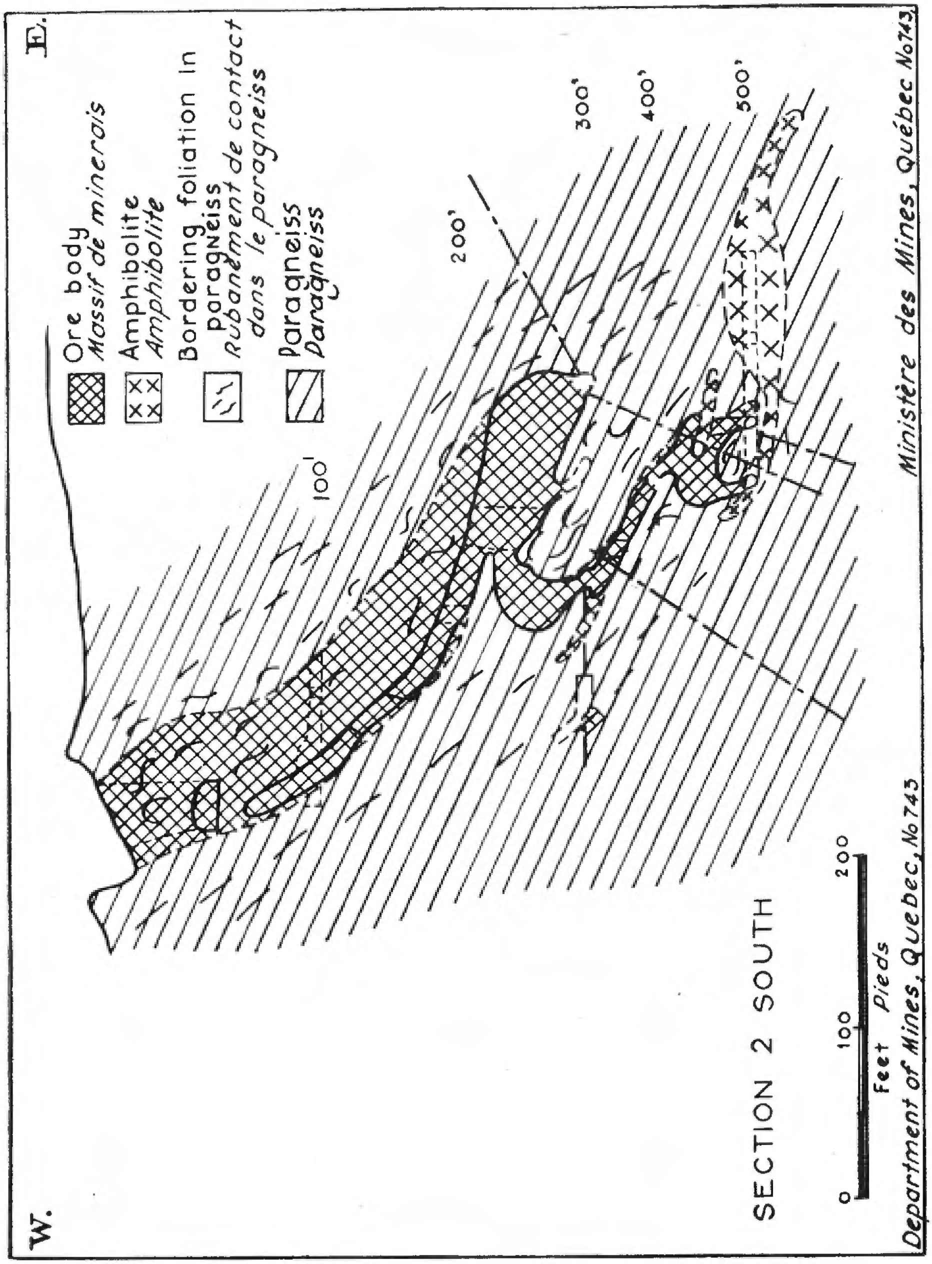


FIGURE 77.—*Vertical section through Tétreault orebody.* Ore, cross-ruled; bordering foliation in paragneisses indicated in broken lines; amphibolite, crosses. (Dept. of Mines, Que., P.R. 136, "Tétreault Mine", 1939).

are paragneisses, which conformably underlie the limestone. These include quartz-biotite and quartz-hornblende-biotite types, some containing garnet and, more rarely, sillimanite and cordierite, and in many places they are injected by much granitic material and are now typical migmatites. A rusty weathered surface is common, due to oxidation of disseminated pyrite and pyrrhotite.

The trend of the foliation, which appears to be also the strike of the original bedding, is approximately north-south, with a swing somewhat east of south in the south limestone lens. The dip is eastward. O'Neill and Osborne interpret the structure as a syncline, with the limestone beds at its central part (p. 12), or as the western, crumpled limb of a much larger syncline (p. 8).

Some 200 feet west of the limestone band, and paralleling it throughout its length, is a dyke or sill of amphibolite, sixty feet wide in places, and a similar but narrower dyke lies between it and the limestone. Their intrusive nature is evident since they send offshoots into the adjacent gneisses and in places hold inclusions of the gneiss.

Much of the surrounding district is underlain by granite or granodiorite, and lobes of a granite batholith approach within two miles of the property on its north and east sides. On the property itself, two small bosses of pegmatite, containing abundant tourmaline and also garnet, intrude the gneisses immediately east of the south limestone lens, near its north end. These have an east-west trend and are some 400 feet long and up to 90 feet wide. There appears no doubt that they are genetically related to the large batholith nearby, and it is considered probable that the ore-bearing solutions that formed the deposits were derived from the same source. The solutions presumably ascended along one or more north-trending faults, of which there are indications in the area, and replaced the limestone rather than the more quartzose and argillaceous beds represented by the gneisses.

The limestone apparently does not extend below the 600-foot level, and there the ore bottoms. If the limestone is a remnant in the trough of a syncline, there would appear little likelihood of ore occurring at greater depth. If, however, it is resting on the crumpled western limb of a large syncline, there is a possibility that it, with its accompanying mineralization, may again be present at greater depth. In this connection, it may be noted that some diamond-drill holes put down to test conditions below the 600-foot horizon failed to encounter mineralization of interest. On the other hand, subsequent drilling did indicate that, slightly west of the orebody, ore or near-ore occurs between the 500- and 600-foot horizons over a length from 900 feet to 1,200 feet north of the main shaft. The drilling data suggest a series of parallel lenses lying one above another and dipping 45° east. The possible importance of this mineralization remains to be determined (Osborne).

Individual orebodies were relatively small and lenticular, with pinching and swelling along their length, both laterally and vertically. The mineralization was found to be fairly uniform along the footwall side, with gradually decreasing dissemination toward the hanging-wall side. Also, it was reported that the richest ore occurred where the alteration of the limestone was most pronounced, and *vice versa*.

The ore is of two types: sphalerite (marmatite) with small amounts of other sulphides, and a complex ore consisting of a fine grained, intimate mixture of sphalerite, galena, pyrrhotite, and minor pyrite and chalcopyrite. Other sulphide minerals present locally, and then in very small amount, include tetrahedrite, stibnite, molybdenite, and arsenopyrite. Electrum and native silver have been reported and account for at least a part of the gold and the silver content of the ore. From their study of polished sections, O'Neill and Osborne concluded that the order of deposition of the sulphides, from oldest to youngest, was: pyrrhotite, chalcopyrite, sphalerite, galena. Gangue minerals, in addition to calcite and tremolite, include anthophyllite, diopside, phlogopite, and, in lesser amount, anorthite, epidote, garnet, scapolite, wilsonite, titanite, and apatite. This assemblage indicates that the deposit is of the high-temperature type.

Ore Occurrences in Vicinity of Tétreault Mine

Montauban Mining Syndicate, Limited.—During 1914-15, this Company investigated occurrences of zinc and lead sulphide mineralization in lots 43 to 45, range I of Montauban township, about three-quarters of a mile northeast of the Tétreault mine. The rocks he e are chiefly dark grey mica paragneisses. Over a width of 300 feet in a band of these gneisses containing garnet and cordierite there are a number of lenticular veins composed of sphalerite, with much less galena, chalcopyrite, and pyrrhotite, and a little pyrite, and some narrow bands in the gneiss are irregularly mineralized with these sulphides. The veins pinch and swell, with the observed maximum width about three feet. Some are only a few feet long, and no vein exceeding 120 feet in length has been recorded. The mineralization was explored in test pits and from two shafts, one 34 feet deep and the other 50 feet with a winze extending to a further depth of 56 feet. A considerable amount of lateral work was carried out from the latter shaft, but no commercial body of ore was encountered (Bancroft, pp. 133-136).

Laurentide Mining Company, Limited.—The mineralization investigated by this Company is in lots 6 to 8 on either side of range-line IV-V, Montauban township, about one mile southwest of Montauban village and three and a quarter miles north of east of the Tétreault mine. It is in a band of quartz-biotite gneiss that lies between quartzites and a batholith of gneissoid granodiorite that occupies a wide area to the south and east. The veins are similar in composition and in character to those on the Montauban property. They have been explored on the surface and by a very limited amount of underground work from two shafts, 30 feet and 62 feet deep, but the results of this work apparently were not encouraging (Bancroft, pp. 139-141).

Gaspé

Zinc and lead mineralization has been found at numerous localities in Gaspé, but apart from some deposits in Lemieux township, which are described briefly below, the individual occurrences appear to be of very limited extent. They are chiefly of interest as indicating that mineralization of this type is fairly widespread in the peninsula and by reason of the possibility that, in some places, more intensive exploration might reveal deposits of commercial size. These occurrences have been described in various annual reports of the Quebec Department of Mines and particularly by I. W. Jones in the reports for the years 1932 and 1933, and in reports by F. J. Alcock, of the Geological Survey of Canada. The following description of the deposits in Lemieux township is based on a summary furnished by Dr. Alcock.

Lemieux Township

Occurrences of sphalerite and galena in the central part of Gaspé peninsula have attracted a great deal of attention since 1909. Most of these are within an area of some twenty square miles at the headquarters of Berry Mountain and Brandy brooks, tributaries of Cascapedia river. A large amount of prospecting, exploration, and development has been done in this vicinity, particularly during the years 1925-30 and 1937-38. This has included very extensive stripping and trenching and the sinking of four shafts, one to a depth of 257 feet, from which lateral work in excess of 3,000 feet has been carried out. The region is of high relief, and in some places trenching at various levels has indicated that the mineralization extends through a vertical distance of 500 feet. A considerable part of this mineralized area is held by the *Federal Zinc and Lead Company, Limited,* and associated interests.

The rocks of the region are of Devonian age. They comprise, from older to younger, a series of limestone and argillaceous beds, with some quartzite and volcanic tuff, known as the Gaspé Limestone series (Lower Devonian); volcanic flows, ranging in composition from intermediate to basic; and a series of sandstones, with some shale and conglomerate, known as the Gaspé Sandstone series (Middle Devonian). The beds are for the most part horizontal, or nearly so. Intruding the Lower Devonian beds are dykes and stocks of syenite, and dykes of porphyry. These have not been observed cutting the Gaspé sandstones. Their time of intrusion was thus late Lower Devonian or early Middle Devonian. They are believed to be outliers of, or generically related to, the granite which outcrops extensively in Hogsback and Tabletop mountains to the north of the area.

The zinc and lead deposits occur in the Lower Devonian limestones, argillites, and tuffs in the form of veins and in brecciated zones along fault and shear planes. The veins contain fragments, having all sizes and shapes, of the country rock. They are younger than the syenite intrusions and in places are seen cutting these or closely following their contact with the sedimentary rocks. Many of the veins strike northeast, but some have a more northerly or even a northwesterly trend. Their dip is steep, usually above 70°.

The vein minerals are chiefly sphalerite and galena, in a gangue of quartz and carbonate. Locally, and notably in the general vicinity of Brandy brook, the veins contain also a considerable amount of chalcopyrite. Less common, and in small amount only, are pyrite and marcasite.

As a rule, sphalerite is more abundant than galena. It has a pale, honey-yellow colour, being practically free from iron.

The vein quartz is of two types, white and amethystine, the latter commonly showing 'comb' structure. The carbonate, which is dolomite or pale yellow ankerite, is intimately associated with the white quartz. The presence of parallel sets of quartz bands along the walls of some of the veins, and of bands with central comb structure, shows that movements took place during the period of mineralization, causing successive reopening of the veins.

The deposits are believed to be genetically related to the deep-seated intrusive rocks of the region. The syenite and porphyry dykes and masses represent early differentiates of the granite batholith which outcrops north of the area and almost certainly extends beneath it. During the late stages of crystallization of the magma, siliceous sulphide-bearing solutions from the still molten part of the intrusion travelled along lines of fracture for considerable distances and deposited their sulphide and silica content along these fracture planes and brecciated zones. Fractures along which dykes had already been intruded were locally reopened and, even after vein deposition ceased, further faulting took place. Practically all the deposits are the result of the filling of cavities, but, where limestone is the country rock, there is local evidence of some replacement.

The region has, for the most part, a heavy overburden of soil and weathered rock, so that a great deal of work is necessary before it will be possible to determine the length, width, and average grade of the veins. A great number of veins have already been found. Some are known to be hundreds of feet in length and up to more than forty feet in width. The amount of ore in the several veins, and at different places along individual veins, varies greatly. In places, there are large masses of practically solid sphalerite and galena; in others, the sulphides are sparsely scattered through the gangue minerals. Assays indicate that the gold and silver content of the ore is negligible.

Marsoui River and Vicinity

In 1916, some occurrences of sphalerite and galena, with a little chalcopyrite, were discovered near the headwaters of Marsoui river, about thirteen miles inland by trail from the Saint-Lawrence shore. The sulphides occur in narrow, discontinuous quartz veinlets in much disturbed slates and limestones of Ordovician age. No intrusive rocks are exposed in the vicinity, but the large granite mass of Tabletop mountains, and the basic intrusion of Mount Albert, are only a few miles distant to the south. These occurrences were investigated by a limited amount of surface work during the years 1932 to 1936 (Jones, 1933, pp. 44-51; 1934, pp. 32-38).

Gaspé Bay Area

This area is of historical interest since, at least as early as 1665, attempts were made to obtain lead and silver from deposits along the shore of Gaspé bay. In recent years, some surface work has been done on occurrences of sphalerite and galena at five or six points near the northeast side of the bay, and at a number of localities in York and other townships on the southeast side, these latter being spread over a length of about thirty-five miles along a zone trending northwestward. The mineralization occurs in veins and brecciated zones in Lower Devonian (Gaspé) limestone near its contact with the overlying Gaspé Sandstone series. Thus, in their mode of occurrence, the veins resemble those in Lemieux township, but the known occurrences are much too small to be of commercial interest (Jones, 1933, pp. 35-43).

Cross Point, Chaleur Bay

Cross point is on the south coast of Gaspé peninsula, near the head of Chaleur bay, opposite the town of Campbellton, New Brunswick. Claims were staked here in 1927 following the discovery of argentiferous galena in lot 1, Restigouche range, Mann township. The galena occurs as a replacement, chiefly along fractures, in Lower Devonian volcanic rock of intermediate composition (andesite). Widths up to nine inches have been exposed, with the best material occurring at intersections of fractures. The occurrence has been investigated by trenching, from an open cut, and by some diamond drilling, but the results of this work did not prove encouraging (Alcock, 1930, pp. 107-109).

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INDUSTRIAL MINERALS

ASBESTOS

(See Volume II, pp. 413-443)

Asbestos has been one of the principal mineral products of the Province for the past sixty years. For nearly two-thirds of that period it was the leading mineral in value of production, in employment of services, and in consumption of supplies for mining. It maintained its premier position until 1930, and since 1934 has ranked second only to gold. In 1946 asbestos again reached first place. The whole of the production has come from deposits in the Eastern Townships, and it may be said that the large-scale industrial use of asbestos is entirely an outgrowth of the development of these deposits, which dates from 1878. For many years they were the source of almost the whole of the world's supply of the mineral and they continue to furnish more than the combined production of all other countries.

Eastern Townships

The occurrence of asbestos in the Eastern Townships was mentioned by Logan in the *Report of Progress* of the Geological Survey of Canada for 1847. Apparently, the deposits received little serious attention until 1876, when there was production of a small amount of asbestos from veins on lot 21, range VI of Melbourne township. Between 1877 and 1879, more extensive deposits of asbestos of excellent quality were found in Thetford township, first on lot 27, range VI, on timber lands held by the Johnson Bros., then on lot 27, range V, and on lot 26, ranges V and VI, where pits were opened that became the Bell and King mines, respectively; and, at about the same time, other deposits were discovered nearly forty miles to the southwest, on lot 9, range III of Shipton township, where the Jeffrey mine is now situated, near the town of Asbestos. All of these mines have been in continuous production since that time. As the years passed, asbestos veins were found at numerous other localities along the Serpentine belt in this general district and many dozens of pits have been operated for production of asbestos.

Progress of the industry was at first slow, and it was not until 1896 that annual shipments exceeded 10,000 tons. In 1910, they had risen to more than 100,000 tons, in 1929 they were in excess of 300,000 tons, and for each of the years 1940 to 1944 they averaged more than 450,000 tons. Altogether, to the end of 1944, the mines of the district had produced well over nine million tons of asbestos. The asbestos recovered represents approximately 5½ per cent of the weight of the rock mined. Thus the amount of rock removed from the mines and pits each year is not far below seven million tons, and since the commencement of operations, it has amounted to about one hundred and sixty million tons. As a consequence, enormous dumps of mill tailings and waste rock have accumulated, for which, up to the present, no use has been found except, in recent years, for surface fill at the mines where the block-caving system of mining is employed. However, research has long been in progress and eventually some use for this material may be found.

The deposits occur in the Serpentine belt, the rocks of which, and also the physical and chemical character of the asbestos and its mode of occurrence and origin, are discussed in Volume II (pp. 413-443). The asbestos is the variety chrysotile, or serpentine-asbestos. It occurs most frequently in veins of 'cross fibre', in which the tightly compacted, but easily separable, silk-like threads lie about at right-angles to the vein walls, and in that case the width of the veins determines the length of the fibre; but some, and particularly in the northern part of the district, in Broughton township, is of the type known as 'slip fibre', in which thin layers of overlapping fibres lie along the faces of fracture or slip planes traversing the serpentinized rock. As seen in the cross-fibre veins, the asbestos appears pale sea-green in colour, but the 'fluffed' fibre is pure white, and the minutely fibrous to almost powdery material has a slightly greyish tinge. Veins up to an inch or so in width are not uncommon, and rarely they are several inches wide.

For the purpose of marketing, the Quebec asbestos fibre is carefully prepared according to a standardized classification, based mainly on the length of the fibre. It is graded into seven subdivisions, designated from '*No. 1 Crude*', consisting of hand-selected cross-vein material, three-quarters of an inch and more in length of fibre, which brings the highest price (quoted $700 to $800 a ton in 1946), down to '*Paper Stock Milled Fibre*' ($40 to $50) and '*Shorts*' ($15 to $30). Intermediate grades are called '*No. 2 Crude*'; '*Milled Spinning or Textile Fibre*'; '*Shingle Fibre*'. The No. 1 and No. 2 Crude constitute only a very small fraction of the total tonnage of the fibre shipped, which in 1946 amounted to over half a million tons (Mining Ind. Prov. of Que. in 1946, pp. 25 and 26).

Most of the commercial deposits, and the main producing mines, are in what are known as the Thetford-Black Lake and the Shipton-Tingwick districts, the latter some forty miles southwest of Thetford Mines. The first named district embraces contiguous parts of the townships of Thetford, Coleraine, Wolfestown, and Ireland; the second consists of Shipton township and the southwest part of Tingwick. There are also important asbestos mines in Broughton township, which adjoins Thetford on the northeast. In these three areas, there have been shipments at one time or another from dozens of pits, but in recent years production has come from only ten or twelve. The others are idle, not because of exhaustion of the asbestos, but for a variety of other reasons. Some have reached the limit in depth at which mining can be carried on, profitably, from open-cast workings; others are the property of one or other of the larger mining companies who hold them in reserve while mining more conveniently situated deposits. Thus, one of the operating companies is a consolidation of seventy-eight organizations which, at various times, controlled and operated thirty mines.

In the early years of the industry, all mining was carried on in open pits, and even today a very substantial percentage of the total output comes from open-cast workings. In some of the larger operations, the pits have grown to enormous size and have attained considerable depth. For economic and other reasons, mining at two properties is now carried on entirely from underground workings beneath the floor of the open pits, and a similar change in system of mining is being introduced at a third property. Mills for recovery of the asbestos from the rock are situated conveniently near the several mines and pits.

The principal operating companies at the present time are as follows:

Asbestos Corporation, Limited.—Currently, this Company is operating four mines. Production is chiefly from the King mine, on lot 26, ranges V and VI of Thetford township. Since 1932, production has come entirely from underground workings, employing the block-caving system. The other three mines are open pit operations. They are the Beaver and Bennett-Martin, on lots 31 and 32, range *C*, Coleraine; the British Canadian, on block *A*, Coleraine; and the Vimy Ridge, on lots 23, 24, and 25, range III, Ireland.

Bell Asbestos Mines, Limited.—The Bell mine is on the northeast half of lot 27, range V, Thetford township. This is an open pit, with some underground workings. The ore is hauled by trucks from the floor of the pit direct to the surface crusher bin by way of an inclined road.

Johnson's Company.—The main mine of this Company is on lot 27, range VI, Thetford township. It is an underground operation, employing the block-caving system. The Company also operates an open-pit mine at Black Lake, on lots 29, 30, and 31, range *B*, Coleraine township.

Canadian Johns-Manville Company, Limited.—The Jeffrey mine of this Company is on lots 8 and 9, range III of Shipton township. This is an open-pit operation. The rock is quarried in benches, loaded on cars by mechanical shovels, and conveyed in trains of cars to the surface crusher bins. In 1944, plans were completed for changing from open pit to underground mining, and shaft sinking had conmmeced. The block caving system will be employed.

Nicolet Asbestos Mines, Limited.—The Nicolet property is on lots 20 and 21, range XI of Tingwick township, about five and a half miles northeast of the Jeffrey mine. The workings are open cast. An electric hoist hauls the rock up an inclined way from the floor of the pit to the crusher bin.

Quebec Asbestos Corporation, Limited.—This Company operates an open-pit mine on lot 13, range IX of Broughton township. In 1944, preparations were made for the opening of another pit, on lot 14*b*, range VI.

Detailed descriptions of the operations of these and other companies are given in the report by J. G. Ross on *Chrysotile Asbestos in Canada*, published by the Mines Branch, Department of Mines, Ottawa, in 1931.

There are numerous other occurrences of asbestos in the district upon which a certain amount of development work has been done but which, up to the present, have not become producers. These are chiefly in the townships of (from southwest to northeast) Cleveland, Shipton, Tingwick, Ham, Adstock, Leeds, Broughton, Tring, Rigaud-Vaudreuil seigniory, Cranbourne, and Talon. They were examined in 1929 by Bertrand T. Denis and are described in Part *D* of the annual report of the Bureau of Mines for 1930.

Far to the northeast, veins of cross-fibre asbestos have been reported in serpentinized peridotite on lots 10 and 11, range IV, Awantjish township, and in Gaspé peninsula on mount Serpentine near Dartmouth river, and near Port Daniel river.

Ottawa River Valley

Occurrences of chrysotile asbestos in the Ottawa River valley have also attracted attention. In many places, serpentine is found as lenses and bands up to several hundred feet in length and fifty feet wide in the crystalline Grenville limestones, where these have been invaded by gabbroic or other intrusive rocks. The serpentine here has been formed from the limestone by reaction with magnesia and silica bearing solutions that emanated from the intrusive rocks. Locally, the massive serpentine is traversed by veins of cross-fibre asbestos, but these have nowhere been found in sufficient number to be of economic importance. It is of interest to note, however, that in 1942 and 1943 a few tons of asbestos was recovered from such veins in a mass of serpentine which is included in the magnesitic-dolomite orebody at the mine of *Canadian Refractories, Limited,* on lot 15, range IX, Grenville township.

Northern and Western Quebec

Asbestos Island, Chibougamau Lake.—In the first decade of the century, veins of chrysotile asbestos were discovered in serpentinized peridotite on Asbestos island, which is near the north shore of McKenzie bay at the extreme north end of Chibougamau lake, in Roy township, Abitibi-East county. Veins were also reported in similar rock along the shores of Bourbeau and Gwillim lakes, in McKenzie township, which adjoins Roy on the west. About that time, exploration was very active in the 'Chibougamau region', and there were highly optimistic reports not only of asbestos but of gold, copper, and magnetite deposits. In 1910, the Quebec Legislature appointed the Chibougamau Mining Commission, with A. E. Barlow as chairman, to visit the area and report on these discoveries. The Commission found that a considerable amount of development work had been done on Asbestos island, but with disappointing results.

Destor Township, Abitibi-West County.—A considerable amount of development work, which included much rock-trenching and some diamond drilling, was done during the years 1938-40 on a group of asbestos claims in lots 36 to 40, ranges V and VI of Destor township. Both cross fibre and slip fibre occur here in a wide body of serpentinized peridotite. In the face of one pit, forty-three inches wide, Bannerman, (pp. 26-27) counted nineteen veins of cross fibre, ten of which were less than one-eighth of an inch wide, seven were one-eighth of an inch, and two were between one-eighth and five-eighths of an inch. He estimated that the rock contained about five per cent of asbestos. In some of the other pits he found a larger proportion of the wider veins, but they were widely spaced.

Gaboury Township, Témiscamingue County.—Some surface work has been done on asbestos prospects in the vicinity of McKenzie lake, in range VII, Gaboury township (see p. 311). Both cross fibre and slip fibre occur here in serpentinized peridotite, a small stock of which intrudes Keewatin-type volcanic rocks. The cross-fibre veins are very narrow and discontinuous, and the fibre is somewhat harsh. The slip fibre crumbles when rubbed between the fingers (Denis, T. C., p. 25; Retty. p, 75).

Duhamel Township, Témiscamingue County.—On the west half of lot 28, range VII, of Duhamel township, a boss of serpentinized rock, about 100 feet by 125 feet in area, rises ten feet above the surrounding clay overburden. In places, the rock is traversed by strings of asbestos, either slip fibre or much deformed veins. The fibres are strong, highly flexible, and white when fluffed. The occurrence has been explored by a pit, sunk to a depth of about twenty-five feet, by some shallow rock cuts, and by 100 feet of trenching through the overburden to bed-rock. The quantity of asbestos in sight is too small to be of economic interest, but the true dimensions of the body of serpentinized rock are concealed by the surrounding clay (J. A. Dresser, personal communication).

Status and Future of the Industry

The United States produces very little asbestos — less than five per cent of the domestic needs — but consumes far more asbestos than any other country. The proximity of the largest producer to the largest consumer is an outstanding benefit to both countries. Transportation conditions between them are naturally favourable, both as to distance and facilities, whether by rail, coast-wise shipping, or inland waters. Thanks to the St. Lawrence, Quebec also has access to industrial centres of western Europe that compare favourably with that of other asbestos-producing countries — chiefly Russia and South Africa.

It should be pointed out that, in a great many of the very diverse manufactures in which asbestos is used, it does not form the main body of the fabric produced. Thus, in so-called asbestos shingles and insulating materials, it comprises perhaps not more than 15 per cent of the material, in which it plays the part merely of a fire-proof binder. As a consequence, it is usually found more economical to manufacture such products at or near the place of use.

Canada's needs for asbestos products are adequately supplied by manufacturers in the Province, but they account for only about five per cent of the total production. All the rest is exported in the raw state, about one-half of it going to the United States, with Great Britain as the next largest purchaser.

In the matter of transport, the grade, or value, of the material is of evident importance. 'Crude' asbestos of suitable length and hand-picked commands a high price that enables it to be shipped to any market. Milled fibre, on the other hand, is of very much less value, but is used in vastly greater quantity. There are, therefore, two classes of material to be considered under the question of transport: 'crude', in small amount, with a wide shipping radius; and milled asbestos, in large volume and having a more limited radius within which it can be profitably shipped. Thus, the United States imports a large tonnage of crude asbestos from Africa, but obtains the whole of its requirements in milled fibres from the nearby Quebec producers (see Table I). The importance in finding a market for milled fibre will be evident from the figures in Table II, giving the relative amount, and also value, of crude and milled asbestos shipped from Quebec mines during the period 1903-29 (Ross, p. 60).

TABLE I.—UNITED STATES IMPORTS OF UNMANUFACTURED ASBESTOS, 1944

COUNTRY OF ORIGIN	CRUDE	MILL FIBRES	SHORT FIBRES	TOTAL
Africa	27,162 tons $3,382,807	———	———	27,162 tons $3,382,807
Canada	1,528 tons $564,545	145,791 tons $9,757,627	205,928 tons $4,720,939	353,247 tons $15,043,111

TABLE II.—SHIPMENTS OF CRUDE AND MILLED ASBESTOS FROM QUEBEC MINES, 1903-1929

CLASSIFICATION	TOTAL SHIPMENTS	% OF TOTAL TONNAGE SHIPPED	% OF TOTAL VALUE OF ASBESTOS SHIPPED
Crude fibre	114,096 tons	3 per cent	21.5 per cent
Milled fibre	3,676,426 "	97 " "	78.5 " "

Although the distance from the most southerly to the most northerly asbestos mine in the Eastern Townships is somewhat more than fifty miles, the combined area of the properties of the principal mining companies is probably not more than twenty square miles, and actual mining operations are confined to but a small part of this. All the rock exposed along these productive sections of the Serpentine belt that appear favourable to the occurrence of asbestos in commercial amount have been pretty thoroughly prospected in the course of the sixty to seventy years that mining has been carried on, but though it is unlikely that any extensive outcropping deposits have been overlooked in this search, this does not necessarily mean that there are no concealed deposits awaiting discovery. Many of the open pits that are now, or that have been, productive are on ground that was drift covered when the quarries were begun, and further stripping of overburden, as well as diamond drilling, around the margins of the pits, shows, in many cases, that asbestos-bearing rock continues beyond the pit limits. Thus there are distinct possibilities that additional deposits of commercial grade, at present hidden beneath overburden, may be discovered in the district.

There seems to be no record of any important asbestos deposit having failed in productiveness at depth. Where operation of an open pit has been discontinued, as it has been in many instances, this has been because of physical difficulties of operating such workings profitably beyond a certain depth, because of the structure and attitude of the deposits, or because the deposits are being held in reserve.

In general, the asbestos deposits and the serpentinized rocks in which they occur are tabular bodies, and they are very rarely if ever horizontal. They most frequently dip toward the southeast at about 60° (50° to 80°). This also is the attitude of the adjacent sedimentary rocks, which were subjected to folding prior to their intrusion by the peridotite and related rocks of the Serpentine belt. As a consequence, when a pit is opened in such a deposit, it becomes progressively narrower with depth. On the one side, the pit wall follows the footwall of the 'orebody', on the other it must, for safety reasons, be maintained more or less vertical. At some depth, the only ore remaining in sight will be beyond the limits of the pit, beneath the hanging wall of the orebody, where it cannot safely be recovered by open-cast mining. Hence the change from open-pit operation to underground mining by the block caving system at three of the largest mines. At the King mine, the first to adopt this method, development was being carried on in 1944 at a depth of 900 feet, and the loading pocket was at the 1,000 foot-horizon. At this depth, there is apparently no diminution in grade of the ore as compared with that mined at the upper levels or in the open pit. Diamond drilling to still greater depths at this and other properties gives no indication of reduced quality or quantity of ore. Consequently, large reserves at depth, in bodies large enough to be profitably mined underground, seem assured.

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BARITE

No large deposits of barite are known in Quebec, but the mineral has been found in several localities along the Ottawa River valley, in the counties of Papineau, Gatineau, and Pontiac, and from one of these there was an annual output of a thousand tons or less for a few years about 1890-1900. The following notes on these occurrences are summarized from descriptions by Spence (pp. 55-60).

Papineau County

Lot 21, Range IV, Buckingham Township.—Barite, with considerable galena and lesser sphalerite, occurs here in six or more parallel veins in Grenville crystalline limestone. The veins are spaced over a width of about

100 feet and have been explored in a number of pits, and at one point in a shaft 40 feet deep, over a length of 250 feet. Individual veins, as exposed, rarely exceed twelve inches in width. The work on this property was done many years ago, with the galena as the chief, or only, mineral of interest. There is no record of any barite having been shipped. An analysis of the barite is given in the accompanying table.

Lot 22, Range V, Buckingham Township.—Importing Corporation Montreal, Limited, did some development on a sphalerite-bearing deposit of barite on this lot in 1941 and shipped seven tons of the material for experimental purposes.

Templeton Township.—Some surface work has been done on barite deposits at three localities in this township: on the east half of lot 11, range VI, on lot 12, range XII, and on the north half of lot 13, range XIII. These occurrences are of no economic importance.

Gatineau County

Lot 7, Range X, Hull Township.—On this property, which is on the east side of Gatineau river, about five miles by road from Ironside station on the Gatineau Valley branch of the Canadian Pacific railway, a vein of white barite, with average width of three feet, traverses Grenville limestone. Many years ago, a pit or rock trench, three to four feet wide and reported to be sixty feet deep, was opened along the vein for a length of 350 feet, and a considerable tonnage of barite was taken out. The last shipments were made by the Canada Paint Company, about 1900. An analysis of the barite is given in the table below. Barite has been reported in this township also on lot 3, range XI, and on lot 4, range XII.

Pontiac County

Lot 12, Range III, Onslow Township.—On this property, which is close to the village of Quyon, a few small pits have been opened in a series of parallel veins of barite traversing Ordovician limestone. Most of the veins are mere stringers, and the largest is not more than twelve inches wide. They are exposed at intervals over a distance of 500 feet. Pale green fluorite is present in considerable amount in the wider portions of the veins. An analysis of the barite is given in the table below.

The barite occurs here on lots 9 to 14. In 1941, some 100 tons was reported to have been mined and sold to the *Pigments and Chemical Company, Montreal.*

Kamouraska County

Lots 34 and 47, range VI, Woodbridge township.—In 1942 some development work was done on barite deposits in these two lots. Analyses of samples, submitted by the owner, are given in the table. The barite occurs here in thin veins. (Hugh S. Spence, personal communication).

Gaspé Peninsula

Barite occurs in veins cutting limestone at Port Daniel, and along streams flowing into Gaspé basin, Bonaventure county.

ANALYSES OF BARITE

	BUCKINGHAM	HULL	ONSLOW	WOODBRIDGE	
	Lot 21, range IV (1)	Lot 7, range X (2)	Lot 12, range III (3)	Lot 34, range VI (4)	Lot 47, range VI (5)
$BaSO_4$	93.51	71.96	92.59	98.11	98.18
$SrSO_4$	1.00	2.70	1.50	....	....
$CaSO_4$	....	14.57	4.50	....	....
$CaCO_3$	3.57	9.46	....	....	....
CaO	....	....	....	Tr.	Tr.
MgO	....	....	....	0.01	0.01
SiO_2	....	....	....	0.56	0.57
P_2O_5	....	....	....	0.06	0.05

(1), (2), (3)—Analyses by Mines Branch, Dept. of Mines, Ottawa, of samples taken by an officer of the Branch to represent average ore.
(4), (5)—Analyses made in Quebec laboratories of Quebec Dept. of Mines of samples submitted by owner of deposit.

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FELDSPAR

There has been production of feldspar from Quebec deposits since 1889, when a few hundred tons of high-grade 'dental spar' were shipped to England and the United States from the Villeneuve mine on lots 31 and 32, range I of Villeneuve township (Ells, p. 158). Shipments continued from this, and from other deposits in the vicinity of Lièvre river, but they were small, with none at all in some years, until 1921, when large-scale production commenced at the Derry mine, on lot 8, range I of Derry township. This mine has been in continuous production since that time and has shipped well over 100,000 tons of feldspar. In 1924, the Wallingford mine, two miles from the Derry, was opened, and two years later the Cameron, or New York, mine, on lots 27 and 28, range IX of Buckingham township, commenced production. In recent years Quebec's output of feldspar has come chiefly from these three mines, with minor shipments each year from eight to ten other properties. Total production to the end of 1944 has been about 300,000 tons. Shipments have fluctuated widely from year to year, but in the three years 1942-44 they averaged more than 17,000 tons per year, with a record output of 17,842 tons in 1944.

In the report on *Feldspar* by Hugh S. Spence, published by the Mines Branch, Department of Mines, Ottawa, in 1932, fifty-eight feldspar mines or deposits in Quebec are described, and there have been shipments at one time or another from all but seven of these. Forty-three of them are in Papineau county, in the vicinity of Lièvre river, in the townships of Buckingham, Derry, Portland, and Templeton, and nearly all of these are within twenty miles of the town of Buckingham. Most of the other deposits are a short distance to the southwest, chiefly in the vicinity of Gatineau river.

All of these deposits have been worked as open pits or quarries, but at the Derry and Wallingford mines there are also extensive underground workings. Until 1930, the whole of the output was exported in the crude state, but in that year the *Canadian Flint and Spar Company, Limited,* who operate some of the largest producing mines, completed the erection of a mill at Buckingham for grinding both feldspar and quartz, and since that time much of the output from the district has been shipped to this mill. Some, also, goes to the plant of *Bon Ami, Limited,* at Pointe-aux-Trembles, at the east end of the island of Montreal. The balance is exported in lump form, mainly to the United States, with some going to England, Malta, and Palestine.

In all these deposits, the feldspar occurs in pegmatitic dykes, many of which are upwards of a hundred feet wide and are exposed, or have been traced, along their strike for several hundreds of feet. Practically the whole of the feldspar mined is the high-potash variety, orthoclase or microcline, but from some of the deposits there is a small output of soda-feldspar, which occurs in the dykes either as separate bands or in intergrowth with the potash feldspar. The potash feldspar goes largely into the manufacture of glazes, enamels, pottery, and glass, and some of the very high grade material is marketed as dental spar.

Following are brief descriptions of the three principal mines, based chiefly on those given by Spence and by mine operators.

Derry Mine, Lot 8, Range I, Derry Township.—This mine is at the crest of a ridge of pegmatite that rises to a height of several hundred feet on the east bank of Lièvre river. The dyke has a width of 150 feet and an exposed length of 350 feet, and for a width of 50 feet along the west wall it consists largely of clean feldspar. In the early stages of operation it was worked by a succession of benches carried along the strike, and the pit attained an overall length of 325 feet, an average width of 70 feet, and a vertical depth of 150 feet. In 1926, an incline was sunk from the floor of the pit to a depth of 200 feet, and from the bottom of this a stope was opened upward to the pit floor. The feldspar is a buff-coloured, high-potash variety of high quality, some of it being of 'dental spar' grade. Production includes quartz as well as feldspar.

Wallingford, or Back, Mine, Lot 15, Range II, Derry Township.—On this property, a pegmatite dyke about 100 feet wide, dipping 45°S.W., is well exposed along a hillside for a length of 500 feet. The main commercial feldspar body is in the hanging-wall of the dyke and consists of an irregular mass, 250 feet long, that ranges in width from ten feet at the southeast end to fifty feet in the central section, beyond which it again narrows, A large body of quartz occupies the centre of the dyke. The walls consist of an intergrowth of feldspar, quartz, and mica crystals.

The deposit has been worked by open cut and also underground by a stope developed from drifts carried into the hillside at levels below the pit. In 1944, the dimensions of this stope were 275 feet by 85 feet high. Both feldspar and quartz are mined. In the past few years, the bulk of the feldspar output of the Province has come from this property.

New-York, or Cameron, Mine, Lots 27 and 28, Range IX, Buckingham Township.—A dyke of white pegmatite is exposed here for a width of 200 feet and a length, between extreme outcrops, of about 1,000 feet. It is worked by open pits, the largest of which, in 1944, had dimensions 300 feet by 85 feet by 88 feet deep. The feldspar is white and includes some soda-feldspar. The quartz in this dyke is confined chiefly to a zone along its east wall.

These three mines, which are respectively 10, 13, and 8 miles north of the village of Buckingham, have been owned, in past years, by various interests, and at the present time are all operated by the Canadian Flint and Spar Company, Limited. Their output of feldspar is all shipped to that Company's grinding plant at Buckingham. The quartz goes mainly to the Buckingham plant of the Electric Reduction Company, Limited, where it is used as a flux in the production of phosphorus.

Other mines in this district from which there have been shipments of feldspar in recent years include: the *Wakefield*, lot 28, range XIII, Templeton and the *Hart*, lots 6 and 7, range V, Portland West, both operated by the *Canadian Flint and Spar Company*; and the *Bigelow*, lot 16, range IX, Buckingham, and the *Lapointe*, lot 2, range V, Portland West, operated by *United Mining Industries, Limited.* In addition to the above may be mentioned the McArthur mine, on lots 47 and 48, range VIII, Aylwin township, a soda feldspar deposit operated by *Bon Ami Limited.*

Quetachou-Manicouagan Bay.—During the years 1923-25, a considerable amount of development work was done on feldspar deposits adjacent to the north shore of the gulf of St. Lawrence at Quetachou-Manicouagan bay, Saguenay county. This locality is some 500 miles below the city of Quebec and is due north of the central part of Anticosti island. On each side of the bay, Grenville rocks are intruded by a band, about one mile wide, of pegmatite, striking northeast, consisting essentially of quartz and feldspar, the latter chiefly microcline. Several thousand tons of feldspar were shipped in 1923 and 1924 (Erlenborn, pp. 107-111).

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GRAPHITE

There was a small production of graphite as early as 1846 from a deposit on lot 10, range V of Grenville township, Argenteuil county, but regular mining of the mineral apparently did not commence until 1866, when mines were opened by the *Lochaber Plumbago Company* on lot 24, range VIII, and on lots 23 and 24, range XI, of Lochaber township, Papineau county, their output being concentrated in a mill on lot 28, range X. Numerous other deposits were discovered about that time, particularly in Buckingham township, which adjoins Lochaber on the west, and from several of these production was more or less continuous until 1876. There was another period of activity in the decade 1888-99, following which nearly all the mines were closed until 1906. Production was then resumed or commenced at several properties, some of them equipped with concentrating mills, and continued until 1930. Apart from small shipments from stock-piles in the years 1933-35, there has been no production of graphite in the Province since that year. Although, at various periods, there have been shipments from two dozen or more mines, their collective output has been relatively small, amounting, during the period 1889-1930, to only 6,337 tons.

Early developments and mining operations are described in various reports of the Geological Survey of Canada, particularly those by Ells (pp. 134-139), Cole (pp. 63-73), Osann (pp. 66-79), and Wilson (Sum. Rep'ts, 1913-16). More complete descriptions of the mines from which graphite has been shipped, and of properties on which surface work has been done, are given on pages 42 to 61 of the report on *Graphite*, by Hugh S. Spence, published by the Mines Branch, Department of Mines, Ottawa, in 1920.

Most of the known deposits are in the townships extending northward from the Ottawa river between Hull and Grenville. Locations of those described by Spence are as follows:

Gatineau County. —Low township: 1 mine (with mill), 1 prospect

Papineau County.— Buckingham township: 12 mines (5 with mills), 14 prospects.
Lochaber township: 4 mines, 9 prospects.
Amherst township: 1 mine (with mill), 2 prospects.

Argenteuil County.—Grenville township: 4 mines (1 with mill), 5 prospects.
Wentworth township: 1 mine, 1 prospect.

From 1920 until the close of all mining and milling operations in 1930, however, only four operators reported production. These were:

The *North American Graphite Company, Limited*, lot 28, range VI, Buckingham.

The Quebec Graphite Company, Limited, lots 1-5, range IV, Buckingham.

Laurentian Graphite, Limited, St-Rémi, lots 15 and 16, range VI, Amherst.

The *Canadian Graphite Corporation, Limited* (successor to the Standard Graphite Company, Limited), lots 27-30, ranges VI and VII, Boyer township, Labelle county. This Company commenced shipments in 1923 (subsequent to the publication of the report by Spence) and from 1926 until 1930 was the only Quebec producer of graphite.

In all the Quebec deposits, the graphite occurs in bands of highly metamorphosed rocks of the Grenville series, either crystalline limestone or calcareous paragneiss, and particularly where these have been intruded extensively by rocks of pegmatitic or granitic character. Most commonly, the graphite is in the form of disseminated flakes which may constitute as much as 30 per cent of the rock but seldom exceed 10 to 15 per cent, the concentration diminishing with distance from the contact with the intrusive rock. Usually, in mining such deposits, only material containing 10 per cent or more graphite has been regarded as 'ore'.

As a result of deformation of the bands of gneiss and limestone in which they occur, the deposits are usually of irregular shape and lack persistence along their strike, so that in most localities they appear as a series of discontinuous lenses. Sulphides of iron — pyrite or pyrrhotite — are almost invariably associated with the graphite and their oxidation gives rise to a characteristic rusty weathering of the gneiss which has been found a good indicator in the search for deposits of graphite.

Origin.—Features common to all the deposits that must be taken into account in studying their origin are that they occur in or adjacent to limestone rocks or to paragneisses that were originally calcareous sediments, and that the vein-like and pockety deposits of more or less massive graphite, and the richer concentrations of disseminated flake, occur at or near contacts with pegmatite or other intrusive rocks. It has been variously contended that:

(1) The graphite is of magmatic origin and represents the carbon content of cyanogen compounds, or of carbon monoxide or dioxide, that accompanied the intrusions and suffered reduction to graphitic carbon.

(2) The graphite represents carbon produced by reduction of carbon dioxide that was present in the original rock as calcium or other carbonate and was released when this was converted to the various lime silicate minerals usually present at the gneiss-pegmatite contacts.

(3) The graphite has been produced by reduction of organic carbonaceous matter present in the original sedimentary rock.

Each of these theories has its adherents, but no one of them appears to offer a completely satisfactory explanation of the origin of the graphite in all types of deposit — disseminated, contact, and vein. However, it would appear reasonable to conclude, with Wilson (p. 367), that "as regards the origin of the aggregated deposits of graphite, there can be little doubt that these are genetically related to the disseminated deposits and differ from them merely in the manner in which the graphite has been deposited".

In general, the graphite has been mined from open pits or from rock trenches opened along the strike of the deposits. Where the deposit is exposed in a hillside, adits or drifts have been opened at one or more levels, and from these stopes have been carried upward, in some cases to the floor of surface workings. At two or three properties, shafts have been sunk and the graphite mined from underground workings. The deepest shaft is on the property of *Laurentian Graphite, Limited,* with levels at depths of 40, 80, and 125 feet. From the uppermost level, a raise connects with the floor of an open cut, 50 feet by 30 feet by 30 feet deep. Most of the ore mined on this property was foliated graphite, approaching 'plumbago' in character but mixed with considerable country rock, so that it required concentration. It occurs at the contact between crystalline limestone and an intrusive rock of gabbroic type.

At the property of the *Quebec Graphite Company,* the ore is all of the disseminated flake type, occurring in a series of bands of calcereous gneiss.

Mining was restricted to widths of the band carrying 14 per cent or more graphite, the maximum width of such ore being about seven feet. Most of the ore was taken from surface workings, but two shafts, about seventy feet deep, were put down on the property.

The ore mined by the *North American Graphite Company* was chiefly of the disseminated flake type, occurring in a series of parallel bands of gneiss over a width of 300 feet and a length of 2,000 feet. The workings consist of a number of surface pits and drifts into a hillside. The largest of these drifts extends for 300 feet into the hill, following a zone of disseminated flake ore which has a maximum width of ten feet. Two shafts were sunk on the hill to meet the drift. A 70-foot shaft was also put down on a vein of 'plumbago'.

At the mine of the *Canadian Graphite Corporation*, the ore occurs as a series of lenses in biotite paragneiss cut by occasional pegmatitic dykes. The main ore zone has a width of eight feet at the surface and has been stripped and mined for a length of about 100 feet, beyond which the zone is exposed or has been traced for an additional 100 feet. The high-grade milling ore carried about 20 per cent graphite.

As will be apparent, there are, in the Province, numerous deposits of flake graphite from which, by suitable milling processes, a product of high quality can be recovered. That the industry has not flourished is due to several causes. Chief of these is that Quebec graphite has been unable to compete, for export, with the similar graphite which is produced at relatively low cost — owing to the availability of cheap native labour — in Madagascar, and also in Ceylon. Madagascar to a great extent controls the world's markets for graphite. A second factor has been the marked decrease in the use of graphite crucibles in the steel industry. Up to about twenty years ago, the manufacture of crucibles for production of "crucible" steel consumed from 50 to 75 per cent of the world's output of flake graphite. Today crucible steel has been almost entirely replaced by various alloy steels. Thus, in the United States, production of crucible steel in 1916 amounted to 300,000 tons. This had fallen to 20,000 tons in 1925, to 700 tons in 1935 and to a mere 24 tons in 1944.

The principal uses of graphite are for foundry facings, crucibles, pencils, paints, lubricants, electrodes and commutator brushes, stove polish, fillers for dry batteries, and boiler compound to prevent formation of scale. Artificial graphite can be used for almost all these purposes, except for manufacture of crucibles. This, again, has restricted the market for natural flake graphite.

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KAOLIN (China Clay)

Saint-Rémi-d'Amherst

During the years 1912 to 1923, about 9,000 tons of kaolin was produced from deposits near the village of Saint-Rémi, in range VI South, of Amherst township, Papineau county. Traversing the western part of this range is a north-south trending, drift-covered ridge, about half a mile wide, flanked on either side by a well marked depression and, beyond this, by rocky ridges of granite and syenite gneiss. Throughout nearly its entire extent, the central ridge is composed of vertical or nearly vertical beds of Grenville quartzite and garnetiferous gneiss, with strike N.20°W. On the east slope of the ridge. the quartzite is massive and unbroken, but on the west side, for a width of about 1,000 feet, the rock is almost everywhere severely shattered. The kaolin occurs within this shattered zone as a filling between quartz grains, as veins following planes of fracture and faulting, and in deposits up to 100 feet wide and several hundred feet in length. Trenches, test pits, and stripping indicate that the kaolinized zone is continuous for about 7,000 feet. It appears to be best developed in lots 2 to 8. The most extensive continuous zone or 'lead' of kaolin so far discovered ranges from a few feet to 100 feet wide, has been traced for a length of 1,400 feet, and has been shown by drilling to extend to a considerable depth. Wilson, who examined the deposits in 1918, estimated that average samples of the material contain not less than 35 per cent kaolin. Discussing the mode of origin of the deposits, he says (p. 23): "The evident association of the kaolin deposits of the St-Rémi district with a zone of faulting and fracture, and the occurrence of masses of kaolin in the deposits, forming a matrix enclosing broken masses of quartzite, would seem to indicate that the kaolin deposits had been formed entirely by the deposition of kaolin in openings resulting from the deformation of the Grenville quartzite; but there is also much evidence to indicate that large masses of kaolin have been deposited by replacement, that is, the quartzite adjoining the planes of faulting and fracture has been carried away in solution by circulating waters and kaolin deposited in its place. The principal observations on which this conclusion is based are: (1) that the surfaces of the quartzite beds adjoining the planes of bedding are channelled and pitted with caverns in which the kaolin has been deposited; (2) that beds of quartzite remain in their original vertical attitude here and there within the kaolin deposits; (3) that the bedded structure of the quartzite is preserved in the kaolin deposits in places; (4) that the quartz grains contained in the quartzite have a marked vertical elongation and this elongation is preserved by the quartz grains contained in the kaolin even where the kaolin constitutes 75 per cent of the deposit"; and he adds (p. 31): "Whether the kaolin originated by superficial weathering and was carried down into the fracture zone, or was brought up from below by thermal waters, the writer is unable to decide. The presence of crystals of tourmaline, a mineral formed at high temperatures, indicating that thermal waters at some time circulated through the fault zone, might seem very positive evidence in favour of the deep-seated origin of the kaolin; on the other hand, the occurrence of oxidized and kaolinized garnet gneiss at a depth of 85 feet in the shaft recently sunk on the property of the Canadian China Clay Company is possibly equally positive evidence favouring the derivation of the deposits from a superficial source".

Osborne, who visited the area in 1936, noted that the quartzite has, in places, been intruded by much vein quartz, and in crystals of this quartz he found included kaolin, proving that the quartz had not ceased to be formed when the kaolin started to form, and, as a consequence, that the kaolin, like the quartz, is of magmatic origin. He considers that (p. 30) "emanations derived ultimately from the igneous (Morin) series penetrated the quartzite, altered most of the feldspar to kaolin, and introduced new kaolin to form the veins associated with the quartz". He goes on to say that "the quartz-kaolin rocks were much fractured through the effects of the intrusion, which allowed ground-water to penetrate them readily when they were finally brought to the surface by erosion . . . Although the 'kaolin minerals' were nearly stable under weathering, they suffered some re-arrangement by ground-water on account of their pulverulent character and were carried into other fissures than those in which they were originally deposited . . . The deposits of kaolin thus show characteristics that relate them to both magmatic and surface alteration and deposition, but the writer considers that the amount of kaolin would be negligible if the magmatic alteration had not taken place".

The Saint-Rémi kaolinic quartzite deposits were discovered in 1894 while digging a well for water on the farm of Philibert Thomas, in range VI South, Amherst township. In 1909, F. R. Lanigan, of Montreal, acquired the mining rights on parts of lots 4 to 8. Following some development work, he leased the rights in 1911 to J. C. Broderick, who organized the *Saint-Rémi Kaolin Company, Limited,* and started mining and working operations. This Company was succeeded in 1912 by the *Canadian China Clay Company, Limited,* and from that year until 1923 there were regular shipments of kaolin, amounting in all to 8,892 tons, with a peak production of 1,750 tons in 1916. The final shipment of 163 tons, in 1923, was from workings on lot 4. In the following year, all work was suspended and the property was placed in the hands of a trustee. In 1937, it was sold to a Toronto syndicate. In the same year, the property was acquired by the *Canada China Clay Company, Limited,* who, having sunk a shaft and built a mill, proceeded with development of the deposits until 1941, when the property was taken over by *Canada China Clay and Silica, Limited.*

In 1931, *Canadian Kaolin Silica Products, Limited,* entered the field to develop and mine deposits of the kaolinic quartzite on lots 10 to 12 of the same range (VI South). A mill was built to treat the rock, with recovery primarily of quartz sand and of the associated kaolin as a by-product. Production of quartz sand was continuous, with incidental shipments of kaolin, until 1940, when the mill burned down and all operations were suspended.

In 1942, Canada China Clay and Silica, Limited, entered into an arrangement with Canadian Kaolin Silica Products, Limited, under which they obtain their raw material from the open-cast workings of the latter company on lot 12. This they process in their own mill for production of silica sand and of a small quantity of kaolin as by-product. The plants on the two properties are a mile and a half apart.

Blake Township, Hull and Papineau Counties.—In 1940, *La Société Minière Gatineau, Enregistrée,* did a considerable amount of development work on a kaolin deposit on lots 21 to 23, range VIII of Blake township. The deposit, which is on the shore of Thirty-One-Mile lake, at its south-east end, is completely covered by overburden and in part lies beneath the lake. Trenching and upwards of 200 bore holes are reported to have outlined a semi-crescent shaped kaolin deposit with a length of 900 feet and a maximum width of 106 feet. The deepest hole was still in kaolin at a depth of 292 feet. The kaolin varies in colour from light cream to buff and is said to be particularly suitable for manufacture of refractory brick.

Arundel Township, Argenteuil County.—Kaolin for use as an ingredient in the manufacture of ornamental pottery is obtained by *Laurentian Art Pottery, Incorporated,* from a deposit on lots 27 and 28, range VIII of Arundel township. The Company's workshops are at Saint-Jérôme, in Terrebonne county.

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MAGNESITE, MAGNESITIC-DOLOMITE AND BRUCITE

Although there is no plant in the Province for the production of magnesium metal, deposits of dolomite, $CaCO_3.MgCO_3$, the ore used in the Pidgeon process for making the metal, are plentiful. Brucite, $Mg(OH)_2$, another possible ore, has also been found at several localities.

Certain minerals containing a high percentage of magnesium are used, and have been used from early times, for the manufacture of refractories and a variety of other products. Chief of these are magnesite and so-called magnesitic-dolomite, deposits of which are found in Quebec and they form the basis of a thriving industry. Brucite, also, may be, and to some extent is, used for the same purposes.

Grenville District

The only deposits of magnesite and magnesitic-dolomite in the Province that have been mined are in the adjoining townships of Grenville (ranges IX, X, and XI) and Harrington (range I), some sixty miles west of Montreal and ten to twelve miles north of the Ottawa river.

The district is one of small farms amongst rocky hills that are sparsely wooded. There are good truck roads in the vicinity of the mines and a railway spur, owned by the operators, connects the mining village of Kilmar with the main line of the Canadian Pacific railway at a point near Grenville station.

The hills consist chiefly of granite, anorthosite, quartz monzonite, or related intrusive rocks. The valleys more often contain older sedimentary rocks — quartzite, garnetiferous gneiss, and crystalline limestone — representing original sandstones, shales, and limestones of the Grenville series. These have been much disturbed and altered by the intrusion of igneous rocks, the beds often standing vertically, but they have preserved a general northerly trend.

The mineral aggregate, magnesitic-dolomite, locally called 'magnesite,' is found in dolomitic phases of the limestones, especially where serpentine or sometimes diopside is present. The workable deposits occur intermittently as one or several bands of different widths, the whole forming zones up to sixty feet wide. Along their course, bands may separate and re-unite. The magnesium content of the rock is thought to be generally higher on the side of the deposit that is near the intrusive rocks, some of which are seldom far distant.

Crystalline magnesite and dolomite are so similar in their physical characters and general appearance that they can rarely be distinguished by casual inspection; also, in these occurrences, they are intimately associated. As a consequence, a quarry or mining site can be selected only by sampling and analysis in order to assure the composition required for various purposes. According to Osborne (p. 74), "the ore may be considered as composed of the three minerals, dolomite, magnesite, and serpentine. Other minerals may be present, but if so they are in minor amount . . . Calcite may occur as a separate mineral mixed with dolomite, but not with magnesite. Dolomite may occur with either calcite or magnesite".

The deposits as thus delineated are termed 'magnesitic-dolomite'. A small amount of serpentine which occurs with the carbonates is included in the ore as far as the silica content allows.

There is some uncertainty as to the manner in which these deposits have originated. Wilson (pp. 33-34) considers them the result of replacement of original beds of Grenville limestone by magnesia-bearing solutions derived from a basic magma. "From the occurrence of the dolomite as scattered inclusions in the magnesite, it would appear that the replacement of the limestone by magnesite was effected . . . by two chemical reactions, dolomite being formed in the first and magnesite in the second. The second reaction was not carried to completion, however, throughout the Grenville magnesite deposits, and, in consequence, included remnants of dolomite remain disseminated through the magnesite".

Osborne (pp. 84-85), on the other hand, is of opinion that the magnesite was introduced as a magma, or highly saturated solution, which was genetically related to an intrusion of quartz monzonite. He points out that the deposits have all the characteristics of dykes or similar small intrusive bodies. They occur in branching bodies, in places there is divergence of strike and dip of the Grenville sediments and the orebodies, and the latter cross bands of rocks of diverse composition, including the quartz monzonite, without significant change in character. Later, the magnesite was in part replaced by other minerals, of which dolomite and serpentine were the most important. Only when, or where, the magnesium carbonate solutions were not sufficiently concentrated to form a 'near' magma, or had reached the hydrothermal stage, have they reacted with the invaded limestone to produce magnesite or magnesitic dolomite.

After some trial shipments, production was begun in 1908 and has been practically continuous since that year. Precise figures of the tonnage mined are not available. Published reports of output usually do not distinguish between raw and calcined or 'dead-burned' ore. However, in the ten-year period beginning in 1923, the mine output appears to have been at the rate of about 20,000 tons a year (Osborne, p. 68). The products made from the ore include a wide variety of dead-burned grain magnesite, cements and plastics, basic brick, heat insulating materials, refractory cements, and a small tonnage of magnesia for the building trade. The mines were particularly active during the periods of both world wars, to the successful prosecution of which their products made contributions that were indispensable. This was made possible by the development of new products through research carried on both by the operating companies and by the National Research Council of Canada.

One of the larger uses of magnesitic-dolomite is for making refractory linings and hearths of metallurgical furnaces. The crude carbonate is roasted at a high temperature to convert it to oxide, and the resulting 'clinker', ground to suitable sizes and with the addition of metallic slags or other binders, is made into magnesite firebrick, or special furnace forms. Carefully controlled calcination at a comparatively low temperature yields a material that may be used in some furnaces and also for making magnesium oxychloride — or Sorel cement — which is used for fireproof flooring and tiles and in fireproof paints. With an asbestos bond, coverings are made for boilers and steam pipes, as well as for other insulating equipment.

Crude magnesitic-dolomite finds a use in making wood pulp by the 'sulphite' process, in which magnesium bisulphite serves as an effective solvent of the resins contained in the wood. It has also been successfully used as a source of carbon dioxide gas.

Companies that have shared in the development and operation of these deposits are as follows: the *Canadian Magnesite Company* (1907-1914) and its successor, the *North American Magnesite Company* (1914-33); the *Scottish-Canadian Magnesite Company, Registered* (1915); and the *International Magnesite Company* (1918-42). In 1933, the North American and the Scottish Canadian companies were merged to form *Canadian Refractories, Limited,* and in 1942 this Company acquired the properties of the International Magnesite Company, thus becoming the sole operator in this field.

SOUTH OF THE ST-LAWRENCE RIVER

In *Geology of Canada, 1863* (pp. 457-458), reference is made to the occurrence in three localities south of the St. Lawrence river of carbonate rocks of high magnesia content. These were known as early as 1847 and hopes were entertained that they might find use for the manufacture of refractories for furnace linings or other purposes. These hopes were not realized. The occurrences are described as follows:

"On the twelfth lot of the seventh range of Sutton, magnesite forms a bed one foot thick, associated with dolomite and steatite, in grey micaceous schists.

"It is mingled with grains of a feldspathic mineral and with small scales of green mica, giving the whole the aspect of a bright green, very micaceous gneiss, weathering rusty-red. The proportion of soluble carbonates in the rock is variable; a pure, slightly coloured fragment gave carbonate of magnesia, 83.35; carbonate of iron, 9.02; insoluble, 8.03 = 100.40. Another portion gave carbonate of magnesia, 33.00; carbonate of iron, 19.35; alumina, 0.50; insoluble, 45.90 = 98.70. The specimens contained small grains of nickeliferous pyrites . . .

"The magnesite rock of the seventeenth lot of the ninth range of Bolton forms a bed many yards wide, interstratified between steatite on one side and an impure serpentine, passing into diorite, on the other . . . Analyses of two different portions gave: carbonate of magnesia, 59.13; carbonate of iron, 8.32; insoluble, 32.20 = 99.65; and carbonate of magnesia, 59.72; carbonate of iron, 10.31; insoluble, 29.90 = 99.93 . . .

"Magnesite also occurs in the twenty-fourth lot of the ninth range of Bolton, where it forms beds in argillite. It here appears as a compact rock with a conchoidal fracture, bluish-grey within but weathering reddish-brown. It contains, like the others, a mixture of siliceous matter and a portion of carbonate of iron. This variety can scarcely be distinguished by its external characters from the magnesian limestone so common in the same region".

None of these occurrences has yet been found to offer economic possibilities.

Magnesitic sand was found in considerable quantity in the drift overlying serpentine near the King asbestos pit at Thetford Mines. It was at one time thought to be a suitable material for the manufacture of refractory brick but has never been utilized for that or any other purpose.

Brucite

Brucite has been found in rocks of the Grenville series in several localities in the Ottawa River valley, both in Quebec and Ontario. Of the Quebec occurrences, the best known is in the vicinity of Wakefield, some twenty miles north of the city of Ottawa. It has been studied recently by J. W. Ambrose, of the Geological Survey of Canada, who has supplied the following summary description:

"The rocks near Wakefield are all of Precambrian age and form part of the Grenville province. The brucitic limestones, in association with masses of lime silicates and crystalline limestone, form nine large, and a dozen or so small, bodies which are scattered, apparently at random, on both sides of Gatineau river south of Wakefield, over an area of about four square miles. They lie within the outcrop area of a body of alkaline (hastingsite) syenite of large size and, although now separated from one another and from rocks outside the syenite body, all are probably roof-pendants in the latter. A fact of importance to those searching for other bodies of brucitic limestone, as well as to those interested in the origin of these rocks, is that they have been found only within the limits of the syenite. Evidently, the syenite played an essential role in producing the brucite.

"In outcrop, the roof-pendants tend to be circular, or slightly elliptical, with fairly smooth outlines. The largest is about 2,200 feet long by 1,200

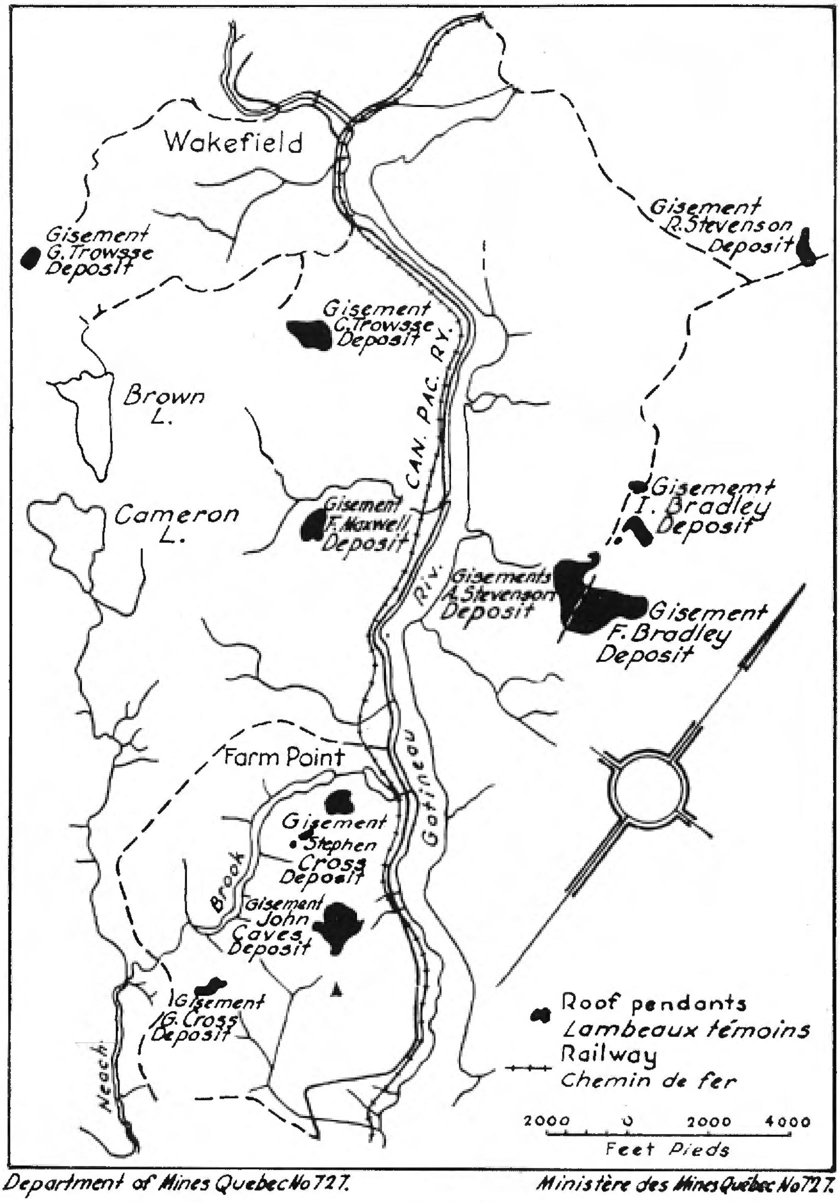

FIGURE 78.—*Brucitic roof pendants in the Wakefield district*—R.S.C., Sec. IV, Vol. XXXVII, p. 10.

feet wide, or some forty acres in area; several others cover more than five acres, and there are numerous smaller bodies. The larger bodies of limestone form rather abrupt hills which rise forty to one hundred and forty feet above the neighbouring valley floors, a feature of decided assistance in both prospecting and quarrying operations. Details of their shapes below the surface are not known, but, from diamond-drill holes which penetrate through them, some of the bodies are known to project downward into the syenite for more than 400 feet.

"The roof-pendants consist of three general types of rock: limestone, brucitic limestone, and masses of mixed lime-magnesia silicates.

"The brucitic limestone is easily distinguished from ordinary limestone, for the brucite granules, evenly distributed through the rock, weather out to leave a characteristic pitted surface, whereas the weathered surface of the limestone containing no brucite is quite smooth. The pits, one to three millimeters in diameter, account for a quarter to a third of the rock surface, and in the bottom of each pit a small amount of chalk-white hydromagnesite is commonly found. The brucite granules are colourless, tan, dark grey, or even bluish. They are not conspicuous on fresh surfaces of the rock, especially if their colour is that of the calcite matrix, but with a little practice they are not difficult to distinguish.

"The ordinary limestone differs in no way from other crystalline Grenville limestone. The amount of brucite in the purer varieties of brucitic limestone ranges between 20 per cent and 30 per cent.

"The brucite content of the purer brucitic limestone is the same in specimens close to the contact with syenite as in those taken several hundred feet away. It forms, in fact, a virtually constant percentage of the rock masses. Also, throughout the area, these limestone roof-pendants are of very uniform composition, corresponding almost exactly to the theoretical formula for dolomite. It is reasonable to conclude that they were once continuous over the area".

A commercial process for making a marketable concentrate of the brucite has been developed by M. F. Goudge, of the Mines Branch, Department of Mines, Ottawa. Goudge made the first discovery of brucite in rocks of the Grenville series, at Rutherglen, Ontario, and later discovered the deposits at Wakefield and others at Bryson, Quebec.

These and other occurrences of brucitic limestone in Masham, Hull, and Grand Calumet townships have been described by Osborne (pp. 8-16). The occurrence on Calumet island is mainly in lots 3 to 9, range II. That near Bryson is best exposed in the Carswell quarry, which has been worked at times for limestone. The limestone here carries 25 to 30 per cent of brucite in a band about eighteen feet wide. The band has been traced northerly from the Carswell quarry to the vicinity of the bridge over the Ottawa river leading to Calumet island.

Fibrous brucite has been found associated with chrysotile asbestos in some of the asbestos mines of the Eastern Townships.

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MICA

There has been production of mica from deposits in the Province of Quebec since about 1886, and well over 90 per cent of the output has been the magnesia mica, phlogopite, or 'amber mica'. Muscovite (potash mica) has been mined in a few localities, but at no time in large amount. In all the phlogopite deposits there is a certain amount, and in some a large amount, of apatite (calcium phosphate), and until about 1890 mines were opened in these deposits primarily for production of 'phosphate' (see p. 490). There was little or no market for the mica, and most of it went to the dumps as a waste product. Many of these dumps have since been re-worked and the mica recovered.

Prior to the development of the phlogopite deposits of Quebec, and of those in adjacent parts of Ontario, muscovite was the only mica used commercially. The Canadian phlogopite was found equal to muscovite in electrical insulation and superior for certain uses, as for example in commutators, since its edge hardness is less than that of muscovite and about the same as that of copper, with the result that the copper and phlogopite segments wear evenly. It was difficult, however, for Canadian mica to compete successfully in world markets with the more cheaply produced Indian muscovite, and soon there arose increasing competition from Madagascar phlogopite which, also, is produced at relatively low cost. As a consequence, although there are literally hundreds of deposits of phlogopite known in the Province, the industry has never attained large dimensions. The most active years appear to have been the decade 1919 to 1928, with annual shipments averaging about 1,600 tons. However, the larger tonnage marketed commencing with the year 1919 was largely due to the growth of the ground mica industry, which utilizes 'scrap' mica that formerly had been a waste product. Following 1929, there was a sharp decline in output, and from 1930 until 1940 shipments averaged only about 330 tons per year. Under the stimulus of war demands, production was then resumed on a larger scale and averaged 1,330 tons for each of the years 1942-44. Actually, the total tonnage does not convey a clear picture of the industry since the mica is marketed in many different classifications, such as cobbed, trimmed, split, and scrap, and the price range of these is very considerable. Shipments in 1943 and 1944 under the several classifications were as follows:

SHIPMENTS OF MICA FROM QUEBEC MINES, 1943 AND 1944

Classification	1943		1944	
	Quantity (pounds)	Value	Quantity (pounds)	Value
Rough, mine run or rifted	171,675	$ 22,113	15,642	$ 1,249
Mica for mechanical splitting	190,209	26,048	427,426	62,842
Splittings	61,350	41,670	36,850	26,348
Ground or powdered	1,061,570	22,372	1,157,270	29,762
Scrap	1,377,165	8,098	494,939	2,482
Trimmed	164,113	123,681	87,482	53,813
Unspecified	60,591	1,864	55,025	2,403
TOTAL	3,086,673	$245,846	2,274,634	$178,899

Phlogopite

The phlogopite deposits are confined chiefly to the area extending northward from the Ottawa river along and between the valleys of the Gatineau and Lièvre rivers, in a belt about twenty miles wide. Most of the deposits that have been worked are from four to twenty miles north of the Ottawa river, in the townships of Hull, Templeton, Wakefield, and Portland, in Gatineau and Papineau counties, but there are numerous others at intervals for seventy or more miles north of the river, and some, also, as much as fifty miles west of the Gatineau river, in Pontiac county and to the east as far as Argenteuil county. One deposit from which there have been shipments is at Petit Pré, in Côte-de-Beaupré seigniory, Montmorency county, a few miles east of Quebec city.

The area north of the Ottawa river is underlain by highly metamorphosed sediments of the Grenville series which in many places have been invaded by intrusive rocks of the Buckingham series, ranging in composition from granite to peridotite, and also by later batholithic masses of granite and syenite (see Vol. II, pp. 166-183). The Grenville rocks include sillimanite and garnet gneisses, crystalline limestones, and a rock composed predominantly of diopside. This rock, which Wilson has named 'metamorphic pyroxenite', has been formed from the limestone of the Grenville series by the action of solutions or emanations derived from the intrusives of the Buckingham series or of the later granitic intrusives. All the commercial deposits of phlogopite occur in the pyroxenite. "Small, isolated bands and masses of this rock occur scattered throughout the region, enclosed sometimes in a country rock of gneiss and sometimes in crystalline limestone. They are seldom persistent for any distance, though in certain districts (*e.g.*, Templeton and Hull townships . . .) a number of such masses occur in fairly close proximity (Spence, p. 37).

Some of the deposits have the form of fairly persistent veins, usually narrow but regular in width, dip, and strike, in which the mica crystals are distributed through a matrix of pink calcite and granular apatite. More often, they are of the 'pockety' type, irregular in shape, size, and course, and lacking persistence, thus accounting for the large number of small abandoned pits scattered through the area. Phlogopite crystals, sometimes of large size, are irregularly distributed in these pockets, together with pink calcite and apatite, the latter being the predominant mineral in some of the pockets.

Depending on its iron content, the colour of the phlogopite ranges from pale amber-yellow to dark brown or almost black — hence such trade names as 'light amber', 'silver amber', and 'dark amber'. A distinguishing feature of the mineral is that reflections from the cleavage surfaces are diffused in contrast to the sharp reflections from plates of muscovite.

The number of active properties varies greatly from year to year, but in each of the years 1941 to 1944 shipments of phlogopite were made by forty-six to sixty-two operators. Substantial production, however, usually comes from less than a dozen properties. The great majority of the operations have been small pits opened on deposits of the 'pockety' type, and few of these have been carried to a depth exceeding seventy-five feet. The pit has been abandoned when the bottom of the 'pocket' was reached. Where the deposit is of the vein type, the mine has usually had a longer life and on a few properties mining has been carried on underground from shafts, the deepest of which is about 300 feet.

Detailed descriptions of all deposits from which there have been shipments, or on which work has been done, are given in the report entitled *Mica*, by Hugh S. Spence (1929), and also in the earlier report by the same author (Hugh S. de Schmid), *Mica: Its Occurrence, Exploitation, and Uses* (1912), both published by the Mines Branch, Department of Mines, Ottawa.

Since the inception of the industry, *Blackburn Brothers, Limited,* have been the leading producers. The original Blackburn mine, on lot 9, range XI, Templeton township, was opened in 1888 as a phosphate mine, and it was in almost continuous production as a mica mine until 1940. It was operated for many years as an open pit, which attained dimensions of 400 feet by 180 feet by 150 feet deep, and later from extensive underground workings from three shafts, the deepest sunk to a depth of 160 feet from the pit floor. The mica is 'silver-amber' of the best quality. The Company acquired and re-opened the Vavasour mine, on lot 11, range VII, Hull township, in 1936, and the Phosphate King mine, on lot 15, range VIII, Templeton township, in 1942. Both were originally worked as phosphate mines, but since their recent re-opening they have been responsible for the major part of the Quebec mica production. Blackburn Brothers maintain a grinding plant at the Vavasour mine, the output from which is sold to the roofing and rubber trades. The sheet mica is cobbed at the mines and transported to the Company's trimming plant at Ottawa, where it is prepared for marketing to the electrical industry.

Phlogopite suited for use in the manufacture of spark plugs for aeroplanes has been produced in recent years by the *Saint-Lawrence Mica Corporation, Limited,* from the Richard mine at Petit Pré (a few miles east of Quebec City), in Côte-de-Beaupré seigniory, Montmorency county, and by the *Saint-Lawrence Mining Corporation, Limited,* from a deposit at Kilmar, Grenville township. This type of phlogopite has been found at only a few localities in Canada and it usually commands a high price.

Other properties from which there have been shipments of phlogopite in recent years include the following:

Township	Location	Name of Mine or Operator
Templeton........	Lots 15 (West ½) and 16, range VIII	*Wallingford mine*, Ed. Wallingford
Hull.............	Lot 12*a*, range XV East	*Dacey mine*, A. G. Martin
"	Lot 10, range XII East	*Vavassour mine*
"	Lot 23, range XV West	*Cascades mine*
"	Lots 15-17, range XVI East	*Horseshoe mine*
Wakefield........	Lot 16, range II	*Kodak mine*, A. G. Martin
Wells............	Lots 47-50, range I	A. W. White Mica, Ltd.
Joliette.........	Lot 2, range II	Francois Bazinet
Wentworth.......	Lot 22, range I	Leopold Joanisse
Hudon............	Mining Claims Q-31818-9	Jos. Delisle
Denholm.........	Lots 49 and 50, range I	A. P. Blood
Portland.........	Lot 13, range III West	*Lake Terror mine*
"	Lot 6, range IX West	D. V. McLean Interest, Ltd.

Muscovite

Muscovite, in sheets of commercial size and quality, has been found in pegmatite dykes in various parts of the Province, but the known deposits are all relatively small. Many of these occurrences are near the north shore of the lower Saint-Lawrence river in Charlevoix and Saguenay counties; others are inland along the Saguenay river, and also north of lake Saint-Jean. Some exploration work has been done in recent years at two old muscovite mines, one, the Pied-des-Monts mine in Lacoste township, the other in Callières township, both in Charlevoix county. These are about seventeen miles northwest and northeast, respectively, of Murray Bay. In Saguenay county, Eugène Simard has done some work on deposits at two localities in Bergeronnes township. From one of these, north of Sirois lake, there was a small production of muscovite during the years 1936-38; from the other, in the northwest part of the township, about 18,000 lb. of knife-trimmed mica was produced during the second World War. Other deposits in Bergeronnes township from which there was some production prior to 1900 are the McGie mine, in block *G*, and the Hall mine. At about the same time there was a small output of muscovite from the Maisonneuve mine, Maisonneuve township, Berthier county.

Many years ago, some muscovite was produced from pegmatite dykes in the Ottawa Valley district. One of the mines—the Villeneuve, on lot 31, range I of Villeneuve township, Papineau county — was re-opened and worked in a small way in 1942.

About 150 tons of mine-run muscovite is reported to have been taken some years ago from a dyke on the east side of the Ottawa river, near Mattawa, in Boisclerc township, Témiscamingue county.

In 1944, a few hundred pounds of high-grade knife-trimmed muscovite was shipped from the Frank Sigouin claim, in Pétain township, Abitibi-East county.

Lepidolite

The lithia mica, lepidolite, appears to be of rare occurrence in Quebec. Of mineralogical, and also historical, interest is a lepidolite-bearing pegmatite dyke, forty feet wide, on the east half of lot 25, range VII of Wakefield township, Hull county. Its principal constituents are white and smoky quartz, light coloured and green microcline with lesser albite or perthite, lepidolite, and tourmaline. Garnet and fluorite are present in minor amount, and the uranium minerals, uraninite and gummite, have been reported (see p. 437). Known as the Leduc mine, this dyke has been worked for mica, feldspar, and tourmaline.

The lepidolite is fairly abundant in coarsely crystalline masses, some more than two feet in diameter and several inches thick. It has a grey to brown colour which renders it almost indistinguishable in appearance from muscovite, and in 1884 about a ton of the material was taken from the dyke in the belief that it actually was muscovite.

The tourmaline, also fairly plentiful, occurs in crystals and columnar aggregates up to two inches in diameter, generally green or bluish-green but in part pink, and much of it more or less transparent. In 1908, a quantity of the mineral was mined with a view to using it for gem purposes but the percentage of gem material was found to be very low and the operation was abandoned.

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NATURAL GAS AND PETROLEUM

During the years 1929 and 1930, Wm. A. Parks, then Professor of Geology at the University of Toronto, carried out, for the Quebec Bureau of Mines, a very comprehensive investigation of the natural gas and petroleum resources of the Province, the results of which were published in two reports. The first of these, entitled *Report on the Oil and Gas Resources of the Province of Quebec,* is a volume of 126 pages containing chapters on Petroleum of Gaspé, Petroleum in Trenton Limestone, Bituminous Shales and Sandstones, and Natural Gas (Annual Report for 1929, Part *B*). The second, a report of 98 pages appearing in Part *D* of the Annual Report of the Bureau for 1930, is entitled *Natural Gas in the St-Lawrence Valley, Quebec.* These two reports give a very complete account of all known occurrences of natural gas, and of drilling for oil, in all parts of the Province up to that time. Summing up the general situation, Parks says (1930, pp. 5-6):

"The Province of Quebec, at the present time, cannot be credited with the production on a commercial scale of any combustible mineral substance. Coal is not known to occur in the Province, but vast stores of peat undoubtedly exist. It is not proposed to consider this fuel; full accounts of its occurrence and manufacture may be found in various reports of the Mines Branch of the (Federal) Department of Mines.

"Besides coal and peat, the common mineral combustibles are petroleum and natural gas; to these must be added bituminous sandstones and shales from which oil, gas, and ammonium sulphate may be obtained by distillation.

"Petroleum is known to occur in Gaspé, where many wells were drilled with indifferent results thirty or more years ago. The presence of petroleum has been suspected, also, in the St-Lawrence valley, but no reward followed attempts to exploit it.

"Natural gas occurs at many places in the lowlands between Montreal and Quebec and as far south as St-Hyacinthe. Development on a commercial scale was attempted and met with a fair measure of success for a time. Failure ensued, however, and at the present date the only production is from shallow wells each of which usually supplies only a single dwelling.

"Bituminous shales and sands are known in Gaspé, at Port Daniel, in the St-Lawrence lowlands, at lake St-John, and near Chicoutimi. No serious attempt has been made to utilize these deposits".

Since the appearance of these reports by Parks there has been some further exploration and drilling in search of natural gas in the St-Lawrence valley and of oil in Gaspé peninsula. The results of this more recent work are summarized below. For information concerning the occurrence of natural gas and oil in the Province, and of developments up to 1930, the reports by Parks should be consulted. Between 1937 and 1945, a number of wells were drilled in Gaspé in the search for petroleum. These operations are described by McGerrigle in Geological Report No. 35 on *The Geology of Eastern Gaspé*, published by the Quebec Department of Mines.

Natural Gas

Following preliminary surveys carried out in 1930, deep wells were drilled by various interests during the years 1930-34 at six locations in the St-Lawrence valley. Samples of the rocks intersected in the drilling were sent to the Quebec Department of Mines, and the drill cores were deposited with the Borings Division of the Geological Survey, Ottawa, where they were logged and studied in detail. None of the borings resulted in productive gas wells.

The logs given in the following brief descriptions of these wells were kindly furnished by the Borings Division of the Federal Geological Survey, Ottawa.

Lot 549, Range III, St-Denis Parish, St-Hyacinthe County

Well drilled by the *Richelieu Gas Company, Limited.* Depth 4,150 feet.

Footage	Formation
0 - 145	Surface deposits
145 - 953	Shale (Queenston)
953 - 960	Igneous rock
960 - 2,105	Shale, sandstone, and thin limestone bands (Richmond & Lorraine)
2,105 - 2,153	Igneous rock
2,153 - 3,360 (?)	Shale (Lorraine)
3,360 (?) - 4,090	Shale (Utica)
4,090 - 4,150	Trenton (presumably)

The igneous rocks met with are apparently offshoots from the Monteregian hills in the vicinity. These are of post-Ordovician age (Devonian or later).

A heavy charge of nitroglycerine was discharged in the well on May 6th, 1932. No commercial supply of gas was released and the well was abandoned (Q.B.M., Ann. Rept. for 1932, Pt. *A*. pp. 47-49).

La Visitation, Yamaska County

Two holes were put down in 1931-32 by *South Shore Oil Lands, Limited.* Depths of 3,200 and 4,400 feet were reached, chiefly in shales. The succession of the rocks proved complex and the wells were abandoned in August, 1932 (Q.B.M., Ann. Rept. for 1932, Pt. *A*, pp. 48-50).

Lot 573, Range St-Antoine, St-Gérard Parish, Yamaska County

Well drilled by *Canadian Seaboard Oil & Gas, Limited*, in 1931-32. Depth 6,030 feet.

Footage	Formation
0 - 50	Surface deposits
50 - 90	Sandstone (Queenston)
90 - 1,190	Red shale (Queenston)
1,190 - 1,280	Grey shale (Queenston)
1,280 - 1,530	Grey shale and limestone (Richmond)
1,530 - 2,260	Grey shale with thin limestone bands (Lorraine)
2,260 - 2,870	Medium grey, sandy shale (Lorraine)
2,870 - 4,400	Dark grey shale (Lorraine)
4,400 - 4,840	Dark grey and brown shale (Utica)
4,840 - 5,330	Dark grey shale with limestone bands (Lower Utica)
5,330 - 5,540	Lower Utica and Upper Trenton
5,540 - 5,980	Limestone (Trenton and Black River)
5,980 - 6,000	Sandstone (basal Trenton)
6,000 - 6,030	Limestone (Chazy)
6,030 (bottom of well)	Shale and sandstone (Chazy ?)

No gas was obtained (Q.B.M., Ann. Rept. for 1932, Pt. *A*, pp. 48-50).

Lot 160, Range Petit Bois, Ste-Angèle-de-Laval Parish, Nicolet County

Well drilled by *Canadian Seaboard Oil & Gas, Limited,* in 1933. Depth 5,280 feet.

Small flows of gas were encountered in the lower Utica and Trenton horizons. They were not in commercial volume but are of significance as showing the capacity of these rocks to act as gas reservoirs. Two features of this well are that rocks of Precambrian age were entered at a depth of 5,100 feet, and that a flow of strongly saline water was found at this depth, at the contact of the Trenton formation with the Precambrian. This brine contained 28.8 per cent (by weight) of various salts, including 17.4 per cent calcium chloride and 8.1 per cent sodium chloride (Q.B.M., Ann. Rept. for 1933, Pt. *A*, pp. 47-48). Following is the log of this well:

Footage	Formation
0 - 20	Surface deposits
20 - 3,270	Shale (Lorraine)
3,270 - 3,520	Lower Lorraine and/or Upper Utica
3,520 - 4,930	Shale (Utica)
4,930 - 5,100	Limestone (Trenton)
5,100 - 5,280	Grey igneous rock (Precambrian)

Lot 300, Grand Rang S.-E., St-Grégoire Parish, Nicolet County

Well drilled by *Canadian Seaboard Oil & Gas, Limited,* in 1934. Depth 6,030 feet.

This well is about four miles south of that in Ste-Angèle parish. Gas was encountered at several horizons, but not in commercial volume. The log follows (Q.B.M., Ann., Rept. for 1934, Pt. *A*, p. 48).

Footage	Formation
0 - 50	Surface deposits
50 - 470	Red and grey shale (Queenston)
470 - 2,950	Grey and sandy shale with limestone (Lorraine)
2,950 - 4,000 (?)	Shale (Lower Lorraine and/or Utica)
4,000 (?) - 4,810 (?)	Shale and shaly limestone (Utica)
4,810 (?) - 5,340 (?)	Limestone (Trenton)
5,340 (?) - 6, 030	Dolomite (Beekmantown)

Both before and during the period in which these wells were being drilled, which was in the years 1931-34, several holes of less depth were bored in search of natural gas. Many of these only reached, or barely penetrated, the bed-rock.

Near Louiseville and Yamachiche, in the vicinity of Trois-Rivières, natural gas was produced in commercial volume in 1905-6, principally from shallow wells. The gas was first piped to Louiseville and later to Trois-Rivières. It was said that the supply was generally sufficient and satisfactory for household uses but did not so well meet the variable commercial demands (Parks, 1930, p. 89). Although the supply of gas seemed favourable, the industry yielded to the competition of electricity after a trial of scarcely two years. The district is deeply covered by drift and the structure of the underlying rocks is not known. Logs of drill holes indicate that they belong to the lower Lorraine and Utica formations.

Shallow wells have yielded natural gas in small quantity in several districts of the St-Lawrence valley, as for example at Ste-Geneviève, Champlain county; Verchères, Richelieu and Verchères county; St-Hyacinthe, St-Hyacinthe county; Lanoraie, Berthier county; St-Grégoire, Nicolet county; and Portneuf, Por neuf county. In some cases, as at Ste-Geneviève, the gas has been used in a few houses for many years. Concerning such shallow wells as a possible source of supply, Parks (1931, p. 83) wrote as follows:

"Experience shows that the bulk of production of natural gas in Quebec has been from shallow wells in the drift. The yield has been obtained, in some cases, without the bottom of the drift having been reached. Usually, however, the best flow has been obtained immediately above the underlying rock.

"The origin of surface gas has been much discussed. It was held by some authors that the gas is due to decomposition of organic matter within the drift. This view is upheld by the fact that it occurs in certain localities far above the underlying rocks. Most observers agree, however, in ascribing surface gas to the slow decomposition of bituminous matter in the underlying rocks — usually shales.

"Productive gas wells in shale are well known; the output is not heavy but it is liable to continue for a long time. Most wells giving surface gas in quantity are located in regions underlain by shales of a more or less bituminous character.

"The shallow wells in the Louiseville, Ste-Geneviève, and Lanoraie districts north of the St-Lawrence river are in drift over the Utica shales or possibly, in some cases, over the lower beds of the Lorraine. The wells in the Verchères district, south of the river, are similarly situated. The productive wells at St-Ours are in drift above beds ascribed to the Lorraine but of whose age we are by no means sure".

Of gas from shallow wells, Parks remarked (1930, p. 93): "It is apparent that the area between and northward of Yamachiche and Louiseville is capable of yielding gas, at almost any point, in sufficient quantity to supply a dwelling. The wells require only a moderate depth in the drift but are capable of yielding a steady supply almost indefinitely. The value of a small well of this kind is estimated by the owners at from $50.00 to $300.00 a year; perhaps $200.00 a year would be a fair average".

Parks (1931, pp. 83-84) quotes the following paragraphs from a report by R. B. Harkness, of the Ontario Department of Mines:

> "The commercial production tabulated below came from gravel beds overlying black shales. The Ridgetown [Kent county] field is by far the largest in the Province [of Ontario] and, so far as the writer is aware, the largest on record. The gas produced from this field is the equivalent of 12,000 tons of coal.
>
> "The following table shows the measured quantity and value of this surface gas used to date. The quantity unmeasured may easily exceed this, as it has been used in homes in these localities for thirty years and more".

Gas from Surface Drift—Sold in Ontario

County	Field	Year to Year	Production (M.cu.ft.)	Retail Value at 60 Cents per 1,000 Cu.Ft.
Kent...........	Ridgetown	1924-1930	248,774	$145,611
Lambton.......	Sarnia	1926-1929	10,632	6,379
Total......	....	....	259,406	$151,990

Commenting on the above, Parks adds:

"These figures indicate that surface gas is not to be despised as a commercial product, and the success, if temporary, of the old company in the Louiseville district sustains the same point of view.

"It is established for Quebec that surface gas from a single well is sufficient to supply a home for many years. Experience in Ontario indicates that wells of this kind may be exploited commercially.

"It is a reasonable conclusion that all areas of Utica shale covered by an impervious cap of glacial clay are capable of voiding gas in moderate quantity for long periods of time. Further, the yield is independent of structural folds. In this connection attention should be directed to the large area of bituminous Utica shales in the counties of Iberville, Laprairie, and Missisquoi. These shales as exposed at Lacolle, Clarenceville, and L'Acadie are dark and bituminous, but I have not learned of any attempt to explore for gas in this district".

Petroleum

Eastern Gaspé

Interest in the economic mineral prospects of the eastern part of Gaspé peninsula has centred, to a large extent, on the possibility of finding petroleum in commercial quantities. At numerous points in this section of the peninsula bordering the York and Saint John rivers, seepages of oil from the Gaspé Sandstones (Middle Devonian) and from the various formations of the Gaspé Limestone series (Lower Devonian) have been observed, and there are outcrops of petroliferous rocks of these, as well as Silurian and Ordovician, ages in various places throughout the peninsula.

Oil seepages were recorded as early as 1836, and in 1860 two wells were drilled by the *Gaspé Bay Mining Company* to test the Gaspé Sandstones near two of these surface showings, some thirteen miles apart. The results were negative, and nothing more was done for thirty years.

Between 1890 and 1903 there was a renewal of interest and of activity in the region, during which some fifty-five wells were drilled. Twenty-four of these showed the presence of oil in sufficient quantity to produce, by pumping, from a few gallons to a few barrels daily. Then followed a period of quasi-inactivity for more than thirty years.

This earlier drilling was not directed by a broad knowledge of the geology of the region. The few wells that were located on favourable structure did not go deep enough to reach or penetrate formations that were 'closed' from communication with the surface.

After a more detailed study of the region, and the mapping of several structures that appeared worthy of consideration, by geologists of the Quebec Department of Mines, *Imperial Oil, Limited,* drilled two wells in 1939 to 1942. The results were disappointing, but they were not decisive, since neither hole reached the formations that, elsewhere in the peninsula, are known to contain at least some oil. The region is extensive, and the few wells that have been drilled since completion of the relatively detailed geological mapping cannot be considered as having adequately tested it for its oil possibilities.

Two general types of oil have been observed in the wells of the Eastern Gaspé field: one light in colour, with a paraffin base, the other a heavier, dark-green to brownish-black oil with an intermediate base.

TABLE OF FORMATIONS IN EASTERN GASPÉ
(After I. W. Jones and H. W. McGerrigle)

Period		Formation	Thickness	Nature of Beds
CARBONIFEROUS	Pennsylvanian or Mississippian	Bonaventure		Red conglom., sandstone, shales, occasional limestone
		Cannes de Roche		Red conglom., red and green shales, sandstones
DEVONIAN	Gaspé Sandstone	Malbaie........upper	2,000	Conglom., sandstones; some shales
		Battery Point } middle	5,000 to 7,000	Greenish-grey sandstone; conglom., shales
		York River } middle	1,000 to 6,000	
		York Lake Series } lower	0 to 4,000	Greenish sandstone; shales
		Fortin Series } lower	0 to 5,000	Grande Grève type limestone; shaly slate, sandstone, limestone, and conglomerate
	Gaspé Limestone	Grande Grève	2,000 to 4,500	Dark, hard, siliceous limestone
		Cap Bon Ami	1,000 to 6,000	Dark, grey, often magnesian, limestones
		Saint-Alban	160 to 3,000	Greenish, soft limestones, argillaceous to arenaceous limestone, red and green shaly limestone
DEVONIAN AND SILURIAN		Dartmouth River	0 to 1,000	Same as Saint-Alban
		Saint-John River	2,500	Much same as Saint-Alban
		Grand River Portage River	0 to 100	Much same as Saint-Alban
SILURIAN	Middle	Mount Alexander Series	5,000+	Like Saint-Alban, zone of volcanics in the middle
		Ladystep Volcanics	1,000	Flows and tuffs, highly altered
ORDOVICIAN	Upper	Matapedia Series Whitehead, Pabos	1,000 to 5,000	Dark grey limestone weathering to dove; dark grey, light-grey shaly limestone
	Middle	Beds at Griffin Cove to Gros Ruisseau		Dark shales
	Lower	Cap Rosiers Beds		Grey to dark shales
CAMBRIAN	Upper	Murphy Creek		Thin grey limestones, separated by ribboned shaly limestone
	Lower	Corner of the Beach		Shales and limestone

A comprehensive description of the geology of Eastern Gaspé, with an account of drilling operations and a discussion of oil possibilities, by I. W. Jones and H. W. McGerrigle, has been published recently by the Quebec Department of Mines (Geol. Rept. No. 35) and should be consulted for more detailed information than can be given in this volume. The following chronological summary of drilling operations is based on data contained in that report.

Chronological Summary of Drilling Operations for Oil in Eastern Gaspé

1860 — *Gaspé Bay Mining Company.* First drilling for oil in Gaspé. Two shallow wells drilled, respectively on lot 16, range II of Gaspé Bay South township (600 ft.) and on lot 17, range I, Douglas township.

1865-1866 — *Gaspé Oil Company* (Conant well), lot A6, range I, Sandy Beach, Douglas township; depth 648 feet. Pumping gave several barrels of oil.

This well was re-opened in 1944 by W. R. McMaster, but abandoned in 1945.

1889 — *International Oil Company* (of St. Paul, Minn.) did some exploration and sank a well in 1891 to a depth beyond 2,200 feet on Galt brook, in block 41, Galt township.

1889-1901 — *The Petroleum Oil Trust*, with headquarters in London, England, began extensive operations in 1889. Subsidiary associated companies were: *Canada Petroleum Company*, *Société Belge des Pétroles du Canada*, and *Oil Fields of Gaspé*. Between 1889 and 1901, these operators drilled fifty-three deep wells, of which *P.O.T.* put down forty-one and *C.P.C.* twelve. The latter Company also erected a central pumping station and a refinery.

Of the fifty-three wells of the *P.O.T.* and its subsidiaries, twenty-four were reported to have yielded oil, by pumping or bailing, to the extent of a few gallons to a few barrels a day. The field covered by *P.O.T.* operations was twenty-five miles in an east-west line and eight miles north-south, maximum measurements. Three of the wells were more than 3,000 feet in depth, the deepest 3,640 feet. Thirty-three were between 2,000 and 3,000 feet, and the remainder were less than 2,000 feet deep.

Failure of the wells to produce oil in commercial quantity led to abandonment of the region by *P.O.T.* in 1904.

1913 — Ten years elapsed after *P.O.T.* withdrew from eastern Gaspé before another drilling venture was undertaken in the field. In 1913, the *Eastern Canada Company* drilled one well to a depth of 2,950 feet near Malbaie river, in Malbaie township. This is the most southerly well in the region and the only one south of St-John river; it is on the north side of Malbaie river, nine miles from its mouth. The results were negative. This well was put down in the Battery Point formation and it was not favourably located as regards structure. No further drilling was done until 1937.

1937-1938 — *Minéraux et Pétroles de Gaspé Compagnie* drilled a well on the north flank of the Northwest Arm syncline, on lot 51, range I, of Baie de Gaspé Nord township, to the depth of 342 feet by churn drill, and continued to 842 feet by diamond drill. The location of the hole was unfavourable.

1939-1940 — The *Compagnie d'Exploration de Gaspé, Limitée*, sponsored by *Imperial Oil, Limited*, started Mississippi No. 1 well in the fall of 1939, in Larocque township, three-quarters of a mile east of the south end of Dartmouth lake. In August, 1940, it had reached a depth of 5,995 feet. No favourable indications of oil or gas were found in this hole which reached the Saint-Alban formation, but did not go deep enough to attain a petroliferous, reefy limestone that outcrops in other parts of the region.

1941 — In 1941, *Imperial Oil, Limited,* moved the drilling equipment from the Mississippi No. 1 well to lot 2, range II North, of Douglas township to drill Haldimand No. 1 well. In November, 1942, this well had reached a depth of 4,779 feet without encountering oil and the well was abandoned. Beginning in the Battery Point formation, it finished in the York River formation without reaching the Grande Grève.

1943 — In 1943, *Continental Petroleums, Limited,* with head office in Montreal, drilled C.P.L. No. 1 well in block 42, Galt township, to a depth of 2,137 feet. It was then plugged until 1946 when it was deepened to 2,728 feet. The well started in the Grande Grève and was still in that formation when operations were suspended at the latter depth. A little oil and some gas were encountered.

1944-1945 — In 1944-45, C.P.L. No. 2 well was drilled in block 40, Larocque township, at a point 113 feet east of P.O.T. No. 20, which well, drilled in 1896, had yielded 1,750 gallons of oil by pumping, at the rate of some five gallons a day. C.P.L. No. 2, in its total depth of 2,932 feet, penetrated 2,362 feet of York River strata and 570 of Grande Grève. Oil shows were met with at several horizons in the York River formation. Acidizing was resorted to in an attempt to increase the flow. After the second acidizing test, made between December, 1944, and January 12th, 1945, with the hole bridged at 2,398 feet, the total oil recovery for the next twenty-five days was 136 gallons. Bailing tests between February 14th and July 25th, 1945, gave a total of 280 gallons. During the final testing period, January 1st to 16th, 1946, the daily average had dropped to 1½ gallons.

1945 — Drilling of the most westerly well in the region was started in Holland township in December, 1945. It is an undertaking of the *Peninsular Oil Corporation,* with headquarters in Montreal, and the well is designated P.C. No. 1. It is some sixteen miles west of P.O.T. No. 40, in Larocque township, which was until then the most westerly well. P.C. No. 1 was started in the Cape Bon Ami formation and in December, 1947, it had reached a depth of 2,257 feet. Considerable interest attaches to this well in view of its westerly site and the low stratigraphic position of its surface location.

Conclusions

It is known, from the 'shows' of oil in seepages and in wells, that there is petroleum of good quality in this region. It has not yet been established that commercial deposits are present, but the fact that sixty-three wells have been drilled without finding such deposits is not proof of their absence. Few of the wells fulfilled the requirements of being favourably located in relation to anticlines and at the same time of having sufficient depth to test closed horizons.

The drilling results to date have shown that, generally, commercial deposits are not present at shallow depths in this region. But the fact that several of the wells did produce some oil despite unfavourable location, and that this production has come from any of three formations — Battery Point, York River, Grande Grève — may be considered encouraging. Furthermore, oil-bearing horizons — such as some reefy limestones of Lower Devonian and of Silurian age — have been observed in different places from the eastern end of Gaspé to the Matapédia valley in the west, but they have not been reached as yet in any of the drilling operations.

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OCHRE

The term 'ochre', as opposed to limonite or bog iron ore, is commonly used to designate those forms of iron hydroxide, usually with admixture of more or less clay, sand, and organic matter, which are used, not as ores of iron, but for the manufacture of pigments and polishing rouge, for colouring oil cloth and linoleum, and for such purposes as purification of coal gas. Deposits of bog iron ore that have been used for making iron are described on pages 395 and 396.

There are extensive deposits of such material in Saint-Maurice and Champlain counties adjacent to the north shore of the Saint-Lawrence river, northward from lake Saint-Pierre and the city of Trois-Rivières, and there has been continuous production from some of these since 1886. Total production to the end of 1944 has amounted to some 325,000 tons and for the four years 1941-44 it averaged nearly 9,000 tons per year.

The iron in these deposits was originally present in ferromagnesian minerals, and in other iron minerals such as pyrite and magnetite, in the granitic and other rocks of the Laurentian highlands. As the result of complete or partial solution of these minerals, the waters draining the highlands are iron-bearing, and where they enter lakes, or where they have spread over the flat, low-lying foreland, their iron content has, in course of time, been precipitated and converted eventually to ferric hydroxide, with which there is usually associated some clay, sand, and vegetal matter. The deposits that were formed in bogs and marshes are seldom more than three feet thick. In lakes that have survived, they are continually accumulating, and from some of these lakes the material has been dredged repeatedly, with intervals of several years to allow new deposits to form.

The principal operators in recent years, and the locations of the deposits they work, are as follows: the *Sherwin-Williams Company of Canada, Limited,* in the vicinity of Red Mill, in Champlain county, seven miles east of Trois-Rivières; *Thomas H. Argall,* Pointe-du-Lac, Saint-Maurice county; *Charles D. Girardin,* Vieilles-Forges, Saint-Maurice county, and Almaville and Saint-Louis-de-France, Champlain county; and the *Mauricy Oxide Company, Limited,* Saint-Adolphe, Champlain county.

The Sherwin-Williams Company operates two 'mines' and a calcining plant. The 'ore', after calcining at a high temperature, is finely pulverized in ball-mills. The product is used as a pigment in the paint and other industries and as a buffing material for plate glass and for polishing optical lenses. The other operators market air-dried, crude ochre for use in the purification of coal gas. Since the latter material has a relatively low value, exploitation of the deposits is governed by nearness to a market for the product.

On the south shore of the Saint-Lawrence, across from Trois-Rivières, there are extensive deposits of ochre but they are, in general, relatively thin and have rarely been worked.

As indicated above, the deposits from which the whole of the present production of ochre is obtained are adjacent to the north shore of the St. Lawrence river, lying within a belt which, from Trois-Rivières, extends southwest for ten miles to Pointe-du-Lac, Saint-Maurice county and northeast for a somewhat greater distance to Batiscan, Champlain county. The ochres occurring along this belt are high-grade iron oxide, most of the calcined material containing about 90 per cent Fe_2O_3, so that they have approximately the composition of goethite, $Fe_2O_3.H_2O$.

Numerous other occurrences, of equally high quality but less favourably situated for present exploitation, are known outside of this belt. Following are notes on some of those which have been investigated, or from which there has been a small production.

Labelle County

Lynch township, range IV, lots 18 to 21. First operated in 1919. Calcining and grinding plant burned down in 1924 (Osborne p. 42.)

Marchand township, range S. W. Rivière Rouge, lots 74, 75; range N.W. Rivière Rouge, lots 76, 77. This deposit is accessible by the automobile road that leads from l'Annonciation to l'Ascension. It lies in the old bed of Rouge river. Average thickness of ochre bed, 39 inches. Total estimated volume of ochre, 17,000 dry tons. Exploitation of the deposit was attempted in 1935 and 1937 (Aubert de la Rüe).

Saguenay County

Iberville township, range II, lots 19 to 22; range III, lots 23, 24, 25. In 1883, a small drying and calcining plant was erected near the mouth of Little Romaine river. It produced three to four tons of ochre weekly and was operated for several years (Faessler, 1931, pp. 103-105).

Bergeronnes township, range I, lots 8 and 9. Ochre deposit 100,000 square feet. Average thickness of ochre bed, 15 inches. Average Fe_2O_3 content, 91.2 per cent (Faessler, 1931, pp. 105-106).

Betsiamites township, Jérémie Islets. Numerous small deposits of ochre, not connected with one another (Faessler, 1933, pp. 130-135).

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PHOSPHATE (Apatite)

Apatite, for commercial purposes usually termed 'phosphate', occurs with mica (phlogopite) in numerous localities along and between the valleys of the Gatineau and Lièvre rivers, north of the Ottawa river, and the deposits were first mined for recovery of phosphate, with the mica going to the waste dumps. Production started about 1875 and during the decade 1882 to 1891 shipments averaged 22,000 tons a year, with a maximum of 28,535 tons in 1885. Then, the industry suddenly collapsed. In 1896, shipments totalled only 570 tons, and although there has been some production each year up to the present, the total for the fifty years 1895 to 1944 amounted to only about 26,000 tons, or an average of little more than 500 tons per year. Actually, although some of the old apatite mines have at times been re-opened for production of this mineral, it may be said that phosphate mining in the Province has long ceased, the small annual shipments representing, in general, material recovered as a 'by-product' in the mining of mica. The collapse of what had promised to be a permanent and thriving industry was not, however, due to exhaustion of reserves of ore, but to the development of extensive, and very much more cheaply mined, deposits of sedimentary phosphate rock (phosphorite) in Florida and Tennessee.

In the early years of the industry, almost the whole of the output was shipped to Great Britain, with minor amounts to the United States, for use in the manufacture of chemical fertilizers. From 1889 until 1902 some went to the fertilizer plant of G. H. Nichols and Company at Capelton, in the Eastern Townships. In 1903, a superphosphate plant was erected by the

Capelton Chemical and Fertilizer Company, Limited, on the Lièvre river, at Masson, near Buckingham Junction, but, with dwindling supplies of apatite from local mines, the ore for this plant was eventually wholly imported. The plant was finally closed down and dismantled in 1932. Earlier than this, in 1897, the *Electric Reduction Company, Limited,* had established a plant in Buckingham for the manufacture, chiefly, of elemental phosphorus and phosphorus compounds. In recent years, all the phosphate produced in Quebec mines has been sent to the Electric Reduction plant, whose present supply of ore comes almost entirely from Florida.

The mode of occurrence of the apatite is the same as that of the phlogopite (see p. 476), most of the deposits containing both minerals, with either one predominating. The deposits occur only in metamorphic pyroxenite and most usually are of the 'pockety' type, though some are distinctly vein-like. Apatite, however, appears to be more restricted in distribution than phlogopite. In referring to its occurrence in Quebec, Spence says (p. 108): "The Quebec apatite region includes some eight townships lying between or adjacent to the Lièvre and Gatineau rivers and situated immediately northeast of Ottawa. The greatest development of phosphate is found in the five townships of East and West Portland, Buckingham, Templeton, and Wakefield, while the mineral occurs to a lesser extent also in the townships of Derry, Hull, and Bowman. The apatite-bearing district may be said generally to include that section of country lying immediately north of the Ottawa river for a distance of some sixteen miles and between the Gatineau and Lièvre rivers. North of this area, as well as to the east and west, the deposits become smaller and more scattered, the most northerly occurrences of any consequence being in the neighbourhood [three miles north] of the High Falls, on the Lièvre river, thirty miles north of its junction with the Ottawa. As an accessory mineral in mica deposits, apatite is found to the west, north, and east of the already outlined region, small amounts of phosphates being found, almost invariably, associated with the mica at those mines of the latter mineral which lie scattered through the country north of the Ottawa river from the township of Calumet, in the west, to Buckingham, in the east. None of these occurrences, however, have proved to be of any economic importance . . . ".

In practically all of the deposits, and particularly in those containing much mica and calcite, some at least of the apatite occurs in well-formed crystals. These range from quite small to several inches, and even a foot or more, in diameter, some of the larger ones having a length of several feet. They are most frequently green, but brown and reddish-brown crystals are common; more rarely they are blue, grey, and even white. Most frequently, however, the apatite occurs as massive, crystalline material, dark green in colour, which forms the bulk of the filling of many of the large 'pockets'. Another mode of occurrence is as loosely coherent aggregates of small, rounded grains, usually with intermixed calcite grains. This 'sugar phosphate' is almost invariably sea-green in colour, with the associated calcite pale blue or greenish-blue.

All but about half a dozen of the very numerous operations were open pits and trenches, or adits opened in hillsides, and not more than about twenty were carried to a depth of 100 feet and only two or three to below 200 feet. The deepest workings are on the North Star property, on lot 18, range VII of Templeton township, on which an inclined shaft extends to a depth of 620 feet. This mine was one of the largest producers. Others were the High Rock mine, on lots 5 to 8, range VII West, and lots 1 and 2, range VIII West, Portland township, which has yielded about 65,000 tons of apatite; the Crown Hill or Little Union mine, on lots 3 and 4, range VII, of the same township, with shipments of some 35,000 tons; and the Emerald mine, on lot 19, range XII, Buckingham township.

With regard to reserves of phosphate ore in the district, Spence says (p. 13): "That large amounts of apatite still exist in the formerly exploited Canadian deposits, more especially in those of the Lièvre River district, in the Province of Quebec, is unquestionable. When the large mines in this area closed down in the early nineties, it was simply on account of the drop in price of the mineral and not because the deposits were exhausted.

Following is a list of the principal properties from which shipments of apatite have been made since 1935.

PROPERTIES FROM WHICH APATITE HAS BEEN SHIPPED

TOWNSHIP	LOCATION	MINE
HULL	Lot 13, range XV	*Connor*
"	Lot 15, range X W.	*Rainboth*
WAKEFIELD	Lot 30, range IX	*O. Perron*
TEMPLETON	Lot 10, range X	*Blackburn*
"	Lot 15, range VIII	*Phosphate King*
BUCKINGHAM	Lot 18, range XII	*Squaw Hill*
"	Lot 19, range XII	*Emerald*
PORTLAND	Lots 3 and 4, range VII West	*Little Union* or *Crown Hill*
"	Lots 5 to 8, range VII West, and lots 1 and 2, range VIII West	*High Rock*
"	Lot 18, range VII East	*North Star*
BOWMAN	Lot 27, range V	*Brazeau*

"The deepest mine in the district — the North Star . . . — was shut down with large bodies of apatite still in sight at 600 feet; and there is no reason to suppose that the majority of other large mines in the district, opened on deposits of a similar nature and carried, in most cases, to only shallow depths, were by any means worked out. The accessible portions of many of these mines still display considerable quantities of phosphate in pockets and bunches in the walls of the openings and there is little doubt that large bodies of mineral still remain, both in the deeper portions of the deposits and also, in some cases, in the pyroxenic rock adjacent to the main openings".

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PYRITE (Sulphur Ore)

Eastern Townships

In most of the copper mines that were active in the Eastern Townships during the period 1860 to 1939 — when the last of them, the Eustis, was closed — the orebodies consisted of pyrite and chalcopyrite, with the former greatly predominating. These deposits are described under the heading of *Copper* (pp. 383-391). In the early years of operation, the ores were shipped to England and the United States or, at some of the mines, were roasted locally and the sulphur dioxide allowed to escape into the atmosphere. As early as 1869, a small sulphuric acid plant was erected near Saint-Jean d'Iberville, for the purpose of recovering the sulphur content of ore from the Eustis mine, but there was at that time no market for the acid and the project failed (Bancroft, p. 27). Commencing about 1880, increasingly large tonnages of ore were shipped from the mines to sulphuric acid works in the United States, and, in 1887, G. H. Nichols and Company (now the *Nichols Chemical Company*), who operated two mines in the district, erected a plant at Capelton, in Ascot township, for the manufacture of sulphuric acid (Bancroft, pp. 221-2; Wilson, p. 57). Thereafter, ore from a number of the mines in the Eastern Townships was shipped to this plant, where its sulphur content was recovered.

In 1936 the pyrite reserve (sulphur ore) of the Eustis mine were stated to be over 1,500,000 tons (Snow and Brownhill, p. 76).

There are no means of estimating how much sulphur was recovered during this period from the ores treated at Capelton, or from those shipped abroad, as it is only since 1926 that production of 'pyrite' ore has been recorded separately from 'copper' ore. From then until 1939, total production of pyrite ore from Eastern Township mines amounted to some 350,000 tons, averaging possibly 40 per cent sulphur. This has come chiefly from the Eustis (lots 2 and 3, range IX, Ascot township), Capelton (lots 3 and 4, range VIII, Ascot), Weedon (lot 22, range II, Weedon), and Huntingdon (lot 8, range VIII, Bolton) mines, but the Moulton Hill (lots 23 and 24, range III, Ascot) and the Howard (lot 5, range XI, Ascot) mines yielded substantial amounts of pyrite ore for a few years prior to 1900. Other contributors mentioned by Wilson (p. 59) are the King (lot 4, range XI), Clark (lot 11, range VII), Sherbrooke (lot 12, range VII), Hepburn (lot 7, range IX), and Suffield (lot 3, range XI) mines, all in Ascot township. Between 1914 and 1916, about 10,000 tons of pyrite ore was shipped from the Stratford pyrite deposit, on lot 8, range VI, Stratford township (Burton, pp. 134-136).

Western Quebec

Lenses of ore consisting largely of pyrite occur in some of the Western Quebec copper mines, and there have been shipments of such ore since 1932. Total production to the end of 1944 amounted to 1,382,038 tons, with the average for the four years 1941-44 nearly 300,000 tons a year. The whole of this has come from the Aldermac (pp. 135-138), Horne (pp. 338-361), and Waite-Amulet (pp. 361-383) mines.

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QUARTZ AND INDUSTRIAL SAND

Sandstone and quartzite account for about 80 per cent of the quartz produced in Quebec for industrial uses, with the remainder obtained from vein and pegmatite quartz and from gravel and sand deposits. Production figures, available only since 1910, show a total output of about 1,800,000 tons for the thirty-five years to the end of 1944. The bulk of the output is used in Quebec, but shipments are made also to Ontario, the Maritime provinces, and Newfoundland.

The expansion in recent years of industries using quartz as a constituent of, or in the manufacture of, their products is well shown by the fact that, of the total tonnage mentioned above, more than one-half was produced in the five years 1940-44. The output of 236,091 tons in 1944 consisted of 146,931 tons of sandstone (Potsdam), 40,088 tons of quartzite (Grenville), 30,000 tons of quartz from veins and pegmatite dykes, and 19,072 tons of sand and gravel.

The quartz is used in a wide variety of industries, some of which consume very large quantities of the material. The chief uses are in the manufacture of glass, pottery and other vitrified wares, silica brick, ferro-silicon and elemental silicon, and carborundum (silicon carbide), and, of the quartz itself, as an abrasive, blasting sand, foundry sand, flux, furnace lining, and retarder in cement. For use in the manufacture of most of the products mentioned, quartz of high purity is essential; for general uses, specifications are less rigid.

Beds of sandstone and quartzite, both Palæozoic (Potsdam) and Precambrian (Grenville), are widely distributed in certain parts of the Province, and in many localities the silica content of the rock closely approaches 100 per cent. Also, and particularly in areas underlain by rocks of the

Grenville series, there are numerous occurrences of quartz in pegmatite bodies and quartz veins. The Province thus has large resources in quartz suitable for industrial uses. Quartz, however, is a comparatively low-priced material and, except in very exceptional circumstances, it must seek local markets. In the opening of quarries, therefore, the first consideration—provided the rock is of suitable character—has been the location of the deposit with respect to transportation facilities and markets.

For a comprehensive survey of the sandstone, quartzite, and other industrial silica resources of the Province, and of their exploitation, reference may be made to the report by L. Heber Cole, entitled *Silica in Canada*, published in 1923 by the Mines Branch, Department of Mines, Ottawa. All analyses given in the descriptions that follow are taken from Cole's report.

Potsdam Sandstone

A belt of Potsdam sandstone, rarely as much as five miles wide, flanks the Laurentian upland southwestward from near Saint-Maurice to Saint-Jérôme, and, at widely spaced intervals still farther westward, beds of the rock occupy small areas along and adjacent to the north shore of the Ottawa river, as near Fassett and Masson, in Papineau county, and near East Templeton, in Hull county.. The formation has its greatest development, however, southward from Saint-Jérôme where, flanked by overlying Ordovician (Beekmantown) limestone beds, the sandstone occupies a strip of variable, but considerable, width which extends across the counties of Two Mountains, Vaudreuil, Beauharnois, Chateauguay, and Huntingdon, and has a width at the International boundary of thirty miles.

Although usually referred to as sandstone, the rock actually is a quartzite in which the original quartz grains are cemented by secondary silica. In general, it is fine grained, cream to white in colour, and crushes easily. Numerous analyses indicate that, in most localities, the rock contains upwards of 97 per cent SiO_2 and that the Fe_2O_3 content is only a small fraction of one per cent. A large output of Potsdam sandstone is recovered each year from quarries in widely separated parts of the Province.

Saint-Canut, Two Mountains County.—Saint-Canut village is five miles southwest of Saint-Jérôme. About two miles east of the village, on cadastral lots 125 to 130 of Saint-Canut parish, a dome-like mass of sandstone rises to a height of forty feet above the surrounding country. Quarrying has been carried on here since 1919, first by the Cascades Silica Products Company, Limited, and since 1929 by the *Canadian Carborundum Company, Limited.* The quarry, which is on the west side of the mass, had a length, in 1947, of 720 feet, a width of 640 to 880 feet, and a face averaging 30 feet high. The stone is white, fine grained, and crushes easily. Average material contains 99.20 per cent SiO_2, and 0.48 per cent Fe_2O_3. The output, after crushing and washing at the quarry, is shipped to the Company's plant at Shawinigan Falls for use in the manufacture of carborundum. Some very finely ground material is sold to the *Canada Cement Company, Limited,* who use it as a retarder in cement.

The sandstone is well developed also at Saint-Scholastique, some five miles south of Saint-Canut, and the rock has been quarried here for use in the manufacture of bottle glass, for steel foundry work, and for furnace linings (Cole, p. 50).

Beauharnois County.—Sandstone outcrops almost continuously along the south shore of the Saint-Lawrence river between Mélocheville and Beauharnois, and several quarries have been opened in the vicinity of the first-named village. Two of these are operated by, respectively, *Saint-Lawrence Alloys and Metals, Limited,* and *Euclide Montpetit.* After coarse crushing, the output from both operations is shipped mainly to the Beauharnois plant of Saint-Lawrence Alloys and Metals, where it is used in the production of ferro-silicon and elemental silicon.

Some fourteen miles south of Mélocheville, the sandstone is well exposed, or lies beneath a very thin cover of soil, over an area of six to seven square miles in what are known as the 'Blueberry flats', near Cairnside, south of Brysonville, Chateauguay county. Still farther south, outcrops are plentiful on lot 6, range III of Franklin township, Huntingdon county, near the International boundary. Analyses show that, in some places at least, the rock has a high silica content, but up to the present no quarries have been opened in these deposits.

At Cascades Point, which is on the north shore of the Saint-Lawrence across from Mélocheville, sandstone was quarried many years ago by the *Cascades Silica Products Company, Limited,* for use in the manufacture of glass, for foundry sand, and as building stone. In 1919, all machinery was removed from this quarry to the Company's property at Saint-Canut, referred to above.

Buckingham District.—Potsdam sandstone forms a prominent ridge near the Canadian Pacific railway in the vicinity of East Templeton, Papineau county. Stone from a quarry about one mile west of East Templeton, operated by the *Ottawa Silica and Sandstone Company, Limited,* was used until 1941 as sand-blasting material and as a retarder in cement. East of here about ten miles, near Masson, at the mouth of Lièvre river, in Buckingham township, the sandstone is quarried for use as a flux in the production of phosphorus and its compounds at the Buckingham plant of the *Electric Reduction Company, Limited.*

Quartzite closely resembling Potsdam 'sandstone' forms a series of ridges adjacent to and paralleling the south shore of the Saint-Lawrence river between L'Islet and Saint-André, in the counties of L'Islet and Kamouraska. Dresser (pp. 14-20) named this the Kamouraska formation and assigned it tentatively to the Middle Lower Cambrian. Except for occasional narrow bands of a conglomerate which contains pebbles of limestone or dolomite, the rock is clean quartzite, high in silica. It has been quarried locally for use as building stone.

The Pilgrim islands, which lie near the shore of the Saint-Lawrence river between Saint-André and Rivière-du-Loup, are formed of this quartzite. Analysis of a sample taken by Cole on Long Pilgrim island gave 98.24 per cent SiO_2, 0.24 per cent Fe_2O_3. There are no quarries on the islands.

Still farther to the northeast, in Rimouski and Matane counties, bands of quartzite of the same general character, lying within Lower Ordovician

(Sillery) shale and sandstone, are numerous adjacent to the Saint-Lawrence and for several miles inland, particularly in the vicinity of Baie-des-Sables and Saint-Moïse. In places, as near Saint-Moïse, this quartzite has been quarried for use as building stone (Aubert de la Rüe, pp. 13-14, p. 38).

Guigues Township, Témiscamingue County.—Ordovician sandstone is quarried by *Flint Sands, Limited,* from beds outcropping on lot 19, range II of Guigues township. The material is used for sand blasting (see p. 306).

Grenville Quartzite

Kilkenny Township, Montcalm County.—Some development work was done during 1943 on a quartzite deposit on lot 1, range II of Kilkenny township. A small crushing and screening plant was installed and some shipments of the product were made for trial purposes.

Saint-Rémi d'Amherst, Papineau County.—Kaolin-bearing quartzite deposits at Saint-Rémi have been worked for many years, first by *Canadian Kaolin Silica Products, Limited,* and later by *Canada China Clay and Silica, Limited,* for recovery of both quartz and kaolin (see p. 467). The crushed quartz is used in the manufacture of glass, carborundum, and silica brick, for sand blasting, and as foundry sand.

Quartzite of the Grenville series occurs at numerous other localities in the Lièvre River district, adjacent to the north shore of the Lower Saint-Lawrence, and elsewhere. On both sides of Batiscan river in the vicinity of Notre-Dame-des-Anges, heavy bands of white quartzite form the most prominent member of the Grenville series (Bancroft, p. 110). Analyses of the rock indicate that it might be suitable for manufacture of ferrosilicon, but the difficulty of obtaining it free from included bands of mica schist might increase the cost of preparing a marketable product (Cole, p. 57).

White quartzite of high purity forms hills several hundred feet high a few miles inland from the Saint-Lawrence river in Bergeronnes and Escoumains townships, Saguenay county, some twenty miles below the village of Tadoussac. Rock of this type is particularly well developed in range VI of Bergeronnes township, near des Iles, Raymond, and Duclair lakes (Faessler, pp. 79-80).

Vein Quartz and Pegmatite Quartz

Buckingham District.—The Grenville rocks in the Buckingham district, northward from Hull, are in many places intruded by pegmatite dykes and cut by quartz veins. These are particularly numerous in the vicinity of Lièvre river. It is from this district that most of the feldspar production of the Province has come (see pp. 461-463), and at several of the mines the output includes quartz as well as feldspar. Small amounts of quartz are quarried intermittently from other deposits, either pegmatite dykes or quartz veins, in this general area and are shipped to the plant of the *Electric Reduction Company, Limited,* at Buckingham, for use as flux.

Lake Saint-Jean Region.—A large mass of white vein-quartz outcrops near Bouchette lake, between lots 2 and 3, range III of Dequen township, some twelve miles south of Saint-Jean lake. The exposed outcrop is 630 feet in length, with a maximum width of 142 feet. Most of the quartz is pure milk-white and massive, with small vugs filled with colourless quartz crystals. A careful sampling of the surface of the mass gave a high tenor in silica (Denis). The accompanying table gives the results of analyses of chip samples taken every six inches across the width of the deposit.

ANALYSES OF BOUCHETTE LAKE QUARTZ

WIDTH (feet)	SiO_2 %	WIDTH (feet)	SiO_2 %	WIDTH (feet)	SiO_2 %
53	99.89	114	99.95	57	99.71
51	99.82	99	99.84	47	99.94
75	99.91	117	99.96	38	99.65
142	99.71	60	99.89	39	99.91

During 1944, several thousand tons of mine-run quartz from this deposit was shipped to the Beauharnois plant of *Saint-Lawrence Alloys and Metals, Limited,* by the operator of the deposit, the *Industrial Silica Corporation, Montreal.*

Watshishou Knoll, Lower Saint-Lawrence River.—Jacques Claveau, Geologist, Quebec Department of Mines, has recently (1944) described an extensive occurrence of quartz on Watshishou knoll, which rises to an elevation of 130 feet above the coastal plain between Watshishou and Little Watshishou rivers at a point seven and a half miles east of the village of Johann Beetz, on the north shore of the gulf of Saint-Lawrence. The locality is 400 miles down the river from Quebec city and immediately north of the central part of Anticosti island. The hill as a whole consists of Grenville-type quartzite which is intruded by basic dykes and by much pegmatite and aplite, adjacent to which the rock is intensely brecciated and injected by quartz. Along the south flank of the hill, the rock is fairly pure quartz over a length, northeast, of more than 2,000 feet and for a maximum width of 200 feet. Away from the border of this zone, the quartz is, as a rule, very pure, analyses of average samples giving 97.67 to 99.35 per cent SiO_2 and only 0.015 to 0.06 per cent Fe_2O_3. With regard to the commercial possibilities of this deposit, Claveau says: "The quartz could be mined cheaply by open pit from the south side of the hill, at its east end, where the lens has its greatest thickness. The most favourable point for loading the ore on small boats would be Watshishou harbour, on the north side of Watshishou knoll and the distance involved would be less than two miles".

ALLUVIAL SAND AND GRAVEL

Deposits of alluvial sand and gravel suited for industrial uses are found in many parts of the Province, and from some of these there are shipments each year of an appreciable tonnage of material, which is used chiefly for core sand, filter sand, and as a filler in the manufacture of fertilizers. Following are some of the localities from which shipments have been made in recent years.

Sainte-Julienne, Rawdon township, Montcalm county (core sand).

Saint-Jovite, Terrebonne county (core sand).

Sainte-Emélie, Joliette county (filter sand).

Joliette district, Joliette and Berthier counties (foundry and filter sand).

Saint-Bruno, Chambly county (filler in manufacture of fertilizers).

Farnham, Missisquoi county (foundry and filter sand).

Brigham, Brome county (foundry and filter sand).

Quartz pebbles for use in tube-mills in gold milling plants have been obtained from a deposit at Ceramic, Témiscamingue county. Quartzite quarried at Glen Almond, Buckingham township, is used as grinding pebbles by the *Canadian Flint and Spar Company, Limited*, at Buckingham.

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SOAPSTONE AND TALC

Massive impure talc, or soapstone, occurs at numerous points along the 'Serpentine belt' of the Eastern Townships, and particularly in the sill-like body of peridotite known as the Pennington dyke, in Broughton township, Beauce county. Like the serpentine elsewhere along the belt, it is a product of alteration of the peridotite. Early settlers in the district made use of the soapstone for lining ovens and fire places, and in 1871 some 300 tons of the material was quarried from a deposit in Bolton township, Brome county. There were intermittent small shipments from various deposits during the years 1886 to 1900, but the industry did not become firmly established until 1920. Until 1939, the output was relatively small, totalling only 28,390 tons to the end of that year, but since then markets for the material have steadily expanded and production in 1944 amounted to 19,013 tons. Most of the output has been shipped in the form of sawn blocks and used for lining alkali recovery furnaces in pulp mills.

Detailed descriptions of the soapstone and talc deposits of the Province are given on pages 95 to 114 of the report by M. E. Wilson on *Talc Deposits of Canada*, published by the Geological Survey in 1926, and on pages 81 to 100 of the more recent (1940) report by Hugh S. Spence on *Talc, Steatite,* *and Soapstone; Pyrophyllite*, published by the Bureau of Mines, Department of Mines and Resources, Ottawa.

Mégantic and Beauce Counties

Referring to the occurrence and mining of soapstone in the Eastern Townships, Spence writes (pp. 82-83): "The whole of the talc and soapstone production of Quebec province for many years past has been derived from deposits in the adjacent townships of Broughton, Beauce county, and Thetford and Leeds, Mégantic county, where for the past eighteen years there has been a small but sustained output. The output of talc has been of minor proportions, consisting of a small tonnage mined from narrow bands of grey talc cutting across the soapstone bodies . . .

"The soapstone of this district is of somewhat variable character, ranging from a less highly altered, impure, medium textured rock . . . to a more highly talcose, fissile type that might more properly be classed as straight talc . . .

"The region undoubtedly contains important reserves of a good quality of soapstone, suitable for general refractory use; and the more highly talcose zones, as on lots 4 and 5, range V of Thetford township, would yield a good grade of off-colour, substantially lime-free, grey talc suitable for grinding. The deposits are relatively narrow, 12 to 20 feet being the average, and the dip is sometimes rather flat, adverse factors to large-scale quarry operations by channeling methods.

"Universal practice in the mining of soapstone in the district has been to cut the stone out in blocks of, roughly, one cubic yard size by means of light drills fitted with chisel-edged steel. The quarry blocks are lifted by derricks onto small flat-cars which run to nearby sawing sheds".

The principal operator in the district is the *Broughton Soapstone and Quarry Company, Limited*, successor in 1930 to the *Robertsonville Soapstone and Quarry Company, Limited.* When the latter Company was formed in 1923, it took over the operation of a quarry near Robertsonville, on lot 4, range V of Thetford township, but in the same year a new quarry was opened on lot 12, range X and XI of Broughton township, about a mile and a half from Leeds station, on the Quebec Central railway. This became, and has remained, the principal operation of the Company. The quarry has surface dimensions 250 feet by 225 feet and is 75 feet deep, exposing a continuous band of uniform, grey-green soapstone. Some other pits have been opened to the west of the main quarry in what appears to be the same band. The stone, which weighs 180 pounds per cubic foot, saws easily, has high structural strength, and has proved excellent material for lining pulp-mill furnaces. This has been the chief market for the output and, besides being used extensively in the Province of Quebec for this purpose, the sawn blocks have been shipped as far west as Dryden, Ont., and east to Bathurst, N.B. The Company also fashions monuments from the stone, as well as crayons and a variety of shaped and turned ornamental objects. The dust from sawing, and also stone specially ground, is marketed as a filler which is used in the roofing, paper, rubber, and other industries and for the manufacture of putty. Much of the material ground for such uses is translucent talc containing chlorite and other impurities, a band of which runs through the middle of the quarry.

This Company has also produced soapstone at various times from quarries on lot 8, range X, Broughton; lot 13, range III, Thetford; and lot 15, range XV, Leeds township.

There has been intermittent production from several other properties in Mégantic and Beauce counties. In recent years, this has included shipments by *Charles Fortin* from a quarry on lot 2, range V of Thetford township, and by the *L. C. Pharo Company, Limited,* whose quarry is on lot 12, range IV of Leeds township.

Richmond and Wolfe Counties

In 1918-26, some 200 tons of soapstone was produced by the *Canada Paper Company, Limited,* from a quarry on lot 23, range IV, Melbourne township, Richmond county. The output was sawn into blocks and used for furnace lining.

In, or prior to, 1888 there was a production of about 150 tons of talc from a deposit on lot 19, range II of Wolfestown township, Wolfe county. The material was ground for use as a dry lubricant and as a filler in fireproof paints (Ells, p. 152).

There has been a small output, also, from deposits on lots 43 and 44, and 49 and 50, range I of Ham township, Wolfe county.

Brome and Stanstead Counties

Surface work has been done on upwards of fifteen soapstone prospects in Brome county, and small shipments have been made from some of these. Most of them are in the townships of Bolton and Brome. Since 1939, however, the only operator in this county has been the *Baker Mining and Milling Company, Limited,* whose property is on lots 5 and 6, range II of Potton township. This is one of the very few occurrences in the district where the talc occurs, not in rock of the Serpentine belt, but in an obscure schist of the Sutton series. The talcose schist is exposed in a steep hillside that slopes toward the Canadian Pacific railway, a few hundred feet north of the workings. The nearest station is at Highwater, a mile and a half distant, but a short railway spur connects the mill with the main line nearby.

Two bands of the talc, from 20 to 40 feet wide and 75 feet or more apart, strike up the hillside in a southwesterly direction, with dip 50° to 60° southeastward. An adit, 190 feet long, has been opened in the hillside and, at a point 150 feet from the portal, a cross-cut has been driven eastward for 165 feet or more. The talc is mined from this cross-cut by a shrinkage stoping system. Up to the present, the operation has been confined to the east band. The broken ore is trammed out of the adit to storage bins, from which it passes over a belt conveyor to a pulverizing mill.

The talc is fine grained, in part foliated, and is greenish-grey to practically white in colour. The entire output is ground, and much of it has been shipped to England.

In Stanstead county, which adjoins Brome on the east, soapstone deposits occur on lots 19 to 20, range V of Hatley township, and on lot 13, range IX, Stanstead township.

Gaspé Peninsula

Early reports of the Geological Survey record the occurrence of veins of steatite of a light green colour along Ste-Anne river near mount Albert, in Gaspé-Nord county (Low, 1885), but apparently the commercial possibilities of these occurrences have not been investigated.

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MINERAL BUILDING MATERIALS

CEMENT

The manufacture of cement is an important industry in the Province of Quebec. Production in 1944 amounted to 3,400,000 barrels (350 lb.), or more than 45 per cent of Canada's total output of 7,300,000 barrels, to which five provinces contributed. The whole of the Quebec production comes from two plants of the *Canada Cement Company, Limited,* one, the larger, in Montreal East, the other in Hull. The chief ingredients for making cement are obtained from deposits adjacent to the plants, both of which use the wet process of manufacture. The following notes are based on data kindly furnished by the late A. G. Fleming, Chief Chemist for the Canada Cement Company.

Montreal East Plant

The plant in Montreal East has a rated daily capacity of production of 10,000 barrels and the output has frequently exceeded that figure. The quarry, which has an area of 204 acres and an average depth of about 85 feet, is in the upper beds of the Trenton formation. The limestone is fine grained, argillaceous, and for the most part thin-bedded, with frequent interbeds of shale. Intruding the limestone are a number of dykes and sills of camptonite, nepheline syenite, and related rock types, and, in quarrying, as much as possible of the nepheline syenite is discarded because of its relatively high alkali content and also because the ratio of silica to iron oxides and alumina in this rock is too low to permit its substitution for more than a very small proportion of the clay or shale required in the composition of the cement 'mix'. Most of the needed alumina and silica is furnished by the argillaceous material in the limestone and by the interbeds of shale, and the average product of the quarry is not very far from the desired composition of the raw mix, a circumstance largely responsible for the establishment of the plant at this locality and for its subsequent expansion. To correct deficiency in silica, a small amount of crushed Potsdam sandstone is added. This is obtained from a deposit at St-Canut, Two Mountains county (see p. 495), from where the crushed material, a waste product, is hauled by truck to the cement plant.

Following are analyses of the limestone and shale from various levels in the quarry, and of the raw mix as sent to the kilns:

Analyses of Limestone, Shale, and Raw Mix, Montreal East Plant of the Canada Cement Company, Limited

	1	2	3	4	5	6
SiO_2	12.87	11.30	12.80	10.66	20.49	13.16
Fe_2O_3	1.15	1.20	1.17	1.09	10.40	6.04
Al_2O_3	4.45	4.10	4.38	3.77		
CaO	42.35	43.25	42.45	44.14	35.00	41.48
MgO	2.00	2.10	2.00	1.99	2.20	2.32
Loss on ignition	36.00	36.70	36.12	37.08	29.80	35.20
	98.81	98.65	98.92	98.73	97.89	98.20

1.—Top 30 feet of strata in quarry.
2.—Middle 20 feet of strata in quarry.
3.—Bottom 20 feet of strata in quarry as exposed in new face in floor of quarry.
4.—General sample of limestone nearly free from shale.
5.—General sample of shale interbeds.
6.—Raw mix as sent to kilns.

The following analyses of core from a drill hole put down at a point 400 feet north of the quarry illustrate the general uniformity in composition of the limestone in the upper beds of the Trenton formation in this area from the surface to a depth of 142 feet.

ANALYSES OF TRENTON LIMESTONE FROM SURFACE TO DEPTH OF 142 FEET. QUARRY OF CANADA CEMENT COMPANY, LIMITED, AT MONTREAL EAST

DEPTH FROM SURFACE (Feet)	SiO_2	Fe_2O_3 $+Al_2O_3$	CaO	MgO	LOSS ON IGNITION	TOTAL
0-10	11.22	4.40	44.60	2.07	38.30	100.59
10-20	11.14	4.46	44.50	2.11	37.20	99.41
20-30	18.46	7.86	36.38	2.69	32.22	97.61
30-40	20.52	10.42	34.83	2.25	29.84	97.86
40-50	12.26	5.26	42.61	2.17	36.42	98.72
50-60	11.62	5.22	43.65	2.21	36.84	99.54
60-70	8.66	4.36	45.87	1.66	38.14	98.69
70-80	10.12	4.86	44.76	1.94	37.52	99.20
80-90	10.58	4.84	44.21	2.28	37.04	98.95
90-100	11.30	5.14	42.52	2.92	36.48	98.36
100-110	10.72	4.94	44.21	2.18	36.78	98.83
110-120	8.14	4.44	46.28	1.98	38.58	99.42
120-130	8.08	4.42	45.50	2.88	38.90	99.78
130-142½	9.16	4.80	45.57	2.26	38.10	99.89

All the above analyses were made in the Company's laboratories. They are reproduced here from the report on *Limestones of Canada*, by Goudge (p. 112).

HULL PLANT

This plant, on the northern outskirts of the city of Hull, was originally owned by the International Portland Cement Company, Limited, who commenced operations about forty years ago, using the dry process of cement manufacture. It was converted to the wet process by the Canada Cement Company in 1929. The installation consists of a huge kiln, 360 feet long and 12 feet in outside diameter, with a capacity of more than 2,500 barrels daily. The limestone quarry, adjacent to the plant, has dimensions 700 feet by 500 feet, with depth 65 feet. As at Montreal East, the limestone is of Trenton age but the beds here are lower in the formation and the rock is a relatively pure high-calcium limestone. Analyses by the Company of chip samples taken at three-foot intervals in a well drilled (with a churn drill) to a depth of 245 feet are tabulated in the report by Goudge (pp. 64-65) already referred to. Goudge (p. 71) gives the following analyses of samples taken in the quarry:

ANALYSES OF LIMESTONE, CANADA CEMENT COMPANY'S HULL QUARRY

Sample No.	SiO_2	Fe_2O_3	Al_2O_3	$Ca_3(PO_4)_2$	$CaCO_3$	$MgCO_3$	Total
1	2.62	0.16	0.36	0.28	95.34	1.72	100.48
2	12.98	0.54	1.14	0.22	83.14	0.53	98.55
3	1.34	0.16	0.32	0.33	95.53	2.66	100.34
4	8.50	0.87	0.67	0.44	85.46	3.80	99.74

1.—Coarse grained part of upper beds.
2.—Fine grained part of upper beds.
3.—Next 21 feet.
4.—Lowest 24 feet.

Besides furnishing limestone for the cement plant, this quarry supplies a large proportion of the limestone aggregate used for concrete construction in the cities of Ottawa and Hull. The stone from the crushers is passed through a screening plant and separated into the sizes most in demand for concrete aggregate, and fines, or minus-quarter-inch material, which goes to the cement plant. Clay to supply the necessary alumina and silica is obtained from a pit to the northeast of the plant, to which, after washing, the clay 'slip' is piped. Following are average analyses of the limestone and clay used for the cement mix:

ANALYSES OF LIMESTONE AND CLAY USED FOR CEMENT MIX
HULL PLANT OF CANADA CEMENT COMPANY

	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Loss on Ignition	Total
Limestone	4.66	0.60	0.22	51.30	1.50	41.24	99.52
Clay	53.70	17.80	9.00	3.72	4.95	8.30	97.47

A certain amount of silica is added to the mix to correct the low ratio of silica to alumina and iron oxide and bring it to the composition used by the Company in all their cement plants. Formerly, this silica was obtained from the sandy overburden of the quarry and from adjoining ground, and, after these supplies were depleted, from a deposit of Potsdam sandstone at East Templeton (see p. 496). Since 1941, however, sandstone from Bells Corners, Ontario, has been used for this purpose.

REFERENCE

GOUDGE, M. F., *Limestones of Canada, Their Occurrence and Characteristics: Part III.—Quebec;* Mines Branch, Dept. of Mines, Ottawa, Pub. No. 755 (1935).

CLAY AND SHALE*

Quebec possesses widespread and abundant supplies of clay and shale suitable for the manufacture of such products as brick, structural and drain tile, and sewer pipe, but up to the present very few deposits of high-grade fire clay or pottery clay have been found in the Province.

*By HOWELLS FRECHETTE, formerly Chief, Ceramics and Road Materials Division, Mines Branch, Department of Mines, Ottawa.

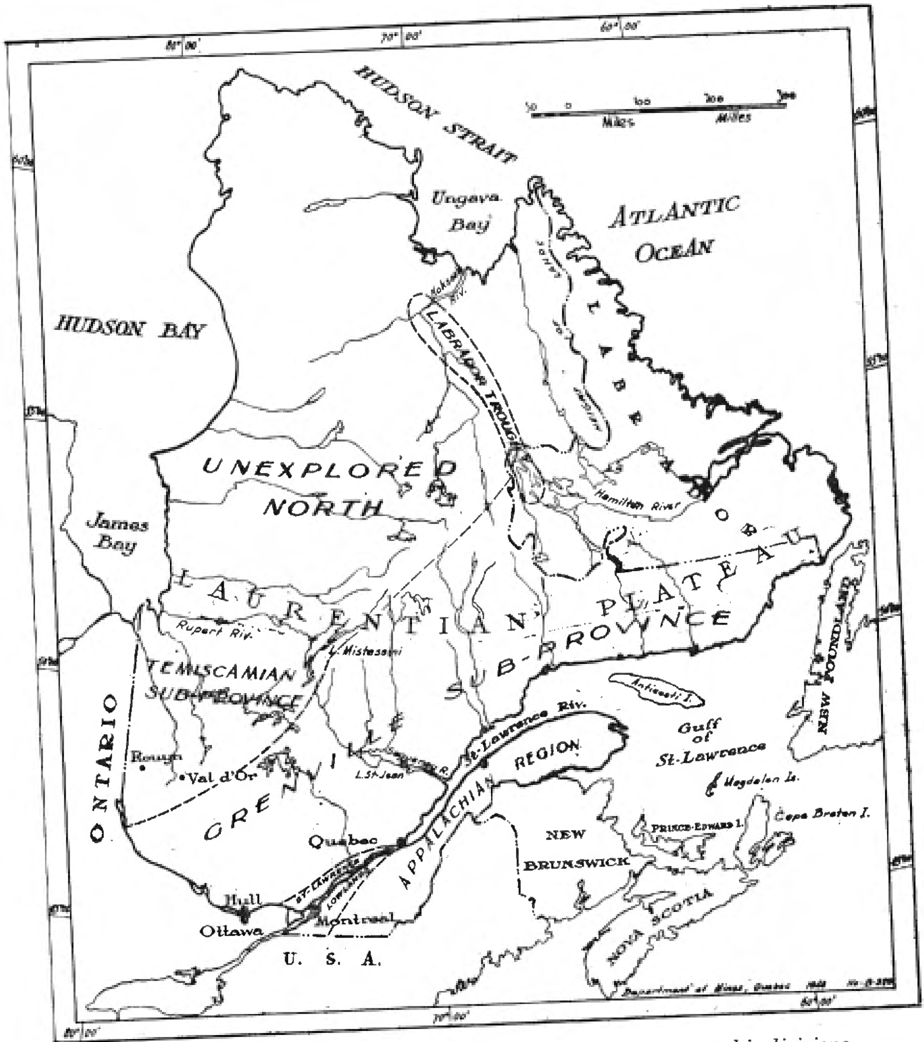

FIGURE 79.—*Sketch map of the main geological and physiographic divisions of the Province of Quebec.*

In 1947, the total value of the mineral production of the Province was \$147,000,000. Twenty-five years earlier it amounted to only \$20,000,000. A major factor in this increase was the discovery and development, in the second quarter of this century, of the metal mining field of Western Quebec, in the Canadian Shield formations. At the same time, however, large increases have been registered in the production from mining centres well established years previously, in the Appalachian region and in the Saint-Lawrence lowlands. In other words, new mineral resources have been discovered and brought into production in the past both in new fields and in long established centres of mineral production.

Clays and shales are classified industrially according to the wares that may be manufactured from them. The suitability of a clay for any special purpose is governed by its degree of purity and by the nature of the impurities. These have a direct bearing on the physical properties of the clay—its plasticity, shrinkage during drying and firing, liability to crack, maturing temperature, firing range, softening temperature, and fired colour.

Residual Clay

Kaolin, or china clay, is a residual clay derived usually from the disintegration of the feldspathic constituent of granite or other rock. The pure material consists of hydrous silicates of aluminium, but frequently a small percentage of iron also is present and, in the actual deposits, there may be a very appreciable amount of admixed quartz and other minerals, from which the kaolin may be separated by washing. When free from iron oxide and other colouring oxides, the kaolin burns white and is valuable as a raw material for the production of high-grade ceramic wares, for the filling and coating of paper, for rubber loading, and for numerous other uses.

Owing to deep erosion by glaciation, the residual deposits that probably existed in Quebec in pre-glacial times have, for the most part, been removed. As a consequence, very few deposits of kaolin have been found in the Province. The most noteworthy occurrence is two miles south of Saint-Rémi-d'Amherst, in Papineau county (see p. 467). These deposits have been worked as a source of both china clay and silica at various times since 1910 and have produced almost the entire reported output of china clay in Canada. There are other occurrences one mile north of Saint-Rémi, on the bank of Pike creek, and twelve miles eastward, at a point four miles southeast of Brébœuf.

Kaolin was discovered in Low township, Hull county, about 1915 on an island in Gatineau river above Paugan falls, thirty-five miles north of Ottawa (Keele, 1920, p. 109). The deposit appeared to be of very small extent and, with the development of the water power at the falls, it was submerged. Several miles to the west of here, near Low, kaolin was encountered in the digging of a post-hole beside the highway.

In 1940, a deposit of kaolin was discovered on the east shore at the southern end of Thirty-One-Mile lake, in Blake township, Gatineau county. Test-pits, trenches, and bore holes revealed that this deposit is of considerable extent and depth and that it contains both white and off-coloured kaolin, but certain mining problems have delayed its exploitation.

Attention is directed to these occurrences of kaolin in the Province, not because they are all of economic importance, but because, occurring as they do at intervals over an east-west distance of about sixty miles, there is a possibility of further discoveries of kaolin in this general area.

Another deposit of what may be classed as a residual clay is reported by P. E. Bourret(*), Mining Engineer, Quebec Department of Mines, as occurring on cadastral lots 427 and 428, parish of L'Ange-Gardien, Côte-de-Beaupré seigniory, about ten miles west of Chateau-Richer. The material outcrops on both banks of Laval river for a distance of about 1,000 feet and

*Personal communication.

over a width, in places, of more than forty feet. Bourret states that it is possibly a highly altered anorthosite and consists of a mixture of semi-granular rock material and clay matter. It varies in colour from greyish-white to pink. Colour, impurities, transportation, and coarseness of the material present difficulties that may delay the exploitation of this deposit, and finding a market for the product.

SHALE

Beds of shale, of various geological ages, occur at numerous points in the Province. Some of these shales are of economic importance as a source of raw material for the manufacture of brick and tile, but in no occurrence has shale been found with a sufficiently high softening point to suit it for use as a refractory.

Sillery Formation

This formation, lying to the south of the St. Lawrence river between Granby and Rivière-du-Loup and extending over a small area near the city of Quebec, consists chiefly of shale interstratified with thin beds of sandstone. In most localities, the shales have been so hardened that they have more the qualities of schist than of shale. Keele (1915, p. 7) states that occasional beds have remained comparatively unchanged, and these, when finely ground and mixed with water, develop some plasticity. In general, the Sillery shales are of little importance as a possible raw material for brick or tile making. Two exceptions are cited by Keele, one on the north side of Boyer river, near St-Charles-de-Bellechase, and the other a short distance east of St-Apollinaire station, Lotbinière county, on the Canadian National railway. The fresh shale at these localities, when ground and wetted, develops fair plasticity. The St-Charles shale has good drying and firing properties and the fired colour is bright red. This shale is note-worthy as possessing vitrifying properties, has a long firing range, and takes a good salt glaze, suiting it not only for the production of high-grade building brick but also of sewer pipe. Keele (p. 9) considered that these unaltered beds of shale of the Sillery formation are, apparently, as good a structural material as has so far been discovered in the Province.

Levis Formation

This formation has a limited development in the neighbourhood of Lévis and at the southwestern tip of the island of Orleans (see Vol. II, p. 392). In most exposures, the shale is slaty in character, but Keele (1915, p. 10) refers to occurrences near St-Joseph-de-Lévis as offering some possibilities for the making of sewer pipe and paving brick, as the shale possesses vitrifying properties. It would also be suitable for dry-pressed building brick.

Utica-Lorraine Formations

Shales of these formations are widely distributed (see Vol. II, pp. 266-268; also Keele, 1915, p. 11) and are of importance as a source of raw material for the production of brick. The *Utica* is the lower member and is somewhat carbonaceous, as a consequence of which it has a tendency to 'bloat' during firing. Most of the Utica shale is red-burning, but that occurring in the vicinity of Quebec has a high content of lime and burns to a buff colour. The *Lorraine* shale is somewhat harsher, and develops less plasticity, than the Utica. The harshness of the Utica-Lorraine shales in most of their occurrences would necessitate the admixture of clay, especially for the production of tile. Owing to the frequent presence of thin interbedded layers of limestone in these shales, and also to their variable character, any attempt to utilize them at new points for the manufacture of clay ware should be preceded by a thorough examination of the beds and by complete testing.

These shales burn to a dense body of fair hardness at cone 06 (1,841°F.), but have a short firing range and fuse at cone 3 (2,093°F.). They are therefore unsuitable for the manufacture of vitrified wares. Face brick and structural tile of good quality are made from them at Laprairie, Delson, and Boischatel.

Queenston Formation

Queenston shales occur at three localities to the south of the St. Lawrence river, in Yamaska and Nicolet counties (see Vol. II, p. 270). They vary from red to brown in colour. Although gritty, they have fair plasticity when ground and wetted and can be used for making brick by the stiff-mud process. Keele, who refers these shales to the Medina formation, states (1915, p. 36) that they are very well suited for the manufacture of structural materials. They are easily ground, will stand fast drying without checking, and burn to a dense body with good colour and little shrinkage at low temperatures. When fired to cone 06 (1,841°F.), they develop a red colour, but at cone 03 (1,976°F.) the colour is brown and the body very dense.

Bonaventure Formation

Shale of the Bonaventure formation is exposed at Fleurant point on the shore of Chaleur bay, in Bonaventure county, Gaspé peninsula. Tests carried out in the laboratories of the Mines Branch, Department of Mines, Ottawa, in 1930-31 showed that it possesses good vitrifying properties that should suit it to the manufacture of roofing tile. When ground and tempered with 20 per cent water, it develops good plasticity. It has low shrinkage in drying and firing. Burned at cones 010 and 03, the product has a pleasing red colour; at cone 1 it is chocolate coloured. This shale should prove excellent raw material for the making of dry-press face brick as well as roofing and other structural tile (Keele, 1915, p. 38; McMahon, p. 59).

Shales of this formation occur also near Percé. While some of these are similar to that at Fleurant point, others have poor firing properties that render them unsuitable for ceramic purposes.

SEDIMENTARY CLAYS

Sedimentary clays are derived from the disintegration of the various rocks of the Earth's crust through the action of natural forces or agents such as rain, frost, wind, running water, glaciation, and chemical action;

particularly oxidation and hydration. The material produced by these agencies becomes more or less sorted, chiefly by running water that transports it varying distances from its source and eventually carries the finest suspended matter to lakes and seas, from whose comparatively still waters it settles, forming beds of clay.

These sedimentary clays are used in the ceramic industry for many purposes, but the usefulness of a clay for the making of a particular product will depend upon its physical and chemical properties. These are governed largely by the nature of the rocks from which the clay was derived and by the degree to which the clay matter and the granular rock material have been separated.

The sedimentary post-glacial surface clays which occur over large areas of Quebec (see Vol. II, pp. 25-29, 33, 104, 183, 218-220, 522-525; also Keele, 1915, pp. 46-106) constitute an important source of material for the manufacture of drain tile, structural tile, and common building brick.

These clays, which are generally red-burning, are of low refractoriness, their softening point seldom being in excess of pyrometric cone 1 (2,057°F.), and the usual effective firing temperature is from 1,750° to 1,850°F. Owing to their relatively short firing range, they cannot be used for making vitrified wares.

Of these clays Keele says (1915, pp. 50-51): "These stratified clays may contain layers of sand or silt alternating with clay layers. These materials probably indicate periods of flood, when coarser materials would be carried farther out into the still water basins and deposited with the clay. When the sand and silt layers occur plentifully through the deposit, brickmakers call it a 'lean' clay. Clays of this description work easily, dry quickly, and have small shrinkages, but they do not burn to a very dense body if the sandy content is too great.

"The deposits which are made up of alternate layers of clay, silt, and sand, if the latter is not too abundant, are the ones sought for by brickmakers, and as a rule give a good, natural, even mixture, and produce a brick of uniform strength. Attempts to obtain an even mixture by adding sand to a stiff, fat clay are not very successful, especially with the simple machinery used in most common brick plants.

"At some localities, the deposits show no layers or bands but, on the contrary, any lines seen are vertical. These vertical lines are the marks of joint planes, which are caused by shrinkage. In some places these kinds of clay are called 'joint' clays, and at other places by the expressive name 'gumbo'. The term gumbo is descriptive of the sticky, adhesive qualities of the stiff and highly plastic, massive or joint clays. These [latter] are known to brickmakers as 'fat' or 'strong' clays; they are generally hard to work, difficult to dry, with drying shrinkages sometimes abnormally high, and are avoided as much as possible in the industry".

Keele gives the following results of tests made on samples of these clays from Chicoutimi, at the head of navigation on the Saguenay river, some thirty-five miles east of lake Saint-John, and from Roberval, on the west shore of the lake. The two localities are sixty-three miles apart.

Chicoutimi (from a terrace of marine clay that is used for making brick) (Keele, 1915, pp. 70-71): "A sample of clay taken from the bank at this plant . . . required 23 per cent of water to bring it to a working consistency. It dries slowly with a drying shrinkage of 5 per cent. When burned to cone 010, the body is hard but porous . . . This clay contains slightly more lime than most of the clays west of this point. It melts to a slag at cone 1. This clay will make a far better brick when used alone than it does with the sand added. The drying problem, however, has to be overcome, and the addition of sand is necessary to accomplish this safely.

"An attempt to make some 3-inch round tile from this clay failed. The clay appears to be lacking in good plastic qualities, being granular to the feel and short, or flabby, in the wet state. It differs in this respect from most of the other low-level clays in the Province. The clay does not appear to be adapted to the manufacture of any other product than the one it is now used for".

Roberval (Keele, 1915, p. 72): A sample of clay collected from the slope of the first terrace above the lake level at the town of Roberval gave the following results when tested:

"This clay requires 28 per cent of water to bring it to a good working consistency. It is fairly plastic, and works easily, but becomes rather flabby with a slight excess of water. It is smooth in texture, and fine grained, 99 per cent of the clay passing through a 200 mesh sieve, but much of this is fine-grained silt. This clay can be dried moderately fast without checking, and has a drying shrinkage of 6.5 per cent. It burns to a light red colour and fairly hard body at cone 010, with an absorption of 15 per cent. When burned to cone 06, the red colour is better and the body slightly denser and almost steel hard. There is no shrinkage in firing at either temperature, and the bricklets have a good ring when struck together. The clay is overfired and shrunken at cone 03, and melted at cone 1.

"This clay is suitable for the manufacture of common brick, preferably by the soft-mud process. A little sand might be added but it does not require much, as the shrinkages are not high and the working qualities good. It will also make field drain tile if necessary. The samples of tile made in the laboratory from this material were satisfactory in average".

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GRANITE

Granite suitable for use as building and monument stone is of widespread occurrence in the Province. In the Eastern Townships, along and adjacent to the International boundary, there are numerous stocks and batholiths of grey granite, and, from scores of quarries opened at convenient localities, there has been a large production of building and dimension stone for the past seventy-five or more years. Since about 1890, granite, for the most part pink, has been quarried at several points in the country north of the Saint-Lawrence, particularly at Rivière-à-Pierre, Brownsburg, and Guenette (Osborne, 1933, p. 43). Alkaline intrusive rocks of the Monteregian hills, and anorthosite in the Lake Saint-John district and elsewhere, are also quarried, chiefly for monument stone, and are marketed under names such as 'black granite'. By far the greater part of the granite production, however, consists of crushed stone, for use as concrete aggregate and for road construction. Specifications for such material are far less rigid than for building and dimension stone and, as occurrences of suitable rock are fairly plentiful, supplies can usually be obtained from deposits, or from excavations that are made, at or in the vicinity of the operation for which the stone is required.

Production of granite in the Province has been recorded only since 1908, and then only in terms of value of sales until 1921. For the past twenty years, production has been of the order of half a million tons a year, with a maximum of 1,178,765 tons in 1942. Of this total, 1,106,678 tons was crushed stone, most of which was obtained in excavating a diversion canal north of the Saguenay river, at Chute-à-Caron, and was used in construction work on a dam and hydraulic power plant at Shipshaw. In 1943, a more normal year, sales were as follows:

QUANTITY AND VALUE OF QUEBEC GRANITE SOLD IN 1943

CLASSIFICATION	QUANTITY (tons)	VALUE
Building stone, dressed	2,938	$ 100,384
Monument stone, rough	5,668	92,330
Monument stone, dressed	3,180	322,259
Curbstone	327	2,364
Paving blocks	800	7,014
Rubble and rip-rap	14,395	12,336
Crushed stone	607,612	627,776
TOTAL	634,920	$1,164,463

There would appear to be excellent possibilities for greater utilization of the abundant supplies of granite to be found in the Province, and particularly of certain unusual varieties of monument and ornamental stone. Commenting on these, Osborne (1933, p. 7) says: "It is worth noting that the geological history of Quebec is quite closely comparable with that of other districts producing stone that competes with the domestic stone in our Canadian markets. The grey granite of the Eastern Townships is of the same age as the granite of the New England States, such as that from Barre, Vermont. The intrusive rocks of the Monteregian hills (described in Burton's report) are similar in composition to the intrusive rocks of Scandinavia that supply so much 'pearly' granite (laurvikite) to the United States and Canada. Fennoscandia supplies a considerable amount of monument stone to the Canadian market, and its vast areas of Precambrian rocks show many similarities to those of the Precambrian of Quebec. More comparisons with other granite-producing districts could be made, but these will suffice to indicate the several formations from which commercial granites are obtained and the possibility of a greater variety of stone being produced in Quebec".

EASTERN TOWNSHIPS

(See Volume II, pp. 448-454)

The granite quarries of the Eastern Townships are in two separate areas. One, the Stanstead-Stanhope area, is at, and immediately north of, the International boundary and extends eastward from lake Memphremagog for forty miles to the Quebec-New Hampshire boundary; the other embraces a zone extending southeastward from Saint-François and Aylmer lakes, through Mégantic lake, to the Quebec-Maine boundary, a distance of about forty miles. Although, in Quebec, the granite cuts no strata younger than Ordovician, it is presumed that here, as elsewhere in the Appalachian region, it was intruded during the general period of Devonian orogeny.

In almost all occurrences, the rock is a biotite, or biotite-muscovite, granite and, depending on the biotite content—which ranges from about 3 to 14 per cent and rarely as high as 20 per cent—it has a very pale grey to quite dark grey colour. In the mass about one mile west of St-Herménégilde, however, the rock is a dark grey hornblende granite. The rock is generally medium grained and massive, but in some localities it is distinctly porphyritic.

As early as 1847, Logan directed attention to the granites of the Eastern Townships as well adapted for building stone. Since that time, numerous quarries have been opened, particularly in the Stanstead area, and have supplied stone for public, institutional, and commercial buildings in most cities of the Province and as far west as Edmonton and Calgary, in Alberta. Quarrying operations are dealt with very fully by Parks in his report on the *Building and Ornamental Stones of Canada: Volume III.—Quebec*, published in 1914, which includes also descriptions, and tabulations of the physical properties, of the stone in the principal operating quarries. More complete descriptions of the quarries are given by Burton in a report on the *Commercial Granites of Quebec: Part I.—South of the St-Lawrence River*, published by the Quebec Bureau of Mines as Part *E* of the Annual Report for 1931.

Stanstead-Stanhope Area

The earliest granite quarrying operations in the Province were in Stanstead township, and quarries here still furnish a high percentage of the total annual production. At the time of Burton's survey, in 1931, thirty-five quarries were operating. Of these, he says (pp. 23-24): "Many of them are small and only equipped to quarry curbstone or paving blocks. A large group are of intermediate size and produce monument stone, curbstone, paving blocks, and occasional stone for small buildings. Two large quarries at Graniteville, owned by the *Stanstead Granite Quarries Company, Limited*, and *Brodie's, Limited*, respectively, are equipped to produce stone of any size for building or monument work".

The granite, presumably representing a continuous stock, is exposed intermittently for three miles eastward from lake Memphremagog, in ranges, IV, V, and VI, for a width of a mile and a half to two miles north of the Quebec-Vermont boundary. It varies somewhat from place to place in composition and appearance and is marketed under appropriate trade names. The best known type is Stanstead Grey; others are Stanstead Light, House Hill (slightly lighter than Stanstead Grey), Stanstead Dark, and B. & R. Dark, the last from the quarry of *Berry and Redicker*, at Beebe. The accompanying tables, reproduced from Burton's report (pp. 21-22), give the mineral composition, by volume, and the physical properties, of typical samples of the stone.

MINERAL COMPOSITION, BY VOLUME, OF FIVE TYPES OF STANSTEAD GRANITE

MINERAL	STANSTEAD LIGHT	STANSTEAD GREY	STANSTEAD DARK	B.&R. DARK	HOUSE HILL
Quartz	32.7	20.0	31.4	23.1	23.6
Feldspar	62.3	71.2	58.0	62.9	66.0
Dark coloured minerals and muscovite	4.1	8.3	10.1	13.8	8.9
Accessories	0.9	0.5	0.6	0.2	1.5

PHYSICAL PROPERTIES OF THREE TYPES OF STANSTEAD GRANITE

STONE	SPECIFIC GRAVITY	WEIGHT PER CU.FT.	PORE SPACE	CRUSHING STRENGTH	TRANSVERSE STRENGTH
Stanstead Grey (*a*)	2.69	166.5 lb.	0.789 %	25,250 lb./sq. in.	1,762 lb./sq. in.
B. & R.	2.62	166.3 lb.	0.378 %	23,295 "	1,833 "
Stanstead Light	2.63	163.9 lb.	1.112 %	26,390 "	1,878 "

(*a*) Average of tests, by Parks, on three samples.

Granite is also quarried at Cassville, on lot 6, range IX of Stanstead township, and as early as 1878 a quarry in range I, on the shore of lake Memphremagog a little north of Magoon's point, produced stone that was used in the construction of a dam at Magog and for various other works in that town.

The following tabulation of some of the larger buildings and other works constructed wholly or in part of Stanstead granite will indicate the wide popularity this stone enjoys, not only in the Province of Quebec but in all Provinces as far west as Alberta.

MONTREAL
- Sun Life Assurance Company
- Royal Trust Company
- Customs House

SHERBROOKE
- Post Office

OTTAWA
- Chateau Laurier
- Royal Mint
- Parliament buildings (approaches to)

TORONTO
- Canadian Pacific Railway offices
- Excelsior Life
- Post-office *F*, Yonge Street

WINNIPEG
- Canadian Bank of Commerce

REGINA
- Parliament buildings

SASKATOON
- University buildings

EDMONTON
- National Trust Company
- Royal Bank

CALGARY
- Canadian Pacific Railway station
- Bank of Montreal

Some six miles east of the village of Stanstead, granite is again exposed at the International boundary and continues eastward, with a maximum width in Quebec of two and a half miles, across the townships of Barnston and Barford for a distance of fourteen miles. The village of Stanhope is about midway along the belt. The stone has been quarried at several points, mainly in the relatively flat country to the north of Stanhope. It is somewhat lighter than Stanstead Grey and has been used chiefly as curbstone, but some building and monument stone has been produced.

Several small isolated bodies of granite outcrop in the country to the north of the main belt. In one of these, on lot 14, range V of Barnston township, a quarry has operated intermittently for sixty or more years and supplied stone for a convent at Coaticook, about five miles northeast of Barnston. Another quarry, on lot 21, range V of Hereford township, which adjoins Barford on the east, supplied stone for the church at the nearby village of St-Herménégilde.

St-Francois Lake to Mégantic Lake

Scotstown.—The village of Scotstown is in Lingwick township, Compton county, about fifteen miles west of Mégantic lake. Granite was quarried here for paving blocks more than fifty years ago, but the area did not become important as a source of building stone until about 1920, when the *Scotstown Granite Company, Limited,* opened a quarry on lot 40, range *D*, a little over a mile northwest of the village. The stone is a biotite granite, lighter in colour and much coarser in grain than Stanstead Grey. Buildings for which it has been used include Provincial Government Building *E*, Quebec city; National Research Laboratories, Ottawa; Mount Royal Chalet, Montreal; and the Sherbrooke Trust Building, Sherbrooke. Burton (p. 83) gives the physical properties of a typical sample of the stone as follows:

Specific gravity	2.67
Weight per cubic foot	167.2 lb.
Pore space	0.760 per cent.
Crushing strength	28,660 lb. per sq. in.
Transverse strength	1,251 lb. per sq. in.

Average stone contains, in percentages by volume, quartz, 23.1; feldspar, 64.4; dark minerals, 12.0; accessory minerals, 0.5.

Little Mégantic Mountains.—These 'mountains', in Whitton and Gayhurst townships, Frontenac county, comprise a group of hills that rise about seven miles north of Mégantic lake and extend northeastward for six miles with a width of about two miles. Several quarries have been opened here, but in recent years only two of these have been active — one, on lots 36 and 37, range IV of Whitton township, operated by *Frontenac Quarries, Limited,* the other, on lot 1, range VIII of Gayhurst, the property of the *Silver Granite Company, Limited.*

The stone is a medium to coarse grained biotite granite, light to medium grey in colour and quite commonly having a faint pink tinge. Burton (pp. 90-91) gives the mineral composition and physical properties of typical samples of the stone as follows:

MINERAL COMPOSITION, BY VOLUME, OF LITTLE MÉGANTIC GRANITE

Mineral	Frontenac Grey	Silver Granite Company	
		Silver Grey Medium grained	Silver Grey (Pinkish) Medium to coarse grained
Quartz	18.0	21.3	22.4
Feldspar	75.5	68.0	69.3
Dark coloured minerals and muscovite	5.6	9.2	7.2
'Iron' (*a*)	0.2	0.8	0.6
Accessories	0.7	0.7	0.5

(*a*) Sulphides and oxides of iron and copper.

PHYSICAL PROPERTIES OF LITTLE MÉGANTIC GRANITE

Stone	Specific Gravity	Weight per Cu.Ft.	Pore Space	Crushing Strength	Transverse Strength
Silver Granite Co.	2.66	165.8 lb.	0.374%	29,600 lb./sq. in.	2,957 lb./sq. in.
Lacombe & d'Allaire (*a*)	2.68	165.7 lb.	1.105%	36,820 "	4,935 "

(*a*) Test by Parks; sample apparently from Frontenac quarry.

Almost the entire output from these quarries is used as building stone. The Frontenac quarry supplied stone for the Seminary in Trois-Rivières, and for the Youville and St-Dominique churches in Montreal. The Silver Granite Company's product was used in the construction of the Provincial Museum, Quebec city; St-Joseph Oratory, Montreal; and the Orleans Island bridge, below Quebec city.

Big Mégantic Mountain.—This prominent hill, seven miles southeast of Scotstown, is rudely circular in outcrop and occupies an area of well over thirty square miles. It lies mainly in Compton county, with its northeastern part extending into Frontenac.

The main mass of the mountain is granite, but on the eastern and northern sides the granite is bordered by a rim, or ring dyke, about one mile wide, of alkali syenite (nordmarkite). So far as known, this is the most easterly representative of the alkaline intrusive bodies of the group known as the Monteregian hills.

The granite here has not been quarried, but stone from a quarry in the syenite, on lots 44 to 46, range I of Hampden township, has been used as a base for monuments, The stone is dark green in colour, and the feldspar has a tendency to be iridescent, a feature which is more pronounced on polished surfaces. The rock has the following mineral composition, in percentages by volume (Burton, p. 98): quartz, 2.5; feldspar, 91.5; dark coloured minerals, 5.0; iron sulphides and oxides, 0.5; accessory minerals, 0.5.

MONTEREGIAN HILLS

(See Volume II, pp. 455-486)

From Montreal eastward, eight hills, known as the Monteregian hills, rise abruptly from the flat plain of the St.Lawrence lowland. Six of these are spaced at intervals of eight to ten miles along an arcuate line, convex to the northeast. These are, from west to east, Mount Royal, St. Bruno, St. Hilaire, Rougemont, Yamaska, and Shefford. All except Mount Royal are east of the St. Lawrence river. Brome mountain, much the largest of the hills, covering an area of about twenty-four square miles, lies immediately south of Shefford, and mount Johnson, with an area of less than one-quarter of a square mile, is about twelve miles due south of St. Hilaire, midway between Mount-Royal and Brome mountain. Shefford and Brome mountains are thought to be laccoliths or the exposed parts of a single laccolith; all the other hills appear to be plugs — possibly volcanic plugs — with vertical walls.

The igneous rocks forming the cores of the hills are all alkaline in composition and, in a general way, closely similar suites of rocks are found in each hill. They range in composition from syenitic to gabbroic types. St. Bruno represents a single magmatic intrusion of essexite. In all the other hills there are two or more types of rock, either separate intrusions or differentiates produced during or following the emplacement of the magma. In Shefford, syenitic rock is rather in excess of basic varieties; in Brome and St. Hilaire, the two types are in about equal amount; in the other hills, basic rocks greatly predominate.

Quarries have been opened on most of the hills, but except on mount Johnson they have been small operations for production of stone for local use. Commercially, the stone is classed as 'granite'.

Mount Johnson.—This, the midget of the Monteregian hills, is in the parish of St-Grégoire, Iberville county, six miles northeast of the city of Saint-Jean. The igneous core of the hill is made up of four principal types of rock which, in horizontal cross-section, have a concentric arrangement. An outer zone of light coloured syenite (pulaskite) is followed by a zone of dark syenite (monnoirite) and this in turn by a ring of essexite, within which is the core of olivine essexite.

Some half dozen quarries have been opened on the east and southeast sides of the hill, all in the essexite zone, but at the present time only one, on cadestral No. 162, concession III, is active, operated by *Brodie's, Limited.* The stone in the outer part of the zone is very coarse and is marketed under the name *Canadian Quincy.* That of the inner 150 feet or so is somewhat finer grained and — probably because of this — darker in colour; it goes under the trade name *Ebony.* Burton (p. 110) gives their mineral composition and physical properties as follows:

MINERAL COMPOSITION, BY VOLUME, OF MOUNT JOHNSON STONE

MINERAL	CANADIAN QUINCY	EBONY
Feldspar	75.9	80.4
Dark coloured minerals	17.1	13.2
Iron oxides and sulphides	5.2	4.9
Accessory minerals	1.8	1.5

Physical Properties of Mount Johnson Stone
(Tests by Parks)

Stone	Specific Gravity	Weight Per Cu. Ft.	Pore Space	Crushing Strength	Transverse Strength
Canadian Quincy..	2.876	179.22 lb.	0.288%	36,500 lb./sq. in.	2,411 lb./sq. in.
Ebony...........	2.836	176.60 lb.	0.249%	40,900 "	3,256 "

Both stones take an excellent polish and the contrast between hammered and polished work is strong, so that carving and lettering stand out well (Burton, p. 110). Formerly, much of the stone produced from the Mount Johnson quarries was used as paving blocks, but the principal product now is monument stone.

Saint-Luc.—Three miles north of Saint-Jean, near the west bank of Richelieu river, a boss of fine grained nepheline syenite porphyry, about 1,500 feet in diameter, outcrops in the parishes of Saint-Luc and Saint-Jean. The stone has been quarried in both parishes but at present only one quarry, in cadastral No. 2, concession I, Saint-Luc, and cadastral No. 89, concession I, Saint-Jean, is active. The output, 10,000 to 15,000 tons per year, is crushed and used for road work and as coarse aggregate in concrete.

Shefford Mountain.—Shefford mountain, in the township and county of Shefford, five miles east of the city of Granby, covers an area of about seven square miles and rises 1,225 feet above the surrounding plain. The igneous core of the mountain consists of three principal rock types, products of three separate intrusions. These are, in the order of their intrusion, essexite, nordmarkite, and pulaskite.

Prior to 1900, small amounts of essexite and nordmarkite were quarried for local use. Dark grey, medium to coarse grained essexite from a quarry on lot 13, range V, was used in the construction of the Roman Catholic church at Waterloo, and very pale grey nordmarkite, quarried on lot 6, range V, was used for foundations for buildings in Granby and as monument stone.

Brome Mountain.—This mountain rises two or three miles south of Shefford and is composed of similar rocks. Quarries in nordmarkite on the northern flank have supplied stone for the construction of two churches in the village of West Shefford and for the Canadian Pacific Railway bridge over Yamaska river at Sheffington.

Yamaska Mountain.—Yamaska mountain, rising to a height of 1,300 feet above the surrounding plain, occupies an area of about five and a half square miles in the parishes of Saint-Paul-d'Abbotsford (Rouville county) and Saint-Pie (Bagot county). The village of Abbotsford lies immediately to the southwest. The igneous rocks of the mountain are of three main types: akerite (alkali syenite), essexite, and yamaskite, a rock composed almost entirely of ferromagnesian minerals. These are thought to be differentiation products of a single magmatic intrusion. The akerite, which occurs chiefly as a narrow zone on the west and north sides of the igneous core, was quarried many years ago for use in bridge construction along the line of the

Canadian Pacific railway. The stone resembles some of the Mount Johnson essexite, but is lighter in colour. Parks (p. 182) gives the following physical properties: specific gravity, 2.757; weight per cubic foot, 170.401 lb.; pore space, 0.992 per cent; crushing strength and transverse strength, respectively, 29,420 and 1,745 per sq. in.

Other Monteregian Hills.—Nepheline syenite was at one time quarried on the northwest flank of Mount Royal for use in road construction and as concrete aggregate, and stone for these purposes is still obtained from quarries in a thick sill of the related rock, tinguaite, which outcrops in several places in the vicinity of the mountain.

There appear to have been no systematic quarrying operations on St-Bruno, St-Hilaire, or Rougemont.

North of the St-Lawrence

North of the St. Lawrence, and in northern and western Quebec generally, granite, or rock which for commercial purposes is classed as granite, is much more widespread, and occurs frequently in much larger bodies, than in the country south of the river. These are the granites of the great Precambrian 'shield'. They are of several different ages, types, and colours, but occurring, as for the most part they do, in areas that lack both settlements and transportation facilities, their commercial possibilities have, in general, not been investigated. Moreover, the rocks are, in very large part, banded or foliated, which would detract from their value or render them useless for most of the purposes for which granite is used. In many places, however, the rock is massive and has all the characteristics requisite in a stone for building and other uses, and such stone has been quarried at some two dozen or more localities. The majority of these have been, or are, small operations to supply stone for local needs, but in three districts — Rivière-à-Pierre, Guénette, and Brownsburg — large amounts of stone have been produced for shipment to outside markets. There have been large quarrying operations also in the Chicoutimi area, chiefly to supply crushed stone for use as concrete aggregate.

The granites and quarrying operations north of the St-Lawrence have been described in some details by Osborne (1933, 1934).

Rivière-a-Pierre District

The village of Rivière-à-Pierre is in Portneuf county, some fifty miles west of Quebec city. It lies at the junction of two lines of the Canadian National railway leading from Quebec and Montreal, respectively, to lake Saint-Jean. The quarries in the district are thus very favourably situated as regards transportation facilities.

Near the village, rocks of the Grenville series are intruded by granite of two types, one a grey hornblende granite in which the feldspar is dominantly oligoclase, the other a rose coloured biotite granite whose feldspar is microcline and albite. The principal quarries are in the latter, which is somewhat coarser grained than the grey variety. In the many quarries that have been opened, the stone breaks readily and joints are sufficiently widely spaced that large blocks may be easily and cheaply extracted, making the stone very suitable for construction work. The physical properties of typical stone from four of the quarries are as follows:

PHYSICAL PROPERTIES OF RIVIERE-À-PIERRE GRANITE

STONE	SITE OF QUARRY	WEIGHT PER CU.FT.	PORE SPACE	CRUSHING STRENGTH	TRANSVERSE STRENGTH
Grey	L. 3, r. I, Bois tp. (a).........	174.9 lb.	0.308%	27,650 lb./sq. in.	3,310 lb./sq. in.
"	L. 5 and 6, r. I, Bois tp. (b)....	171.686 lb.	0.355%	24,730 "	2,950 "
Rose	L. 14, r. I, Bois tp. (b)........	168.176 lb.	0.406%	29,600 "	1,740 "
"	L. 13, r. III, Bois tp. (a)......	171 lb.	0.840%	28,590 "	1,802 "

(a) Tests by Burton on samples collected by L. H. Cole (Osborne, 1933, pp. 20, 37).
(b) Tests by Parks (pp. 140, 141).

Osborne (1933, pp. 13-38) describes thirty-one quarries in this district and two others, in rock of somewhat finer grain, near the railway station of Rousseau Mills, ten miles southwest of Rivière-à-Pierre. Their output has consisted chiefly of building and large construction stone, and curbstone; some monument stone has been produced. Buildings constructed wholly or in part of stone from Rivière-à-Pierre quarries include the following:

The Cathedral at Chicoutimi
The Monastery of the Redemptorist Fathers, Quebec city.
Churches at Rivière-à-Pierre, St-Thècle, Jonquière, St-Vallier, St-Adolphe, Limoilou, Beauport, and Quebec city (Notre-Dame-de-Grâce church).
The Arsenal, Quebec city.
Langelier building, Quebec city.

Stone from Rivière-à-Pierre was used for some of the piers for the Quebec bridge; in the construction of the Lauzon drydock, at Lévis; and for the National War Memorial at Ottawa.

Guénette District

The village of Guénette is in range *D* of Campbell township, Labelle county, on the Mont Laurier line of the Canadian Pacific railway about 140 miles northwest of Montreal. Intruding the Grenville rocks that underlie the general area is an easterly trending, dyke-like body of granite whose southern margin is about one mile north of the village. Here the dyke has a width of about a mile, but it tapers somewhat from west to east. It was mapped by Osborne for a length of ten miles and it is known to extend much beyond the limits of his examination. The rock is pink in colour and fine grained, with the texture of aplite, and its relationship to aplite is confirmed by the presence of apatite, allanite, tourmaline, and fluorite as accessory minerals.

The principal quarrying operation is that carried on by *Brodie's, Limited*, on lot 4, range *B*. This quarry has a length, north-south, of 380 feet and a width of 270 feet, and the workings extend in places for a vertical depth of 110 feet. It is the only quarry in Canada producing a stone that meets the exacting requirements for use as press rolls for paper mills (Osborne, 1933, p. 46). Besides these, the output includes monument stone and large quantities of paving blocks and curbstone. The physical properties of the stone, as determined by Parks (p. 146) are: weight per cubic foot, 165.274 lb.; crushing strength and transverse strength, 34,800 lb. and 2,810 lb. per sq. in.

There are three or four quarries in the vicinity. One of these, on lots 1*a* and 1*b*, range *A*, operated by the *Guénette Granite Company, Limited,* supplied stepping stone for the Hospice Ste-Anne, in Mont-Laurier, and building stone for the sacristy of the cathedral in that town. Curbstone also is produced in this quarry.

A quarry in the town of Mont-Laurier, on lot 24, range I of Campbell township, yields an entirely different type of stone, a rose coloured augen gneiss. This was used for the main part of the cathedral. Curbstone, also, was produced here.

Brownsburg District

Brownsburg is in Chatham township, Argenteuil county, about four miles west of Lachute and forty-five miles northwest of Montreal. The southern margin of the Laurentian plateau closely follows North river a mile or two south of the town and the general area is underlain by a complex of Precambrian rocks, including altered sediments of the Grenville series and granitic and other intrusive rocks of various ages. The youngest of these intrusive rocks form what is known as the Chatham stock, which extends westward from Brownsburg for nine miles and has a width, north-south, of five miles, lying for the most part in Chatham township. This is a composite body consisting (in order of their intrusion) of syenite porphyry, syenite, granite, and quartz porphyry. For about three miles west from Brownsburg the rock is chiefly granite, and it is in this granite that all the quarries of the district have been opened. Osborne, who mapped the area in 1932, considers that the syenite, also, has commercial possibilities, particularly for use as monument stone.

The granite is a hornblende variety, fine grained in some places, coarse in others. On the east side of the stock it is prevailingly grey in colour, but farther west the surface rock is in general reddish, from chocolate-brown to rose. In one quarry at least, it has been found that, with depth, the reddish tint becomes progressively paler until, on the lower levels, the rock is grey. The red colour thus appears to be a surface staining from weathering of iron-bearing minerals, and Osborne is of opinion that at a depth of 200 feet or so below the surface the rock is grey.

Quarrying in the district dates from 1890, when a quarry was opened on the Brunet property in ranges VII and VIII, about a mile and a half west of Brownsburg. There has been a very large production of building and monument stone, and of curbstone and paving blocks, from two quarries, each with dimensions more than 200 feet by 300 feet. The stone, which varies in colour from pink to brown, has the following physical properties, as determined by Parks (p. 148): weight per cubic foot, 164.4 lb.; crushing strength and transverse strength, 37,590 lb. and 2,810 lb. per sq. in. Stone from these quarries was used for the Bordeaux gaol and for columns for the Bank Canadienne Nationale at Trois-Rivières and the court-house at Sherbrooke.

In recent years (since 1940), the Brownsburg quarries have been producing at a somewhat reduced rate, and a new field has been developed some six miles west, in the vicinity of Rawcliffe, Grenville township. The rock here is syenite. Osborne (1933, pp. 53-54), who mapped the geology of this area before the opening of quarries, observed that this syenite offered possibilities for use as monument stone. It varies somewhat in texture and mineral composition from place to place, but generally is a medium to coarse grained rock consisting of red or pink feldspar and black hornblende.

The three principal quarries in this newly developed area are operated by: *Scotstown Granite, Limited,* on lot 2, range VI; *Gaboriault and Nevers Reg'd.* on lot 3, range V, and the *Canadian Red Granite Company, Limited,* on lot 8, range IV. They are all in the vicinity of the village of Rawcliffe, five miles north of Grenville station on the Canadian Pacific railway line between Montreal and Ottawa.

Lake Saint-Jean District

Saint-Gédéon Area.—Saint-Gédéon, in Signay township, Lake Saint-Jean county, is on the shore of lake Saint-Jean, at its southeastern end. The branch line of the Canadian National railway from Chambord to Chicoutimi passes through the village. Extending eastward from lake Saint-Jean and for many miles to the north is a body of anorthosite and related gabbroic-rock — perhaps the largest body of such rock in Canada — whose southern margin is a few miles south of Saint-Gédéon. About a dozen quarries have been opened in the anorthosite in the adjoining townships of Signay and Labarre. From some of these, production has consisted entirely of crushed stone for local use as road metal or concrete aggregate. Since about 1930, however, there has been an increasing demand for this 'black granite' for use as building and monument stone, with the result that Saint-Gédéon has become a somewhat important area in the industry. The stone is marketed chiefly in Quebec and Montreal, in both of which cities may be seen large buildings constructed in part of Saint-Gédéon 'black granite'. Extensive quarrying operations are carried on by *National Granite, Limited,* whose quarry is on lot 31, range X of Signay township, about three and a half miles north of Saint-Gédéon. This Company also produces fine grained, pink, hornblende granite from a quarry on Alma island, which lies in the Saguenay river about seven miles northeast of Saint-Gédéon. Both the anorthosite and the pink granite were used in the construction of the post-office, and of the church and presbytery, in Saint-Joseph-d'Alma.

Other operators of quarries in the Saint-Gédéon area are the *Silver Granite Company,* on lot 32, range VII of Signay township, and *Polycarpe Moreau,* on lot 14, range III of Taillon township.

Roberval.—Roberval, on the west side of lake Saint-Jean near its south end, is underlain by Palæozoic limestones, which here form a narrow strip adjacent to the lake shore. West of this for many miles, the country is occupied by granite, known as the Roberval granite (see Volume II, pp. 205-207). This is a granite containing both hornblende and biotite, with microcline the dominant feldspar, and quartz ranging from 25 per cent to only 5 per cent, so that some types might be classed as syenite. The rock is relatively coarse grained and has a somewhat porphyritic appearance. It has a bluish, bluish-rose, or pink colour, the pink variety being younger than the blue. The stone has been quarried at three localities, each about two miles west to northwest of Roberval, and has been used locally for public buildings and monuments; some has been shipped as far as Quebec city. The largest quarry is the Bernier, on lot 4, range *B* of Roberval township. The court-house and church at Chambord and the church at Saint-Prime are built of granite from this quarry, which also supplied the whole or part of the stone for the church and City Hall at Roberval and the railway station at Jonquière (Osborne, 1934, p. 34).

A church in Saint-Jérôme-de-Metabetchouan is built of coarse grained, rose coloured Roberval granite quarried on lot 1, range I of Matebetchouan township, immediately south of lake Saint-Jean.

Chicoutimi Area.—The town of Chicoutimi is on the south bank of Saguenay river, about thirty-five miles east of lake Saint-Jean and three or four miles beyond the east margin of the anorthosite mass adjacent to that lake. Eastward from this mass, the country is underlain chiefly by granite or syenite. At and for a few miles eastward from Chicoutimi, however, remnants of highly altered Grenville rocks lie within the granite on both sides of Saguenay river. They are intruded by numerous sill-like bodies of pyroxene granulite. The 'granite' is gneissoid 'Laurentian' granite or syenite except in two areas where there are intrusives of younger Roberval-type granite and syenite. A large body of such rock surrounds Ha!Ha! bay and a smaller mass outcrops north of the Saguenay opposite Arvida.

At numerous points between Shipshaw and Ha!Ha! bay quarries or large excavations have been opened in the granitic rocks. Osborne (1934, pp. 45-53) lists, and gives brief descriptions of, twenty-five operations. Nearly all of them are south of the Saguenay, from Chicoutimi westward to Chute-à-Caron, but there are half a dozen or so in the Roberval-type granite adjacent to the west and south shores of Ha!Ha! bay.

The output from most of the quarries has consisted of crushed stone for use locally as road metal and concrete aggregate. Very large amounts of such stone, much of it obtained in the course of excavating a diversion canal on the north side of the Saguenay, at Chute-à-Caron, was used in the construction of the dam and hydro-electric power plant at Shipshaw. Some of the quarries have supplied building and monument stone. The most important of these is on the south shore of the Saguenay, two a and quarter miles east of Chicoutimi, stone from which —a green pyroxene granulite or syenite — was used for the hospital and city hall at Chicoutimi. A quarry in similar rock on the north side of the river supplied stone for the wharf at Chicoutimi. Laurentian granite-gneiss from quarries on lots 3, 4, and 5, range XIV S.W. of Chicoutimi township furnished stone for the Chicoutimi-Ste-Anne bridge. The Academy Saint-Louis, Bagotville, the City Hall, Port Alfred, and some buildings in Saint-Alexis-de-Grande-Baie, are constructed of Roberval-type granite, obtained in each case from nearby quarries along the shore of Ha!Ha! bay. Stone from two quarries on lot 5, North range, of Jonquière township, was used for the church at Kénogami.

Other Localities North of St-Lawrence River

Granite has been quarried at numerous other localities north of the St-Lawrence river, but most of these operations have been relatively small, to produce stone for local use. Descriptions of them may be found in the report by Osborne (1934). Below are listed some of the localities at which quarrying operations have been carried on.

Saint-Canut, Two Mountains county.
Saint-Jérôme, Terrebonne county.
New-Glasgow, Terrebonne county.
Saint-Gabriel-de-Brandon, Berthier county.
Saint-Alexis-des-Monts, Maskinongé county.
Shawinigan-Grand'Mère Area, Saint-Maurice county.
Valcartier, Quebec county.
Baie-St-Paul, Charlevoix county.
Escoumains, Saguenay county.
Ville-Marie, Témiscamingue county.
Témiscamingue, Témiscamingue county.

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LIMESTONE

Deposits of excellent limestone, well suited for various uses, are widely distributed in the Province. Most abundant are limestones of Ordovician age, including beds of the Trenton, Black River, Chazy, and Beekmantown formations, from which by far the greater part of the limestone production of the Province is obtained. These formations, practically unaltered and generally flat-lying, occupy large areas west of the Champlain and St-Lawrence fault in the country south of the St-Lawrence river and west of Richelieu river (see Vol. II, pp. 255-266), and also north of the Ottawa and St-Lawrence rivers. Crystalline limestone of the Grenville series occurs at numerous points in the hilly country north of the Ottawa and St-Lawrence rivers, particularly in Pontiac, Gatineau, Papineau, Labelle, and Argenteuil counties. Silurian or Devonian limestone is found east of the Champlain and St-Lawrence fault and is quarried at Lime Ridge, in Dudswell township, Wolfe county, and there are quarries in limestone of this age in Bonaventure and Gaspé counties, Gaspé peninsula.

As would be expected, the general rule has been for quarries to be opened only in places or in districts where there is a local demand for the output for such uses as building stone, concrete aggregate, road material, and agricultural limestone, or in the vicinity of plants which use large quantities of the rock, as in the manufacture of cement and lime — or, conversely, such industries have been established where supplies of suitable limestone are available. While the products of these plants may enjoy a wide market, limestone itself, apart perhaps from building and monument stone, is seldom shipped far from the point at which it is quarried.

Production of limestone from year to year naturally depends on activity in the operations or industries using the stone, or products made from it. In recent years the annual output has amounted to about four million tons, with a maximum of 4,937,456 tons in 1941. Production in 1944 totalled 3,848,888 tons, made up of 883,792 tons of industrial limestone and 2,965,096 tons classed as 'building-material' limestone. The distribution of the output, by uses, was as follows:

Industrial Limestone		
Lime making	538,364	tons
Agricultural limestone	159,364	"
Pulp and paper mills	132,433	"
Flux	50,734	"
Poultry grit	573	"
Other uses	1,808	"
Total	883,792	tons

Building-Material Limestone		
Crushed stone	1,928,166	tons
Cement manufacture	923,203	"
Rubble and rip-rap	68,168	"
Lime making	27,454	"
Building stone	9,074	"
Asphalt filler	9,031	"
Total	2,965,096	tons

For a detailed account of the occurrence of limestone in the Province, with descriptions of all quarrying operations, the reader is referred to the report by M. F. Goudge entitled *Limestones of Canada: Part III.—Quebec,* published in 1935 by the Mines Branch, Department of Mines, Ottawa. Goudge concludes his report with the following *Summary* (p. 266):

"Quebec is abundantly supplied with resources of calcium limestone ranging from the pure high-calcium variety suitable for chemical purposes and for making lime to the argillaceous type used in the manufacture of Portland cement. There are also large resources of impure dolomite and magnesian limestone, but pure dolomite is found only in scattered deposits of Precambrian age in the hilly country north of the Ottawa river. Among the Precambrian deposits in Argenteuil country are also some of the rare magnesitic dolomite, which consists of a mixture of magnesite and dolomite and which is being quarried for the making of refractory materials.

"The limestones are found principally in the southwestern part of the Province, near the large centres of population, but other areas occur at lake Témiscamingue; lake St-Jean; Baie St-Paul; Murray Bay; Gaspé peninsula; and on Anticosti island and on the Mingan islands in the gulf of St-Lawrence.

"The principal quarry centres are at Hull, Kilmar, Montreal, Joliette, St-Marc-des-Carrières, Quebec City, and Château Richer in the territory north of the St. Lawrence river; and south of the river the principal quarry centres are at Philipsburg, Bedford, and Lime Ridge in the Eastern Townships, and near Nouvelle in the Gaspé peninsula. In addition, small quarries are worked in many other places.

"The products of the numerous quarries include road metal, concrete aggregate, railway ballast, stone for the manufacture of Portland cement, stone for use in chemical processes (notably for the manufacture of calcium carbide, glass, and sulphite pulp), building stone, marble, stone for making lime, agricultural limestone, stone for refractory products, flux, asphalt filler, terrazzo, stucco dash, poultry grit, stone for making whiting substitute, chips for making artificial stone, and a number of minor products.

"The above list of products, though by no means complete, serves to show the importance of the limestone resources to the industrial activities of the Province."

Dimension Stone.—Limestone for use as building and monument stone has come almost entirely from the Trenton and Chazy formations. In past years, there were dozens of quarries in and near Montreal producing dimension stone, and the great majority of the public, institutional, and large commercial buildings, and numerous private dwellings, in that city were built of limestone quarried nearby. With the growth of the city, many of these quarries have been filled in and built over, and others have been abandoned, and to-day very little dimension stone is produced from quarries on the island of Montreal. There is, however, still an important production from the adjacent Ile Jésus. In recent years, quarries in Trenton limestone in and near Saint-Marc-des-Carrières, Portneuf county, have been the chief source of dimension stone. The product of these quarries, known as Deschambault stone, has been used extensively for buildings in Montreal and Quebec city. Trenton limestone is quarried also at and in the vicinity of Hull for use as building stone in that city and in Ottawa. Other districts in which dimension stone is produced from time to time include Quebec city, Joliette (Joliette county), St-Cuthbert (Berthier county), St-Dominique (St-Hyacinthe county), and Roberval (Roberval county).

Descriptions of the quarries and of the stone they furnish may be found in the report by Wm. A. Parks on the *Building and Ornamental Stones of Canada: Volume III.—Province of Quebec,* published in 1914 by the Mines Branch, Department of Mines, Ottawa.

MARBLE

Production of marble in the Province of Quebec has come chiefly from beds of metamorphosed Palæozoic limestone in the Eastern Townships, but there is some output also from quarries in Grenville limestone in the Laurentian plateau region north of the St-Lawrence river. Statistics of production are available only since 1921 and the largest output in any year was 17,866 tons in 1936. Latterly, shipments have averaged about 7,000 tons a year. Of this total, only a few hundred tons is ornamental and monument marble. The rest of the output is marketed as crushed stone and is used chiefly for making terrazzo, stucco dash, and artificial stone. Descriptions of the quarrying operations and of the stone produced are given on pages 193-225 of the report by Wm. A. Parks on the *Building and Ornamental Stones of Canada: Volume III.—Province of Quebec,* published in 1914 by the Mines Branch, Department of Mines, Ottawa.

Palæozoic Marble Deposits

Philipsburg, Missisquoi County.—The most extensive marble quarrying operation in the Province is at Philipsburg, near the northeast end of lake Champlain, on the property of the *Missisquoi Stone and Marble Company, Limited.* The beds here are limestone of lower Ordovician age, largely at least belonging to the Beekmantown formation, which, over a width of about 1,000 feet, has been metamorphosed to marble. The main quarry, lying partly in the village of Philipsburg and partly in the adjoining parish of St-Armand, is some 700 feet long, 100 feet wide, and 80 feet deep. It yields marble of various shades of grey, green, and rose which are marketed under names such as *vert rose, vert gris, emeraldo, sea green, regina,* and *rex* (a green, veined stone), and *sovereign, silver,* and *dark grey.* The physical properties of the dark grey stone, as determined by Parks (p. 214), are given in the accompanying table. This stone is used for exterior as well as interior work. For many years, Quebec's entire production of dimension marble has come from this quarry, adjacent to which are well equipped dressing sheds. The output includes also large amounts of granulated and pulverized stone. Missisquoi marble may be seen in buildings in most of the larger cities of Canada from coast to coast, as for example in the Post Office and Bank of Commerce, Vancouver; Parliament buildings, Edmonton; University of Saskatchewan buildings, Saskatoon; Bank of Nova Scotia, Winnipeg; Post Office, Parliament buildings, and Royal Ontario Museum, Toronto; Union Station and Chateau Laurier, Ottawa; Windsor Hotel and Windsor Station, Montreal; and the Custom House, Quebec city.

PHYSICAL PROPERTIES OF QUEBEC MARBLES

	MISSISQUOI *Dark grey*	SOUTH STUKELY *Dark jaune royal*
Specific gravity	2.716	2.781
Weight per cubic foot	169.273 lb.	173.050 lb.
Crushing strength, dry	20,380 lb./sq. in.	17,450 lb./sq. in.
Transverse strength	2,256 "	3,115 "
Shearing strength	1,135 "	1,665 "

South Stukely, Shefford County.—During the years 1910-15 there was a large production of ornamental marble from a quarry on lot 8, range II of South Stukely township, operated by the *Dominion Marble Company, Limited.* In earlier years, the quarry had produced stone for lime making. It is in a band of metamorphosed Lower Ordovician limestone, about 160 feet wide, bounded on both sides by mica schists. The band is reported to have been traced for a length of a mile and a quarter. The stone is a fine grained marble, veined, mottled, and clouded in shades of yellow, pink, green, and blue, and it takes an excellent polish. The physical properties of the variety known as *dark jaune royal,* as determined by Parks (pp. 204-205), are given in the accompanying table. Stone from this quarry may be seen in the Bank of Ottawa building, Regina; Royal Bank, Saskatoon; Confederation Life building, Winnipeg; Y.M.C.A. building, Brantford, Ont.; Canadian Pacific Railway offices, Toronto; Chateau Laurier and Union Bank, Ottawa; and the *Standard,* Builders Exchange, and other buildings, Montreal.

North Stukely, Shefford County.—In the adjacent township of North Stukely, a quarry on lot 13, range VII has been operated intermittently for production of both ornamental marble and stone for lime making. This is a fine grained marble of pleasing appearance, banded in light grey and bluish tints. It was used in the construction of the church of Notre-Dame-de-Bonsecours, near North Stukely, erected in 1878.

Orford Mountain, Sherbrooke County.—Crossing lots 10, 11 and 12, ranges *A* and *F* of Orford township, is a band of marble about 100 feet wide lying between walls of chloritic schist, large inclusions of which occur in the marble. The band is very irregular in shape but has a general east-west trend, with vertical dip.. The marble is of two varieties red and green, and the red variety is in places veined by white calcite. Commenting on these deposits, Parks says (p. 211): "The red stone is a very handsome material but insufficient work has been done to establish its extent or the possibility of quarrying it on a commercial scale". Some blocks of this red marble were used in the Parliament building, Ottawa.

Magoon Point, Stanstead County.—A deposit of Silurian marble on lot 12, range II of Stanstead township was at one time quarried extensively for the making of lime. The quarry is near the tip of Magoon point, which is the promontory between Fitch bay and lake Memphremagog proper. The stone is a banded, light blue, fine grained marble, much veined by white calcite (Goudge, p. 240).

Dudswell, Wolfe County.—At various times during the past thirty years, Siluro-Devonian limestone in the vicinity of Lime Ridge and Marbleton, in Dudswell township, has been quarried for production of marble and lime. Much of the stone outcropping in this district is metamorphosed to marble, and many years ago a quarry was opened on lot 22, range VII for extraction of marble, but was abandoned. In *Geology of Canada, 1863*, Logan commented (p. 432) as follows on the commercial possibilities of the stone: "The light grey limestones . . . sometimes exhibit 300 feet of vertical thickness in a single exposure. The colour of the rock, from light grey, becomes, in some layers, of a uniform yellowish-white or cream colour. The beds of this colour seem to be more compact than other portions of the rock, and some will probably yield excellent marble. Both these beds and others near them of a mottled dark and light grey, are penetrated by a multitude of reticulating veins of yellow dolomite. On the surface of cut slabs, portions of the grey limestone occasionally approach to black. If any of these beds should be found to give a more uniform or a darker grey, or a black, they would yield a marble approaching in character to the celebrated Portor, or black and gold marble (of Italy). In this, also, the black ground is a pure limestone, while the yellow, reticulating veins are dolomite".

R. W. Ells mentions that fine flagging stone, consisting of a bluish dark limestone, in beds ranging in thickness from one to eight inches, was extensively quarried in lot 15, range V, of Dudswell, stating that slabs of almost any required size could be taken out. (Geol. Surv. Can., Vol. II, Part J, p. 69, 1886). This, however, was before the use of concrete and cement for walks and platforms.

Kingsey, Drummond County.—A fine grained red marble, probably Sillery, outcrops on lots 4 and 5, range 1 of Kingsey township. Exposures are few and widely spaced, but the band of marble probably has a width of

100 feet. "The red marble is cut by numerous veins of white calcite and is a very handsome material. Unfortunately, quartz veinlets also occur in abundance; none of the exposures are free from them and in consequence it is doubtful if any workable material could be quarried . . . The general appearance of the stone is very like that of the red marble from Orford mountain" (Parks, p. 225).

St-Joseph, Beauce County.—Red marble similar to that in Kingsey township and probably of the same age was quarried in a small way in 1920-21 on the east side of Chaudière river, on cadastral lots 422 to 425 of the parish of St-Joseph-de-Beauce. The marble occurs as a lenticular band, some twenty feet wide, between reddish Sillery slates, which also were quarried. The stone is irregularly veined by calcite and occasional quartz stringers, and in places contains inclusions of slate. This quarry was re-opened in 1942 by *Mab, Limited*, for production of crushed marble.

Port Daniel, Bonaventure County, Gaspé Peninsula.—Limestone of Silurian age was formerly quarried at Port Daniel and used for lime making, but there has been no production here since 1905. In some places the stone exposed is a very fine grained reddish marble through which are scattered veins and patches of white and more coarsely crystalline calcite. Of this stone, Parks says (p. 224): "The better portion of the limestone bands would make handsome decorative material, but the alternating character of the beds and the shattered condition of the formation would entail a large amount of waste in quarrying. There is no doubt, however, that fairly large blocks could be obtained in places".

Grenville Marble Deposits

Portage-du-Fort, Pontiac County.—Marble of the Grenville series has been quarried at several points in and near Portage-du-Fort. The quarry formerly operated by the Pontiac Marble and Lime Company, Limited, on lots 30 and 31, range 1 of Litchfield township, is in a belt of white, or slightly greenish, coarse grained (up to 10 mm.) marble which is estimated to extend over 100 acres. The stone has the composition of dolomite. A vertical drill hole put down from the floor of the quarry showed seventy feet of marble of this type followed by five feet of blue, banded stone with pink veinlets. The output from this quarry was used for monument stone and as trim for buildings.

Some similar marble, but of somewhat finer grain, from an opening about 150 yards northeast of this quarry was used in the Parliament buildings, Ottawa.

The only quarry now active at Portage-du-Fort is that of the *White Grit Company, Limited*. The entire output is crushed marble for use in making terrazzo flooring and for stucco work.

Bryson, Pontiac County.—A small quantity of marble has been produced from time to time from the Carswell quarry near the village of Bryson, which is about six miles north of Portage-du-Fort. The quarry yields stone of various types — pure white, banded grey and white, and blue and white with sharply defined bands of black argillaceous material. The Court House in Bryson, built in 1891, is trimmed with the white marble, which has been used also for other buildings in the village, some of them more than eighty years old. Much of the quarry output was used for making lime.

L'Annonciation, Labelle County.—White dolomitic Grenville limestone or marble is quarried by the *Canada Marble and Lime Company, Limited*, on lot 40, range II of Marchand township, one mile southeast of the village of L'Annonciation. The crushed material is used for terrazzo flooring and for stucco dash.

St-Thècle, Champlain County.—Crossing lots 200, 201, and 202, range *B* of (Price seigniory), St-Thècle parish, about four miles northwest of the village of St-Thècle, is a band of crystalline Grenville limestone having a length estimated at 1,000 feet and up to 200 feet wide, bounded on either side by micaceous rocks. In 1911, a quarry was opened here with the object of extracting marble for interior decorative use, but apparently there was no actual production. From another opening, half a mile to the north, the stone has been quarried for lime making.

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SANDSTONE

Although sandstones of various geological ages are widely distributed in the Province of Quebec, and the deposits in some localities at least would yield excellent stone for building purposes, there has been very little production of dimension stone in recent years. For the sixteen-year period 1929 to 1944, the output of such stone averaged less than 1,000 tons a year and the bulk of this was 'rough' stone. In earlier years, considerable amounts of building sandstone were quarried, particularly in the vicinity of Quebec city and Lévis, and many of the older buildings in those cities are constructed entirely or in part of Sillery sandstone extracted from nearby quarries. Sandstone quarried in various parts of the Province has also been used extensively in some cities as paving stone for streets and sidewalks.

There is, however, a fairly large production each year of crushed sandstone and rubble and rip-rap. The output of this material averages about 80,000 tons a year but in some years has been very much more than that, with a record of 848,070 tons in 1931. In general, such material is quarried from deposits near the particular construction work in which it is to be used, or is excavated in the course of the work. Thus, the large production in 1931 and in the immediately preceding and following years was for the most part stone extracted in excavating the Beauharnois canal and used, as crushed stone, in builiding the power plant at the upper end of lake St. Louis, and crushed stone from quarries near Quebec that was used in the construction of deep-water wharves at Wolfe's Cove. More ordinary uses of the crushed stone are as road metal, concrete aggregate, and railway ballast. The output in recent years has come chiefly from deposits in or near Quebec city; at Lévis, L'Islet, Trois-Pistoles, and other points along the south shore of the St-Lawrence; Causapscal in Notre Dame county, New Carlisle in Bonaventure county, and Pointe-à-Bourdeau near the head of Chaleur bay, in Gaspé peninsula; Kingsbury, Richmond county; the Beauharnois area; and between Papineauville and Montebello on the north shore of the Ottawa river, in Argenteuil county.

Descriptions of the sandstone quarries of the Province and of the stone extracted from them are given on pages 117 to 138 of the report by Wm. A. Parks on *Building and Ornamental Stones of Canada: Volume III.—Province of Quebec*, published in 1914 by the Mines Branch, Department of Mines, Ottawa. The notes that follow, dealing with stone that has been used for building purposes, are based chiefly on information contained in Parks' report.

Building Sandstone

Several houses in Beauharnois are built of white *Potsdam* sandstone from a quarry at the falls on St. Louis river just west of Beauharnois village. Similar stone, but of Beekmantown age and in part dolomitic, has been quarried also at Ville de Léry, near Chateauguay, a few miles to the east. This stone, grey-buff in colour, may be seen in St. Paul school, in Westmount.

The largest production of dimension stone has been from quarries in *Sillery* sandstone near Quebec city and on the south shore of the St. Lawrence at and northward from Lévis. The stone is for the most part green or greyish-green. In Quebec, much of the old city wall is built of this stone and it was used also in the Citadel, the basement of the Parliament, Court House, and other government buildings, for the Roman Catholic church of Notre-Dame-du-Chemin, St-Matthews church, and numerous private dwellings. Quarries in the parish of St-Jean-Chrysostome, Lévis county, supplied stone for the church at St-David, for the Hospice St-Joseph, the College, and drill sheds at Lévis, and for the basement of the Parliament buildings in Quebec.

Trenton sandstone from a quarry at Murray Bay, Charlevoix county, was used for a school in that village and also for the Court House in Quebec city. Building stone has also been quarried at Pointe-au-Pic in Charlevoix county.

Sandstone of *Upper Ordovician* age (Richmond formation) occurring on St. François river, near Pierreville, Yamaska county, has been used locally as building stone. This stone, which Clark has named 'Pierreville sandstone', is white, fine grained, and splits easily into flat slabs.

Silurian sandstone (Niagara formation) quarried on lots 18 to 20, range I of Guigues township, on the east shore of lake Témiscamingue north of Piché point, was used for buttress capitals and coping stone for the Presbyterian church at Haileybury.

Devonian sandstone is widely distributed in Gaspé peninsula and is particularly well exposed in the area west of Causapscal, a station on the Canadian National railway between Campbellton and Mont Joli. At the time of the construction of the Intercolonial railway, considerable amounts of the stone were quarried for use in connection with that work, and some stone was shipped to Montreal for building purposes. Typical stone is brownish-red in colour and fine grained. Parks (p. 136) gives the following physical properties:

Specific gravity	2.689
Weight per cubic foot	160.64 lb.
Crushing strength	31,200 lb./sq. in.
Transverse strength	913 "
Shearing strength	1,740 "

In his description of this stone, Parks says (p. 136): "The Causapscal stone is a very desirable material on account of the fineness of grain and the uniformity of colour, which is very like that of the brown Credit Valley stone from Ontario. The quarries were worked for about nine years and a force of 200 men was employed. It is much to be regretted that this stone is not now in the market for it could be employed to advantage in repairs and additions to buildings constructed of Credit Valley brown freestone, which is no longer procurable in quantity".

The *Carboniferous* sandstone which occurs along the north shore of Chaleur bay has been quarried in the vicinity of Pointe-à-Bourdeau, Bonaventure county. Typical stone is dark olive-green. Quarries here have yielded a considerable amount of building stone, a good example of which may be seen in the church at Mission Point, on Restigouche river.

SLATE

Slate has been quarried in Quebec only on the south side of the St-Lawrence river and there only in rock of two series of formations, Farnham and Sillery, of Middle and Lower Ordovician age, respectively. The principal output has come from quarries in slate of the Farnham series in Richmond county.

Production of slate commenced soon after 1854 and for a period the industry was quite active, with the value of the output in some years approaching one hundred thousand dollars. The material was used almost entirely as roofing slate. Records of quantity of output are very fragmentary and for some years the amount is given, not in tons, but in 'squares', that is, the quantity sufficient to cover 100 square feet of roof. For the seven years 1903 to 1909, the total number of squares produced was 37,911. In subsequent years, production steadily declined and the last of Quebec's slate quarries discontinued operations in 1923. The only shipments of slate since that year have been small amounts from the waste dumps of the New Rockland quarry, in Richmond county. The total value of the production appears to have been about one and a half million dollars.

Farnham Slates

These slates, commonly referred to as black, are steel-grey in colour. They split freely and are relatively strong and tough; splittings having a thickness of a quarter of an inch, or even less, make durable roofs. They are somewhat variable in composition but are essentially clay slates, containing quartz and feldspar in fine grains, with sericite and chlorite (see Vol. II, p. 403).

The largest output has come from the *New Rockland quarry*, on lot 23, range IV, Melbourne township. This quarry was opened in 1868 and was operated almost continuously until 1912. The slate was cut, split, and trimmed at the quarry in well equipped sheds which turned out mantels, table tops, and other products, in addition to roofing slate. Employees in the quarry and sheds often numbered as many as one hundred and fifty, practically all of them expert quarrymen from Wales who, with their families, formed a village locally noted for its adherence to national customs and culture. Skilled men from New Rockland were recruited for the opening of quarries in other parts of the Province and in the eastern United States. Where the New Rockland quarry reaches a depth of about 150 feet, quartz pebbles appear in the slate, making it unsuitable for most uses. These pebbles evidently mark the top of the basal conglomerate of the Farnham series in this locality.

There has been considerable production also from the *Melbourne quarry*, which is on lot 22, range VI, about two miles northeast of the New Rockland quarry. It was opened in 1860 and was worked for some eighteen years. Its products were similar to those of the New Rockland quarry.

Geological conditions at these two quarries are similar. At the west side of both, the slate is in contact with a large body of serpentinized peridotite, to the intrusion of which the adjacent slate owes its high quality. Thus, for a width of a few hundred feet from the contact, the slate is hard and tough, whereas farther away it is relatively soft and not suited for use as roofing material.

Probably the earliest slate quarrying operation in the Province was that at the Steel quarry, on lot 6, range XV of Cleveland township, three miles northeast of the Melbourne properry. This quarry was opened in 1854 and was again worked in 1886-88. The slate is of good quality, similar to that in the New Rocklnad and Melbourne quarries, but the band is too narrow to admit of profitable operation.

Eleven miles to the northeast is the *Danville 'school slate' quarry*, on lot 7, range IV of Shipton township. The band of slate worked here is a mile distant from the serpentinized peridotite intrusive and the slate is too soft for roofing purposes. However, it proved excellent for use as school 'blackboards', which formed the principal output of this quarry.

Slate somewhar similar to that at New Rockland has been quarreid on lot 29, range V of Brompton township, Richmond county, and on lot 2, range V of Orford township, Sherbrooke county. More important production came from a quarry in slates that are thought to be of the Farnham series that was opened in or about 1912 near Glendyne, a flag station on the Canadian National railway, in Témiscouata county. This quarry was in operation for ten years producing slate which was used chiefly for roofing. Much of the output was shipped to Halifax.

Sillery Slates

The Sillery slates that have been quarried in Quebec are red, green, or mottled red and green; the red types range in colour from light purple to dark chocolate, according to the abundance and condition of the iron oxide they contain. As compared with the 'black' Farnham slates they have coarser texture and less clean cleavage, and, as shown by the microscope and indicated by chemical analysis, they contain more feldspar (see analysis, Vol. II, p. 390). They have been quarried in the counties of Richmond, Drummond, Sherbrooke, Bagot, Wolfe, Beauce, and Dorchester, but in much lesser amount than the Farnham slates.

As early as 1857, a quarry was opened in these slates on lot 4, range I of Kingsey township, Drummond county, and was connected by a 4-mile spur line with the Grand Trunk (Canadian National) railway near Richmond station. The slate is purple, green, and mottled, and it retains its colour after long exposure, as may be seen in the roofing tiles of buildings that were erected seventy or more years ago. The deposit is large and apparently working conditions were favourable, but the operation was discontinued after two or three years owing, it is reported, to lack of market for the output.

A similar fate met the *Rankin Hill quarry*, opened in 1875 on lot 26, range V of Acton township, Bagot county. It is beside the Canadian National railway, four miles east of Actonvale station. The slate is red, with large patches of green. The quarry has dimensions 150 feet by 60 feet, with maximum depth of 35 feet. Production in 1877 amounted to 600 'squares' of slate, and at the end of that year all work was suspended (Ells, p. 129).

Quarrying of Sillery slate has been carried on also on lot 18, range X, Brompton township, Richmond county; lot 24, range IV, Melbourne township, Richmond county, half a mile southeast of the New Rockland quarry; lot 2, range V, Orford township, Sherbrooke county; lot 15, ranges VIII and IX, Garthby township, Wolfe county; and lot 2, range X, Frampton township, Dorchester county.

During 1921, 1922, and 1923, about 10,000 tons of crushed Sillery slate, valued at $80,000 was produced from three Quebec quarries for use as roofing granules. These quarries were near Kingsbury, Richmond county; at St-Joseph, Beauce county; and at St. Anselme, Dorchester county. Referring to this new development, Dufresne wrote (p. 69): "Nearly the whole of this production represents the sale of granulated slate for the preparation of composite paper for roofing. The manufacturers prepare this product by depositing a layer of broken slate on a paper thoroughly impregnated with bitumen or asphalt. The manufacturers of roofing paper chiefly look for slate of bright colour. The red or green slates of [Sillery] age fully meet this requirement". As with all other slate quarrying operations in the Province, this production of crushed slate ceased in 1923.

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UNDEVELOPED MINERAL RESOURCES OF THE PROVINCE OF QUEBEC*

While the undeveloped forest, hydraulic-power, and soil resources of a country are, so to speak, open to inspection, the undeveloped mineral deposits mostly exist within the crust of the earth, where they constitute hidden concentrations extremely small, compared to the total volume of the rock formations which contain them.

The surface outcrops of rocks afford in general only a single more or less horizontal cross-section of these formations, and if the interesting metalliferous or other concentration does not show on this surface, but lies completely below it, only most unusual skill or good-luck will locate it. Moreover, in the Province of Quebec, there is the added difficulty that about ninety per cent of this solid rock surface is concealed by overburden of soil, moss, or water.

Prospectors have to meet very adverse conditions. The success so far achieved is remarkable and encouraging, but even a slight acquaintance with these conditions leads to the conviction that many more deposits remain to be discovered, even in the areas in which there are already numerous mines in profitable production.

On the other hand, perhaps it is fortunate that such conditions obtain. It would be impossible to over-stress the fact that developed mineral resources are wasting assets, and that deposits now being mined represent a crop that took a thousand million years to mature. Future generations will doubtless be grateful that nature supplied a brake to our aspirations to reap more than our share of the harvest.

Since it is not possible to line up our undeveloped mineral resources in order to inspect and appraise them, it is by indirect approach, by means such as geophysics and geological mapping, followed by diamond drilling, that their existence may be established. Their discovery offers a wide field of interest to the geologist and the prospector, as individuals or as agents for enterprising organizations in search of mineable deposits.

In Canada, the physiographic unit which is the most interesting from the standpoint of metallic mineral resources is the "Canadian Shield". It occupies somewhat more than one-half of the area of the country, in the form of an uplifted peneplain or 'plateau' of Precambrian rocks, "with its base on the Arctic ocean and narrowing to a point in the United States south of lake Superior;... its area is approximately 1,800,000 square miles or about half of all Canada" (*Geology and Economic Minerals of Canada;* third edition, p. 11).

The share of the Province of Quebec in this physiographic unit is an unbroken region of half a million square miles, which is designated the "*Laurentian Plateau*", as its southern limit follows a sinuous line parallel to and not far distant from the St. Lawrence river and its main tributary, the Ottawa. From here it extends northward to Hudson strait, a maximum distance of 1,700 miles in an air line.

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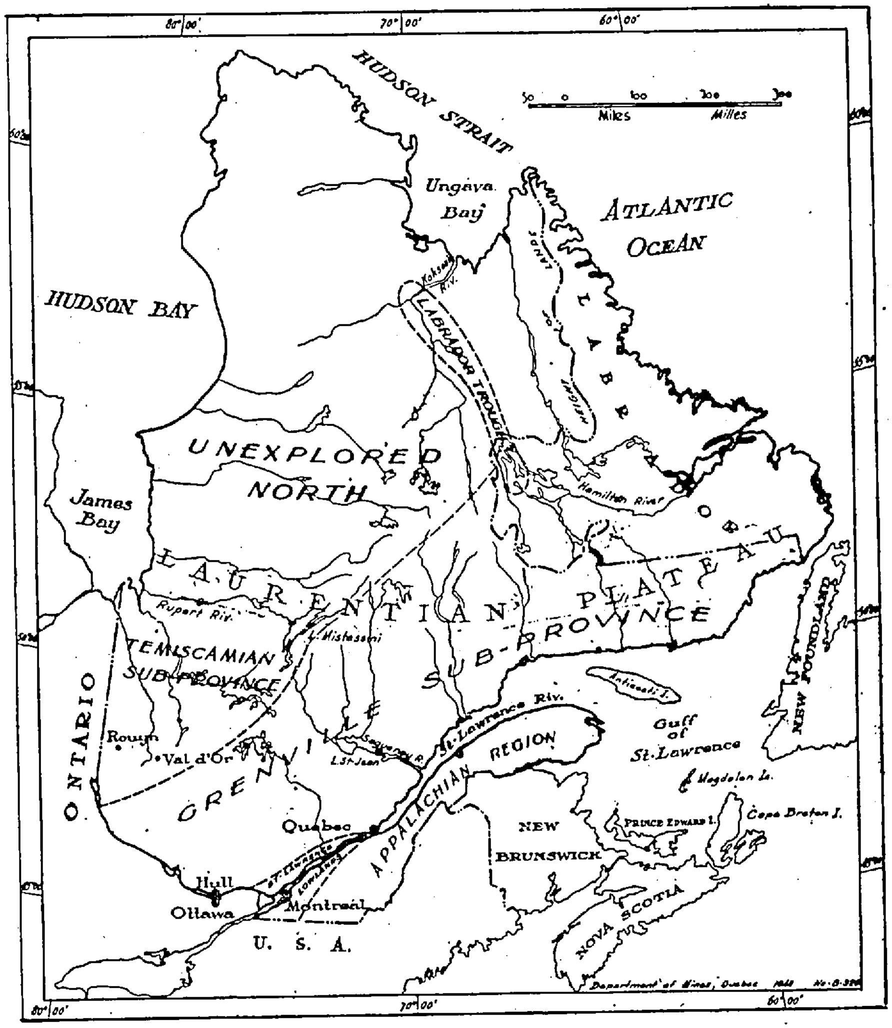

FIGURE 79.—*Sketch map of the main geological and physiographic divisions of the Province of Quebec.*

In 1947, the total value of the mineral production of the Province was \$147,000,000. Twenty-five years earlier it amounted to only \$20,000,000. A major factor in this increase was the discovery and development, in the second quarter of this century, of the metal mining field of Western Quebec, in the Canadian Shield formations. At the same time, however, large increases have been registered in the production from mining centres well established years previously, in the Appalachian region and in the Saint-Lawrence lowlands. In other words, new mineral resources have been discovered and brought into production in the past both in new fields and in long established centres of mineral production.

The situation is very similar today. The programmes for the development of the iron ore deposits of New Quebec, and of the ilmenite of the North Shore region, indicate that other mining camps are on the horizon in new areas. At the same time, new gold and base-metal mines are being brought into production in Western Quebec, and an apparently important new asbestos discovery has been made in the Appalachian region.

Mineral occurrences are very numerous, but mineable deposits are rare. Moreover, in the case of the latter, a great deal of work must be put into the deposit before it can be proved a valuable undeveloped mineral resource.

Prospectors — using this term in its broadest sense — should remember that the initial phase of a new mining development may be the discovery of new orebodies, but it may also be the result of laboratory research in discovering processes of utilization of minerals previously regarded as valueless.

The Province of Quebec produces at least fifty different mineral substances, but a very small number of these account for 95 per cent of the value of the total production. These are the metals gold, copper, and zinc from Western Quebec; asbestos from the Appalachian region; and materials of construction — cement, limestone, sand, brick — chiefly from the Saint-Lawrence lowlands.

The remarkable expansion of the mining industry in Quebec shows that, up to the present at least, we have been able progressively to find new mineral resources that go to satisfy our needs. But 85 per cent of the Province is still virgin territory. Successful exploration is still under way in the areas close to mining regions with long histories of production, and plans have been announced that will bring into existence new mining centres. There is no reason to believe that the geologically unexplored part of Quebec Province is less well endowed than the rest. Only unjustifiable pessimism could inspire doubt that it contains its share of major mineral deposits, as yet undiscovered and undeveloped.

Reference

Geology and Economic Minerals of Canada; Geol. Surv. Can., Econ. Geol. Series No. 1, 3rd edit. (1947).

APPENDIX

STATISTICAL TABLES

OF

MINERAL PRODUCTION

TABLE 1.—ANNUAL VALUE OF THE MINERAL PRODUCTION OF THE PROVINCE OF QUEBEC SINCE 1898

YEAR	VALUE	YEAR	VALUE	YEAR	VALUE
1898	$ 1,673,337	1914	$11,732,783	1930	41,158,740
1899	2,083,272	1915	11,465,873	1931	36,051,366
1900	2,546,076	1916	13,287,024	1932	25,683,066
1901	2,987,731	1917	16,189,179	1933	28,164,540
1902	2,985,463	1918	18,707,762	1934	31,310,752
1903	2,772,762	1919	20,813,670	1935	39,141,734
1904	3,023,568	1920	28,392,939	1936	49,755,985
1905	3,750,300	1921	15,522,988	1937	65,203,976
1906	5,019,932	1922	18,335,153	1938	68,877,345
1907	5,391,368	1923	21,326,314	1939	77,312,141
1908	5,458,598	1924	18,952,896	1940	86,418,853
1909	5,552,062	1925	23,824,912	1941	99,700,027
1910	7,323,281	1926	25,740,002	1942	104,404,146
1911	8,679,786	1927	29,124,110	1943	101,840,299
1912	11,187,110	1928	37,325,237	1944	90,198,739
1913	13,119,811	1929	46,454,820	1945	91,570,982

TABLE 2.— MINERAL PRODUCTION OF THE PROVINCE OF QUEBEC, BY CLASSES, 1910-1945

YEAR	METALS		INDUSTRIAL MINERALS		BUILDING MATERIALS		TOTAL
	VALUE	%	VALUE	%	VALUE	%	
1910	$ 158,597	2	$ 2,861,933	39	$ 4,302,751	59	$ 7,323,281
1911	275,591	3	3,265,823	38	5,138,372	59	8,679,786
1912	670,502	6	3,320,872	30	7,195,736	64	11,187,110
1913	866,678	7	4,065,216	31	8,187,917	62	13,119,811
1914	865,229	7½	3,068,264	26	7,799,290	66½	11,732,783
1915	1,362,338	12	3,861,301	34	6,242,234	54	11,465,873
1916	1,859,734	14	6,148,804	46	5,278,486	40	13,287,024
1917	2,262,431	14	8,479,869	52	5,446,879	34	16,189,179
1918	2,855,120	15	10,511,655	56	5,340,987	29	18,707,762
1919	1,014,088	5	11,709,341	56	8,090,241	39	20,813,670
1920	483,888	2	15,854,194	56	12,054,857	42	28,392,939
1921	84,895	½	5,549,282	35½	9,888,811	64	15,522,988
1922	11,503	—	6,563,142	36	11,760,508	64	18,335,153
1923	110,420	½	8,045,912	37½	13,169,982	62	21,326,314
1924	380,804	2	7,191,115	38	11,380,977	60	18,952,896
1925	1,034,188	5	10,915,663	46	11,875,061	49	23,824,912
1926	1,897,528	8	10,837,745	42	13,004,929	50	25,740,202
1927	2,412,268	8	11,328,885	39	15,382,957	53	29,124,110
1928	8,127,152	22	12,058,974	32	17,139,161	46	37,325,287
1929	13,671,009	29	14,249,646	31	18,534,165	40	46,454,820
1930	13,926,682	35	9,322,151	22	17,909,907	43	41,158,740
1931	12,367,932	34	5,516,899	15	18,166,535	51	36,051,366
1932	13,914,089	54	3,671,634	14	8,097,343	32	25,683,066
1933	16,360,011	58	6,043,308	22	5,761,221	20	28,164,540
1934	19,258,094	61	6,579,453	21	5,473,205	18	31,310,752
1935	23,804,792	61	8,824,178	22	6,512,764	17	39,141,734
1936	30,643,787	62	12,388,178	25	6,724,020	13	49,755,985
1937	38,615,175	59	17,232,860	27	9,355,941	14	65,203,976
1938	43,199,795	63	14,931,649	22	10,745,901	15	68,877,345
1939	47,650,509	61	18,360,017	24	11,301,615	15	77,312,141
1940	54,235,364	63	19,229,099	22	12,954,390	15	86,418,853
1941	59,126,794	59	26,562,446	27	14,010,787	14	99,700,027
1942	61,083,964	59	28,625,041	27	14,695,141	14	104,404,146
1943	59,727,333	59	29,656,316	29	12,575,910	12	101,840,299
1944	51,520,713	57	26,763,353	30	11,914,673	13	90,198,739
1945	48,082,317	52	29,045,463	32	14,442,702	16	91,570,982
TOTAL	$633,921,814	44	$422,620,130	30	$377,756,356	26	$1,434,298,591

Noto—Average prices of metals in 1945 (Canadian Funds)
(*Dominion Bureau of Statistics*)

Gold (fine) .... $38.50 per ounce
Silver .... 47.00 cents per ounce
Copper .... 12.55 cents per pound
Lead .... 5.00 cents per pound
Zinc .... 6.44 cents per pound
Molybdenite (MoS_2) .... 50 cents per pound
(Canadian funds)

TABLE 3.—MINERAL PRODUCTION OF THE PROVINCE OF QUEBEC DURING 1945

SUBSTANCE	NO. OF WORKMEN	WAGES	QUANTITY	VALUE	VALUE IN 1944
METALLICS					
Arsenic.....lb.	....	....	1,821,263	$ 118,557	$ 153,944
Chromite.....tons	26	$ 22,698	5,755	160,752	748,494
Copper.....lb.	1,855	3,674,117	102,685,669	12,886,976	12,966,621
Gold.....oz.	4,121	7,211,576	661,063	25,450,926 (a)	28,690,008 (a)
Iron.....	25	18,462	....	....	....
Lead.....lb.	....	....	9,229,726	461,486	471,953
Molybdenite.....lb.	181	189,729	978,117	411,663	1,078,616
Selenium.....lb.	....	....	160,720	308,582	263,434
Silver.....oz.	....	....	2,147,498	1,009,324	1,075,175
Titaniferous iron ore.....tons	68	22,369	14,147	67,575	165,195
Zinc.....lb.	662	1,139,385	111,909,565	7,206,976	5,907,273
Diamond drilling contractors.....	1,230	2,105,124	....	....	....
Assessment work on claims.....	22	32,700	....	....	....
SUB-TOTALS.....	8,190	$14,416,160		$48,082,817	$51,520,718
NON-METALLICS					
I.—INDUSTRIAL MINERALS					
Asbestos.....tons	3,852	$ 5,856,706	466,894	$22,802,511	$20,619,516
Feldspar.....tons	103	106,437	26,389	247,242	177,271
Fluorite.....	....	....	....	....	670
Industrial lime.....tons	283	370,103	285,352	1,949,407	2,309,828
Industrial limestone.....tons	....	....	400,231	772,742	456,031
Kaolin.....tons	....	....	446	3,771	5,758
Magnesitic-dolomite and brucite...	335	573,129	....	1,278,596	1,139,281
Marl.....tons	....	....	7,713	3,085	4,749
Mica.....lb.	142	107,752	2,856,858	121,011	178,899
Mineral water.....gal.	14	6,224	236,476	125,523	78,226
Ochre and iron oxide.....tons	48	44,629	9,407	124,168	126,030
Peat: For fuel.....tons	537	242,474	34	365	3,597
Peat: Peat moss.....tons			18,517	387,499	359,724
Petroleum.....	14	14,133	....	....	....
Phosphate.....tons	4	2,607	291	4,236	6,716
Pyrite.....tons	....	....	218,638	445,534	453,501
Quartz and industrial sand....tons	212	234,402	195,857	626,079	639,429
Soapstone and talc.....tons	71	71,955	14,225	153,694	204,127
SUB-TOTALS.....	5,615	$ 7,630,551		$29,045,463	$26,763,353
II.—BUILDING MATERIALS					
Building lime.....tons	....	....	24,081	$ 235,224	$ 185,572
Building limestone.....tons	986	$ 1,017,998	1,966,419	2,110,006	1,896,140
Cement.....brl.	466	846,538	3,872,373	5,985,077	4,736,004
Clay products: Brick.....M.	702	957,086	82,319	1,806,738	1,303,666
Clay products: Other products....			....	723,261	571,667
Granite.....tons	386	401,311	77,145	887,113	830,238
Marble.....tons	53	51,354	5,805	57,407	42,826
Sand and gravel.....tons	1,992	835,112	8,971,960	2,279,537	2,140,856
Sand-lime brick.....M.	19	32,572	8,353	131,560	102,177
Sandstone.....tons	156	104,820	211,962	224,352	104,629
Slate and shale.....tons	2	108	1,464	2,427	898
SUB-TOTALS.....	4,762	$ 4,246,899		$14,442,702	$11,914,673
TOTALS.....	18,567	$26,293,610		$91,570,982	$90,198,739

a) Value in Canadian funds. The standard value at the rate of $20,671834 per ounce troy is $13,665,385 for 1945 and $15,404,547 for 1944.

TABLE 4.—PRODUCTION OF MINES OF WESTERN QUEBEC, 1927-1945

YEAR	ORE TREATED (Tons)	SHIPMENTS											
		COPPER (Pounds)	GOLD (Ounces)	SILVER (Ounces)	ZINC (Pounds)	LEAD (Pounds)	SELENIUM (Pounds)	TELLURIUM (Pounds)	PYRITE (Tons)	ARSENIC (Pounds)	TUNGSTEN (Pounds)	MOLYBDENITE (Pounds)	VALUE
1927....	7,570	463,471	741	2,611	....	....	....	....	....	....	....	....	$ 76,674
1928....	271,614	33,019,311	53,397	185,579	....	....	....	....	....	....	....	....	6,022,692
1929....	498,280	51,101,054	86,162	333,792	....	....	....	....	....	....	....	....	11,210,882
1930....	980,419	75,435,415	141,747	555,578	9,754,160	....	....	....	....	....	....	....	13,286,327
1931....	1,100,121	62,018,221	299,869	509,571	....	....	....	....	....	....	....	....	11,814,979
1932....	1,331,104	60,584,116	401,005	605,258	....	....	....	....	121	....	....	....	13,472,818
1933....	1,886,617	63,417,206	382,834	451,732	....	....	22,131	....	....	....	....	....	15,864,182
1934....	2,436,233	63,057,942	390,061	455,022	....	....	48,764	....	7,312	....	....	....	18,912,070
1935....	2,809,654	74,471,124	469,560	504,985	....	....	206,421	1,708	....	....	....	....	23,056,076
1936....	3,390,412	62,746,930	665,930	556,745	....	....	168,417	19,502	....	....	....	....	29,857,913
1937....	4,189,618	92,040,922	710,638	789,124	5,102,330	....	208,531	26,439	500	....	....	....	37,917,227
1938....	5,380,452	109,130,545	876,628	1,177,414	5,315,852	....	217,952	41,577	7,366	....	....	....	42,853,857
1939....	6,124,976	115,389,836	951,681	1,160,401	28,758,759	....	23,841	2,940	73,628	....	....	....	47,559,599
1940....	6,998,759	134,166,955	1,016,162	1,340,500	27,696,721	....	43,510	....	124,716	....	....	....	54,406,895
1941....	7,534,829	143,783,978	1,084,429	1,656,548	46,389,581	....	203,162	....	298,761	2,056,000	989	....	59,521,841
1942....	7,643,279	140,911,876	1,090,558	1,631,957	72,358,553	....	326,208	....	351,573	6,349,074	2,981	5,000	61,089,246
1943....	6,926,856	131,163,776	926,552	2,111,700	116,382,081	404,295	216,498	....	277,690	2,744,921	5,401	499,828	58,232,127
1944....	6,025,198	107,409,439	740,987	1,841,210	109,209,766	527,143	146,352	....	240,371	2,268,067	....	2,010,049	48,840,160
1945....	5,174,214	101,946,243	656,283	1,598,088	84,901,366	512,313	160,720	....	218,638	1,821,263	....	978,117	45,589,850
TOTAL	70,710,205	1,628,258,360	10,945,224	17,467,815	505,869,169	1,443,751	1,992,507	92,166	1,600,676	15,239,325	9,371	3,492,994	$599,585,415

TABLE 5.—PRODUCTION OF COPPER, ZINC, AND LEAD IN THE PROVINCE OF QUEBEC, 1910-1945

YEAR	COPPER		LEAD		ZINC	
	QUANTITY (pounds)	VALUE	QUANTITY (pounds)	VALUE	QUANTITY (pounds)	VALUE(*)
1910	877,347	$ 111,757	....	....	....	....
1911	2,436,190	301,503	....	....	....	....
1912	3,282,210	536,346	....	....	....	....
1913	3,455,887	527,679	....	....	670,000	$ 6,700
1914	4,201,497	571,488	....	....	1,938,000	10,017
1915	4,197,482	725,115	40,401	$ 2,262	600,000	16,500
1916	5,703,347	1,551,424	698,760	59,485	1,663,200	212,956
1917	5,015,560	1,363,229	1,378,001	153,468	1,786,740	159,038
1918	5,869,649	1,445,577	2,110,059	195,180	2,802,928	228,691
1919	2,691,695	503,105	2,280,000	158,825	1,752,000	128,562
1920	880,638	153,724	905,472	80,949	1,120,200	85,931
1921	352,308	44,045	595,881	34,215	....	....
1922	....	....	....	....	....	....
1923	....	....	520,041	37,334	366,240	24,197
1924	1,893,008	246,546	1,058,983	85,820	2,909,008	184,547
1925	2,510,141	352,474	2,051,100	187,060	9,936,000	757,322
1926	2,674,058	368,886	3,729,636	251,788	12,904,176	956,109
1927	3,119,848	403,084	6,496,577	341,461	17,189,046	1,064,690
1928	33,697,949	4,909,792	6,218,336	284,518	21,057,760	1,156,745
1929	55,337,169	10,019,901	5,358,304	270,616	19,653,440	1,058,505
1930	86,310,363	10,425,891	....	....	9,754,160	351,160
1931	68,376,985	5,723,154	....	....	....	....
1932	67,336,692	4,296,216	....	....	....	....
1933	69,943,882	5,214,177	....	....	....	....
1934	73,968,545	5,487,948	....	....	....	....
1935	79,050,906	6,162,350	2,047,624	64,156	5,322,844	164,955
1936	66,340,175	6,287,058	2,047,689	80,126	6,896,123	228,606
1937	94,653,135	12,378,737	1,521,182	77,732	8,566,927	419,951
1938	112,645,797	11,233,039	....	....	5,315,852	163,356
1939	117,238,897	11,831,749	....	....	28,758,759	828,606
1940	134,166,955	13,532,079	....	....	27,696,721	944,735
1941	143,783,978	14,502,052	....	....	46,389,581	1,582,349
1942	140,911,876	14,212,372	437,634	14,713	73,940,811	2,522,121
1943	131,163,776	15,411,744	2,435,523	91,430	128,169,810	5,126,792
1944	108,055,172	12,966,621	10,487,842	471,953	137,378,439	5,907,273
1945	102,685,069	12,886,976	9,229,726	461,486	111,909,565	7,206,976
TOTAL	1,728,828,186	$186,687,838	61,648,771	$3,404,577	$686,448,330	$31,551,570

(*)The *value* of the metal contained in *zinc concentrate* exported from the Province of Quebec is calculated at the average yearly market price of the refined metal as established by the Dominion Bureau of Statistics, less an empirical smelter deduction of five units.

TABLE 6.—PRODUCTION OF GOLD IN THE PROVINCE OF QUEBEC, 1898-45,

YEAR	QUANTITY (Ounces)	VALUE	YEAR	QUANTITY (Ounces)	VALUE	YEAR	QUANTITY (Ounces)	VALUE
1898	370	$ 6,500	1914	998	$ 21,064	1930	147,747	$2,930,480
1899	272	4,916	1915	1,158	23,082	1931	300,075	6,476,103
1900	*nil*	*nil*	1916	632	13,041	1932	401,105	9,417,576
1901	80	1,400	1917	1,116	22,570	1933	382,886	10,950,540
1902	300	5,400	1918	1,578	32,615	1934	390,103	13,458,554
1903	55	1,000	1919	1,446	29,420	1935	470,545	16,558,478
1904	20	160	1920	935	19,346	1936	666,905	23,361,682
1905	191*	3,940	1921	648	12,317	1937	711,482	24,894,755
1906	155*	3,412	1922	*nil*	*nil*	1938	876,628	30,835,390
1907	*nil*	*nil*	1923	667	13,340	1939	951,681	34,394,703
1908	*nil*	*nil*	1924	881	18,372	1940	1,016,162	39,122,237
1909	193*	3,990	1925	1,834	37,909	1941	1,084,432	41,750,632
1910	124*	2,565	1926	3,679	76,070	1942	1,090,659	41,990,372
1911	590	11,800	1927	8,331	172,214	1943	927,620	35,713,370
1912	980	19,924	1928	60,006	1,240,435	1944	745,195	28,690,008
1913	738	14,794	1929	90,798	1,876,900	1945	661,063	25,450,926

*Figures from the Federal Department of Mines.

TABLE 7.—GOLD PRODUCTION OF MINES IN THE PROVINCE OF QUEBEC IN 1945

PROPERTY	YEAR OF FIRST PRODUCTION	ORE RAISED (Tons)	ORE TREATED (Tons)	GOLD (Fine) SHIPPED Ounces	SEE FOOTNOTE
GOLD MINES					
Belleterre	1936	125,701	112,918	41,317	(b)
Canadian Malartic	1935	327,093	327,093	36,362	(b)
East Malartic	1938	304,890	304,890	39,031	(b)
Francoeur	1938	77,962	77,962	11,524	(c)
Lamaque	1935	157,365	157,365	44,983	(b)
Malartic Gold Fields	1939	187,315	187,315	32,463	(b)
Mic Mac(1)	1942	190,869	190,615	23,629	(a) (c)
O'Brien	1926	47,939	48,297	25,116	(a) (b)
Perron	1933	110,829	106,485	19,432	(b)
Powell Rouyn	1937	100,034	98,519	14,746	(c)
Senator Rouyn	1940	86,812	84,005	12,534	(b)
Sigma	1937	299,608	299,608	48,920	(b)
Siscoe Gold	1929	267,722	266,166	33,610	(a) (b)
Sladen Malartic	1938	175,737	175,737	18,777	(b)
Stadacona	1936	125,927	125,927	21,874	(b)
Sullivan	1934	152,634	124,060	28,643	(b)
West Malartic	1942	72,443	72,443	6,244	(b)
Other sources	....	....	....	202	
SUB-TOTAL	....	....	....	459,407	
BASE-METAL MINES(1)					
Aldermac (Moulton Hill)	1944	40,468	40,468	2,229	(c)
Golden Manitou	1942	283,150	283,150	11,712	(b) (c)
New Calumet	1943	198,202	197,672	2,551	(c)
Noranda	1927	1,330,534	1,331,718	171,267	(c)
Normetal	1937	204,068	204,068	4,380	(c)
Waite Amulet:					
Waite	1930	59,957	59,913	892	(c)
Amulet	1928	50,185	50,130	762	(c)
Amulet-Dufault	1941	407,771	407,170	7,863	(c)
SUB-TOTAL	....	....	....	201,656	
TOTAL	....	....	....	661,063	

(a) Amalgamation, (b) cyanidation, (c) smelter.
(1) Ores of these mines are complex; base-metals, silver, and other metals also are produced.

TABLE 8.—DIVIDENDS PAID BY MINING COMPANIES OPERATING IN THE PROVINCE OF QUEBEC, 1925-1945

YEAR	GOLD	BASE-METALS	ASBESTOS
1925	*nil*	$ 985,985 (1925–1928)	(c)
1926	*nil*		$ 391,445
1927	*nil*		571,927
1928	*nil*		971,927
1929	*nil*	654,309	750,000
1930	*nil*	5,599,430	300,000
1931	*nil*	1,119,886	140,000
1932	$ 500,620	2,844,914	25,000
1933	644,545	3,457,315	150,000
1934	875,961	4,479,544	300,000
1935	1,065,354	4,479,544	......
1936	1,395,683	6,719,316	400,000
1937	1,672,268	7,279,259	1,904,348
1938	2,275,731	8,959,088	3,499,210
1939	4,491,978	8,959,088	1,790,615
1940	6,328,743	9,289,088	8,763,843
1941	5,738,347	10,279,088	5,429,944
1942	4,516,212	10,325,308	5,564,936
1943	3,344,202	11,315,308	2,531,000
1944	2,420,256	11,645,308	5,990,000
1945	1,778,155	11,434,088	2,360,000
TOTAL	$37,048,061	$119,825,866	$41,834,195

(c) Unknown.

TABLE 9.—PRODUCTION OF ASBESTOS IN THE PROVINCE OF QUEBEC, 1910-1945

YEAR	ROCK MILLED (tons)	ASBESTOS SHIPPED (tons)	TOTAL VALUE OF PRODUCTS SHIPPED	NUMBER OF WORKMEN 300-DAY BASIS (a)
1910	1,556,015	80,605	$ 2,685,441	3,730
1911	1,384,691	102,224	3,046,108	2,911
1912	1,630,743	111,175	3,082,442	2,910
1913	2,110,990	136,609	3,850,750	2,776
1914	1,717,629	107,401	2,900,839	2,509
1915	1,795,472	113,115	3,566,181	2,251
1916	1,882,461	133,339	5,211,151	2,705
1917	2,260,191	137,252	7,237,997	3,134
1918	2,185,572	142,375	9,053,945	2,984
1919	2,636,783	135,862	10,995,300	3,806
1920	2,668,946	179,893	14,792,107	3,533
1921	1,673,685	87,475	5,229,325	1,920
1922	2,166,385	160,339	6,063,861	2,246
1923	3,217,580	216,804	7,382,054	2,852
1924	2,760,470	208,762	6,571,593	2,109
1925	3,386,752	273,522	8,987,459	2,502
1926	4,002,626	279,389	10,105,744	2,588
1927	3,820,024	274,778	10,632,114	2,626
1928	4,109,823	273,033	11,251,830	2,943
1929	4,885,023	306,055	13,179,884	3,227
1930	3,737,780	242,113	8,402,577	2,489
1931	2,164,060	164,296	4,818,838	1,507
1932	1,029,709	122,977	3,043,090	1,158
1933	1,329,814	158,367	5,214,392	1,423
1934	1,953,129	155,980	4,939,806	1,691
1935	2,256,994	210,467	7,056,667	1,940
1936	3,568,992	301,287	9,960,539	2,456
1937	5,440,607	410,024	14,508,842	3,540
1938	4,874,548	289,793	12,892,659	3,165
1939	5,548,765	364,454	15,861,422	3,526
1940	5,908,226	346,805	15,624,656	3,647
1941	6,366,670	477,846	21,475,645	3,661
1942	6,795,459	439,460	22,671,208	3,576
1943	6,828,532	467,196	23,176,250	3,563
1944	6,587,740	419,265	20,623,055	3,837
1945	6,459,815	466,894	22,806,405	3,854
TOTAL	122,762,699	8,497,231	$358,902,362	
1879-1909	....	....	23,391,204	
GRAND TOTAL	....	....	$382,293,566	

a) Not available for the years 1910 to 1912. The figures given for these three years represent the average number of workmen.

ALPHABETICAL INDEX