C. M. Sternberg

CANADA
DEPARTMENT OF MINES
HON. T. A. CRERAR, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

BUREAU OF ECONOMIC GEOLOGY
GEOLOGICAL SURVEY

MEMOIR 185

Chibougamau Lake Map-area, Quebec

BY

J. B. Mawdsley and G. W. H. Norman

OTTAWA
J. O. PATENAUDE, I.S.O.
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1935

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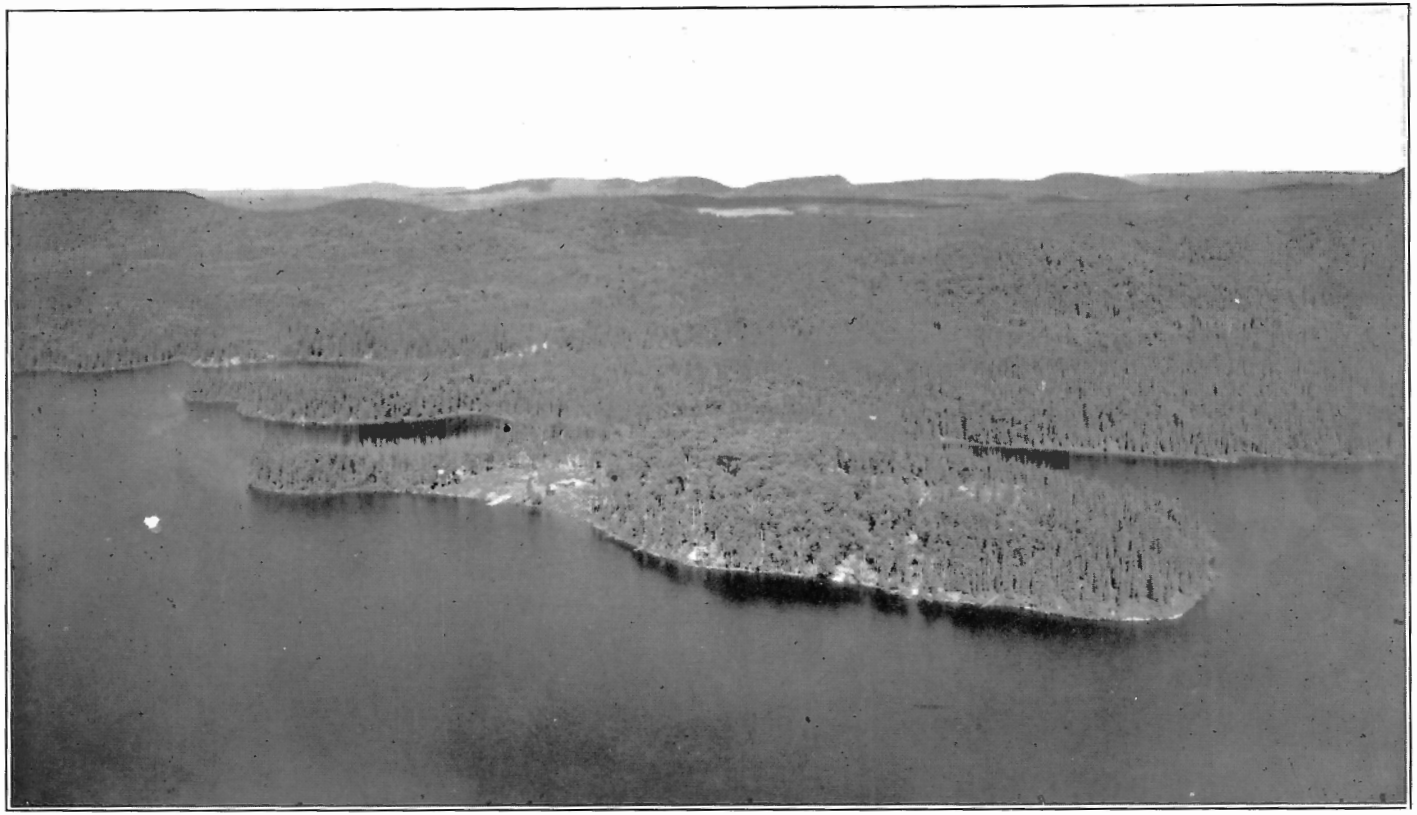

A. 4737-58 R.C.A.F.

Aerial view looking west from the entrance to Cedar bay on lake Doré. Cedar Bay camp on point in foreground; Doré Lake hilly belt in middle foreground with intervening central lowland and Bourbeau Lake hilly belt in background. (Photo by Royal Canadian Air Force.)

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Chibougamau Lake Map-area, Quebec

CHAPTER I

INTRODUCTION

Gold-bearing copper sulphide and gold-quartz deposits occur in Chibougamau Lake map-area. Some of the deposits and also small amounts of asbestos and low-grade iron ore were discovered as early as 1903, but their distance from the railway and the rather heavy growth of vegetation incident to a moist climate hampered systematic exploration in the district. In recent years, however, aerial transportation has put the district within 1½ hours flying time of the railway and has made possible more effective exploratory and development work. No mining operations have as yet commenced, although two deposits in the area have reached an advanced stage of exploration. One—a copper-gold deposit at Cedar bay, Doré lake (*See* Plate I)—has shown sufficient merit to warrant the sinking of a 500-foot prospect shaft and other underground exploration, now under way, by the Consolidated Mining and Smelting Company of Canada. The other—a gold-bearing quartz vein on the south side of Bourbeau lake—has been systematically drilled (1933-34) by the Noranda Mines, Limited, with promising results.

Chibougamau Lake map-area lies in the eastern part of Abitibi territory, Quebec, about 320 miles north of Montreal, and 224 miles east of the western boundary of the province. It comprises an area of about 370 square miles, which is bounded by the parallels of latitude 49° 45′ to 50° 00′, and of longitude 74° 00′ to 74° 30′. The map-area includes the greater part of McKenzie, Roy, Obalski, and Lemoine townships, the extreme eastern parts of Barlow and Scott townships, and the extreme western parts of McCorkill and Rinfret townships.

The consolidated rocks are Precambrian in age. They consist principally of a thick group of ancient volcanics of Keewatin aspect that are intimately and extensively intruded by rocks ranging from ultrabasic types to granite; and to a small extent of younger, perhaps Huronian, sediments. Apart from the large masses of ultrabasic rocks, serpentine and pyroxenite, and of anorthosite, the rock types of the map-area are comparable with those present in large areas of western Quebec and northern Ontario.

Detailed geological mapping of this map-area on a scale of 1 mile to 1 inch was commenced by J. B. Mawdsley in 1930, and completed by G. W. H. Norman in 1934. During the field season of 1930, J. B. Mawdsley mapped that part of the map-area west of the Roy-McKenzie township line and northwest of Doré lake; a strip 1 mile wide along the west side of Roy township; Portage island; and the greater part of the peninsula between

Doré and Chibougamau lakes. Within the area mapped in 1930 lie most of the mineral deposits that have for some years attracted prospectors to this region. Mawdsley had the competent co-operation of A. H. Lang in the field and also the able assistance of S. Dadson. The balance of the map-area, left unfinished in 1930, was mapped during the field season of 1934 by G. W. H. Norman, who was assisted in this work by H. J. MacLean and R. A. Brown. Norman also revised the mapping of Portage island and examined the development work undertaken since 1930 at Bourbeau lake, Cedar bay of Doré lake, and at a few other points. H. J. MacLean made a reconnaissance trip into McCorkill township at the close of the 1934 season to determine the general trend of the rock formations east of the map-area (*See* Figure 1).

The writers gratefully acknowledge their indebtedness to the various companies and many individuals working in the district for assistance kindly given in many ways. The Department of Surveys, Quebec, in 1930 supplied valuable information regarding topographic features. In the same year the Quebec Bureau of Mines, through the courtesy of the Director, A. O. Dufresne, furnished Mawdsley with manuscript copies, which have since been published, of J. A. Retty's report on, and geological map of, McKenzie township. The information afforded by the manuscript copies was of great aid in planning field work. Maps made from air photographs and ground traverses of parts of Roy township and other parts of the map-area, providing considerable geological information, were kindly furnished to Norman in 1934 by Lloyd Rochester of the Prospectors Airways. These maps were prepared by J. B. Mawdsley and George Shaw and were a valuable guide in systematic mapping. The privilege, extended by the Department of National Defence, of making reconnaissance flights over this area in 1934 proved of great assistance in picking out rocky areas for detail study, and structural features of the area. The flights were made with the Royal Canadian Air Force, detachment No. 7, commanded by Flying Officer R. C. Hawtrey, who was in charge of aerial photographic operations in this district.

MEANS OF ACCESS

Chibougamau lake can be reached by two canoe routes: one from Oskelaneo River station, 284 miles west of Quebec city, on the Quebec-Cochrane branch of the Canadian National railways; the other from St. Félicien at the west end of lake St. John. The former route is the easier and somewhat shorter; it is well marked, much travelled, and about 170 miles long. There are twenty-five portages of which one is 1¼ miles long, but the others are well under a mile and, with a couple of exceptions, are dry and afford good passage. Experienced canoemen with an average load can travel this route in about a week, just half the time it takes to travel the route from St. Félicien. An excellent map of the route from Oskelaneo, on a scale of 3 miles to the inch, may be obtained from the Department of Lands and Forests, Quebec. The cost of freighting material by this route was 20 to 25 cents a pound in 1930. A winter trail from St. Félicien to the south end of Chibougamau lake is used for freighting by horse and

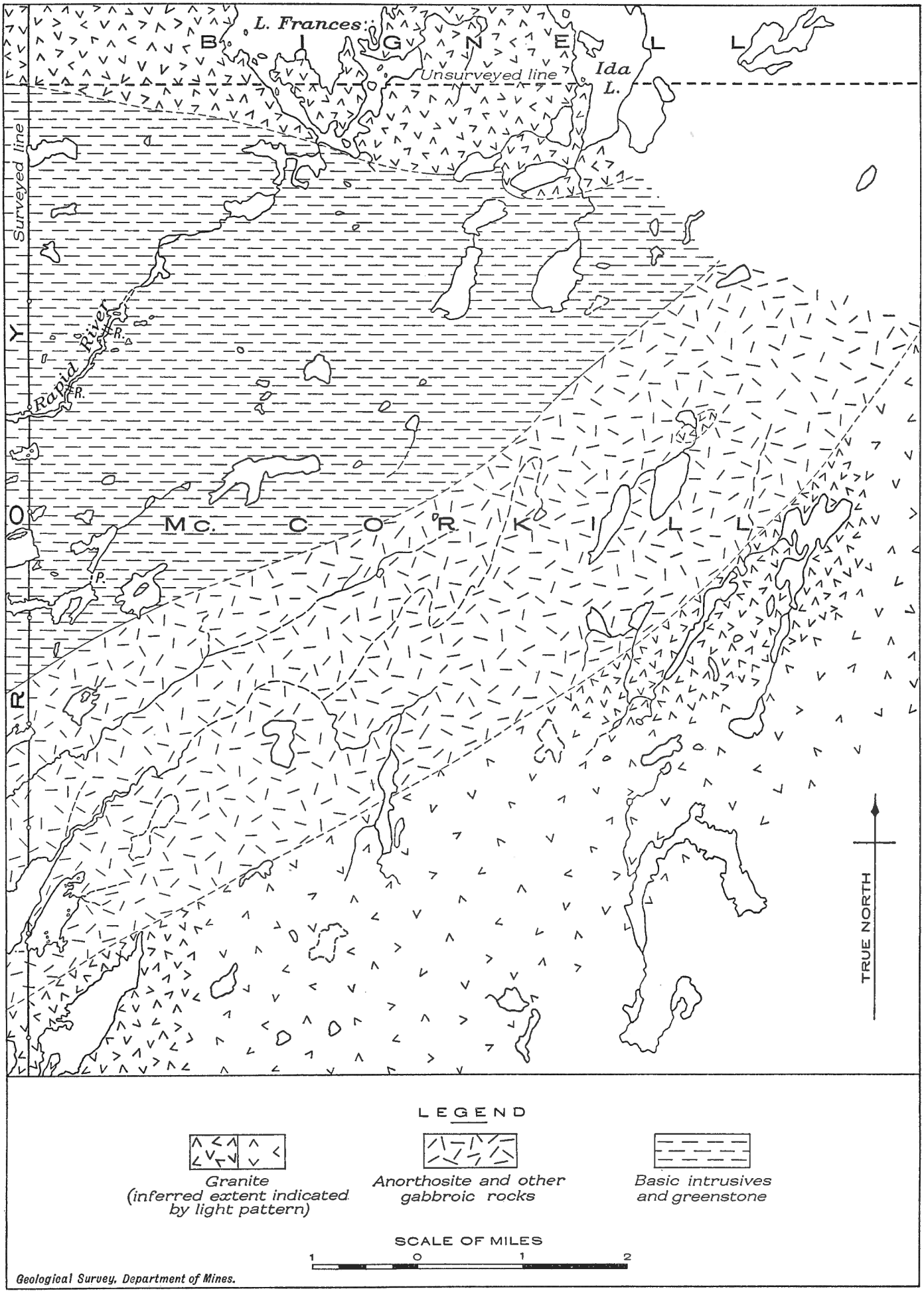

Figure 1. Sketch map (from aerial photographs) of parts of McCorkill and Bignell townships, Quebec.

dog sleigh, at a cost of almost half the above. Aerial transportation to the district is provided from a number of points.

PREVIOUS WORK

The region was visited during the seventeenth and eighteenth centuries by fur traders, missionaries, and explorers seeking a route from lake St. John to James bay. A complete and interesting account of this early exploratory work, as well as all work done in the region up to 1910, is to be found in the report of the Chibougamau Mining Commission,[1] now out of print but available in all large scientific libraries.

The first systematic geological work was done by the Geological Survey, Canada, in 1870, when James Richardson made an exploration in this area. In 1884 the Bignell-Low Mistassini expedition took place, and in 1892 and 1905 A. P. Low did further geological exploration in the vicinity of lake Chibougamau. The results of the geological work of these members of the Geological Survey were published in Annual Reports of the Geological Survey for the years 1870-71, 1885, and 1892-93, and in Publication No. 923, published in 1906. In 1903 Mr. Peter McKenzie discovered what were believed to be valuable deposits of asbestos, copper, and gold. As a result of these finds Mr. J. Obalski made a report in 1904, and in 1908 Professor E. Dulieux made an extensive examination of the then known mineral deposits in Chibougamau region. This work was published by the Department of Mines, Quebec, in 1904 and 1908, respectively. Interest in the area during the next few years became very marked and the Quebec Government was pressed to build a railway for the exploration of the gold, copper, and asbestos deposits of the area. It was finally decided to have an unbiased and authoritative report on the mineral occurrences and economic possibilities of the area. Accordingly, the Chibougamau Commission was appointed composed of Dr. A. E. Barlow, Special Lecturer in Economic Geology at McGill University, as Chairman, Mr. E. R. Faribault, of the Geological Survey, Canada, and Professor J. C. Gwillim, Professor of Mining at Queen's University. The commission, with a large party, entered the region in 1910 by the arduous route from lake St. John. The long and able report of the commission, together with a reconnaissance map covering 1,100 square miles, was published in 1911. It was pointed out that there were no asbestos deposits of economic importance and although the country gave promise of reward to the prospector, none of the gold or copper deposits so far found was commercially valuable even if railway facilities were available. This report dampened interest in this region for many years.

The completion of the Canadian Northern railway (now Canadian National) from Quebec to Cochrane, has made the region more accessible and the rich finds of the Rouyn area, Quebec, once more turned the attention of prospectors to Chibougamau region. Since the publication of the commission's report in 1911 other discoveries with copper and gold values have been made.

[1] Report on the Geology and Mineral Resources of the Chibougamau Region, Quebec. Department of Colonization, Mines, and Fisheries, Mines Branch, Province of Quebec.

In 1927 Mawdsley[1] did detailed work in Lake David area, a strip of country 15 miles long east and west and having a maximum width of 6 miles. The eastern 10 miles of this strip lies within Chibougamau map-area, extending from its west boundary in a direction slightly north of east and including the following parts of four townships; northeast corner of Scott, northwest of Obalski, and a strip along the south boundaries of Barlow and McKenzie. The then known deposits within this area were also studied.

In 1929, C. Tolman[2] carried on a reconnaissance geological survey in Obatogamau River area lying mainly to the south and west of the Chibougamau quadrangle, including the east part of lake David and waterways immediately to its south, which lie in the southwest corner of Chibougamau map-area. In the same year J. A. Retty [3] geologically mapped in detail, for the Quebec Bureau of Mines, McKenzie township, of which all but a northern strip, 1½ miles wide, lies within the map-area.

Topographic work was done in the region for the Department of Surveys, Quebec, by Henry O'Sullivan in 1898, C. E. Lemoin in 1899, C. S. Lepage in 1906, J. H. Sullivan in 1907, and J. M. Roy in 1929; by the Chibougamau Commission in 1911; and by A. C. Tuttle of the Geological Survey, Canada, in 1929. Aerial photographic work of part of the region was also carried out for the Department of Surveys, Quebec, during 1929, and by the Royal Canadian Air Force, Department of National Defence, in 1934.

PHYSICAL FEATURES

Topography

Chibougamau Lake map-area lies just north of the height of land between St. Lawrence river and James bay. It has a maximum relief of 725 feet which is much greater than is usual near this drainage divide. The topography of the northern part of this map-area is in striking contrast with that of the southern part. The northern part, north of David, Doré, and Chibougamau lakes, is a rocky region of marked relief with elevations ranging from 300 feet to 600 feet. The relief is formed by belts of hills and ridges separated by lowlands and narrow valleys that follow the rock structure in a general easterly direction. The hills and ridges are the most prominent features of the northern part of the area and lakes, where present, are small. The southern part, *See* Plate II, is a low, rolling country and is largely drift covered except possibly in the unexplored territory southeast of Chibougamau lake where at least one very prominent ridge occurs 4 miles southeast of Dufresne bay. About half the surface of the southern part consists of lake-filled depressions, of which lake Chibougamau, the largest, is 5½ miles wide and 16 miles long.

Two main belts of hills and ridges, *See* Plate I, occur in the northwestern quarter of the map-area—the Bourbeau Lake belt immediately south of Bourbeau lake, and the Doré Lake belt immediately north of Doré lake. They are separated from one another by a wedge-shaped,

[1] Geol. Surv., Canada, Sum. Rept. 1927, pt. C, pp. 1-22.
[2] Geol. Surv., Canada, Sum. Rept. 1929, pt. C, pp. 20-32.
[3] Quebec Bur. Mines, Ann. Rept. 1929, pt. C, pp. 41-72.

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Aerial view looking southwest across southern outlet of lake Chibougamau towards part of the southern lowland. Southwest tip of Portage island in near background. (Photo by Royal Canadian Air Force.)

central, lowland tract that terminates near the Roy-McKenzie township line where the two hilly belts coalesce to form one wide belt of broken, hilly country that extends in an easterly direction beyond the eastern border of the map-area. A second and more northerly lowland tract lies along the north side of the Bourbeau Lake hilly belt and its continuation to the east.

The northern lowland tract in the map-area extends from the northern part of Gwillim lake to the vicinity of Oreille lake, a distance of 15 miles; but it is part of a larger area which lies west and north of the map-area. A block of hilly country, situated immediately north of the western half of Bourbeau lake, breaks the continuity of the lowland. The block is about 2 miles long in an easterly direction and 1½ miles wide and is composed of irregular hills and easterly trending ridges that rise locally to elevations of over 300 feet above the lowland. The lowland, with the exception of a comparatively flat, featureless sand-plain northwest of Bourbeau lake, is a low hummocky region with fairly numerous, small ponds, lakes, and muskegs. It includes also parts of Gwillim, Rush, and Bourbeau lakes. The elevations are rarely more than 50 feet in height and are in part rocky and in part drift. The largest muskeg area, about 2 square miles in extent, lies immediately northwest of lake Orielle. South of this muskeg, and extending for 2 miles west to Blondeau lake, eskers and sandy drift hills are common and rock outcrops scarce. The sand-plain northwest of Bourbeau lake extends from the east side of Gwillim lake to and beyond Noorna lake on the north boundary of the map-area. It has an average width of 1½ miles for 4 miles eastward from Gwillim lake and widens considerably beyond this point. Low sand hills are present near Noorna lake, but few outcrops occur in this sand-plain. Parts of Gwillim, Noorna, and Dufault lakes lie within this sand-plain, which otherwise, with the exception of streams, is comparatively free of water.

The Bourbeau Lake hilly belt extends from the east side of Gwillim lake, near the western boundary of the map-area, to within a mile of the Roy-McKenzie township line. At this latter point it merges, as already stated, with an east-northeasterly continuation of the Doré Lake belt and the two hilly belts continue eastward as one. West of the Roy-McKenzie township line the boundary between the Bourbeau Lake hilly belt and the northern lowland lies along the stream draining Larone lake and extends from Larone lake to the south shore of the main part of Bourbeau lake. East of the Roy-McKenzie township line the boundary between the continuation of the Bourbeau hilly belt and the northern lowland is a subdued, scarp-like feature, locally quite distinct, which extends from the east end of Bourbeau lake in an easterly direction and passes about ¼ mile south of the western end of Blondeau lake. East of Blondeau lake the boundary becomes less distinct and finally disappears in country that contains numerous minor rocky elevations.

The Bourbeau Lake hilly belt averages about 1½ miles wide. It consists of a series of ridge-like hills, 1½ to 2 miles in length, many of which rise 300 feet or more above the neighbouring lowlands and valleys. A few have cliff-like escarpments, most of which face north.

Deep, east-west trending, lineal valleys which occur in this hilly belt form a strong contrast with the hills. The most pronounced lineal valley lies between steep-sided high ridges, half a mile south of Bourbeau lake. It extends westward from a narrow lake situated ⅓ mile south of mile 2 on the McKenzie-Roy township line for a distance of about 4½ miles across the east-west trending part of the southwest bay of Bourbeau lake. Numerous small lakes with rocky shores also lie either within, or border, the hilly belt. One of these, lake Berrigan, which lies ½ mile east of the discharge of lake Antoinette, has a cirque-like basin 100 feet in elevation above the latter lake.

A narrow, central lowland belt, continuous with low country west of the map-area, lies immediately south of the Bourbeau Lake hilly belt. The boundary between these two belts is not clearly marked, but the rougher country lies mostly north of a line trending a little east of north from Gwillim lake to the south shore of lake Antoinette. From this latter lake the boundary extends eastward to a point ¾ mile south of the southeast bay of Bourbeau lake. At the west boundary of the map-area the lowland is 1½ miles wide; 4 miles east it widens to 4 miles, and from there on progressively narrows to a blunt end situated 1 mile west of the Roy-McKenzie township line. With the exception of a level, sandy plain, 2 square miles in area, just west of Gilman lake, the surface of the lowland is rough and broken by rocky and stony hills. Ponds and small lakes form a small percentage of its surface.

The Doré Lake hilly belt, which lies along the north side of Doré lake, flanks the south side of the central lowland area. It is comparable in length and width with the Bourbeau hilly belt, but is less linear in form and has less relief as the individual hills are of lower elevation. The Doré Lake hilly belt consists of two parts, which have different trends and somewhat dissimilar forms. The more western part is continuous with a few prominent hills west of the boundary of the map-area. It extends eastward from the boundary as a belt 1½ miles wide along the Barlow-Scott, McKenzie-Obalski township line for a distance of 5 miles. The hills in this section are low and not pronouncedly ridge-like and tend to be isolated from one another. The other part is an arc-like belt that extends northwestward and northward from the shore of Doré lake, one mile south of Cachée bay, to join the western part of the belt near the Obalski-McKenzie township line. A part of it skirts the western side of Cachée bay, which is flanked to the south, west, and north by high ground. From the Obalski-McKenzie township line north of Cachée bay the hilly belt extends along the north side of Doré lake for 7 miles to a union with the Bourbeau Lake hilly belt in a wide tract of hilly country in Roy township.

The north boundary of the eastern part of the Doré hilly belt is an almost straight and continuous, prominent scarp, 7 miles in length. It extends along the south shore of Savage lake, the south bay and southeast shore of Gilman lake, through various small lakes to the head of Proulx bay on Doré lake. Within the hilly belt south of the scarp there is a pronounced depression 4½ miles long that extends in a crescent-like curve, convex to the north, from the northeast end of Cachée bay on Doré lake, to the north end of Cedar bay on the same lake. This valley

passes just north of two small lakes south of Gilman lake and ½ mile north of Doré lake. The ridge-like hills present in this part of the belt more or less parallel the above two pronounced physiographic features. The highest hill is just north of the crescent-shaped valley near the two small lakes south of Gilman lake and has a fire ranger's observation tower on its highest point.

The wide belt of hilly country that extends eastward from the Roy-McKenzie township line, where the Bourbeau and Doré hilly belts unite, is broken into two parts by an irregular northeasterly arm of Chibougamau lake. The western part of this belt, between Portage bay and the northern lowland tract of the map-area, consists of a series of steep-sided ridges, hills, and intervening valleys with occasional small lakes at various elevations above Chibougamau Lake level. The highest hills are prominent features, of which Cumming mountain, elevation 1955[1] feet, situated about 2 miles north of Portage bay and 1¼ miles west of the westernmost extremity of McKenzie bay, is the highest point in the map-area. The region east of the northeast arm of Chibougamau lake and between Rapid river and Island bay of lake Chibougamau has a varied topography consisting of prominent easterly trending ridges and irregular stretches of lower hummocky to gently rolling ground. The more conspicuous features, the ridges and deeper depressions, are less continuous than in the western part of the map-area. The lack of continuity is in part due to a depression that extends from Bag bay to Taché lake. The most prominent ridge, Sorcerer mountain, rises abruptly from the south side of Bear bay to an elevation of 500 feet above the lake, and extends eastward to the head of Bag bay. The ridge stands up in marked relief to the wide area of low hummocky ground that lies between its steep southern slope and lake Chibougamau. A westerly continuation of this ridge is separated from Sorcerer mountain by the northeast arm of lake Chibougamau and extends across the southern side of Portage island, north of Copper point and Portage lake. The ridge gives place to low ground at the southwest outlet of lake Chibougamau, but rises to a moderate elevation immediately southwest of this outlet and forms the greater part of the narrow neck of land separating Doré and Chibougamau lakes between Bateman and Eaton bays. The northern part of Portage island is on the whole an irregular rocky region with one conspicuous hill that lies a quarter of a mile north of the lake in the centre of the island. This rocky region is separated from the ridge along the south side of the island by a wide depression which extends in an east-northeasterly direction from Bateman bay. A second narrow and distinct depression with a similar trend lies immediately north of the conspicuous hill already mentioned.

The northeastern part of the map-area north of Rapid river contains scattered, rocky hills of moderate elevation, with low drift-covered and muskeg intervals. For about half a mile on either side of Rapid river is a rolling sand-plain with few outcrops.

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[1] Chibougamau Mining Commission.

Drainage

The area drains northward into James bay. The height of land between Hudson bay and the St. Lawrence drainage basin is believed to pass a few miles east of Chibougamau lake, across the southeast corner of the map-area. Lake Chibougamau and the irregular lake expanses and short connecting rivers through which the lake drains westward by a circuitous route to Chibougamau river and ultimately to Nottaway river, is the main drainage system in the map-area. A very small part of the map-area northeast of Bourbeau lake drains northeastward to lake Wakonichi. Lake Chibougamau is rectangular in outline, has an area of about 90 square miles, and is approximately 1,230 feet above sea-level. It drains through two outlets into Doré lake, which is about 12 feet lower in elevation. The outlets, *See* Plate II, are situated on either side of Portage island and display a succession of small falls and cascades. The water of Doré lake flows southwestward to Merrill lake, which lies at the extreme southwestern corner of the map-area. Merrill lake drains northward into David lake, a roughly circular body of water 3 miles in diameter, with an intricately crenulated shore and many islands. The estimated difference in elevation between Doré and David lakes is 7 feet and is evidenced by three short rapids and a few stretches of swift water. The drainage of David lake is westward through the irregular-shaped lake Simon to the long and narrow, northeasterly trending lake Asinitchibastat, which in turn empties into the equally long and narrow lake Gwillim, 7 miles of which angles across the northwest corner of the map-area. Gwillim lake, which is little more than an expansion of Chibougamau river, lies about 43 feet below lake Chibougamau and at an elevation of 1,187 feet above sea-level. Bourbeau lake, approximately 1,335 feet above sea-level, drains northward through lake Dufault, and Dufault creek, a narrow and tortuous stream, into Faribault river which empties into Gwillim lake at the north margin of the map-area. A tributary of Faribault river drains Noorna lake by means of underground seepage.

Gwillim lake drains from its northern end through a circuitous section of Chibougamau river into Rush lake. The southeastern part of Rush lake lies in the northwest corner of the map-area, and at an elevation approximately 7 feet lower than Gwillim lake.

The lakes in the southern lowland part of the map-area differ from those in the northern hilly part. In the southern part the lakes trend in a northeasterly to north-northeasterly direction parallel to the ice movement in the region, which has played an important part in their formation. Islands in these lakes such as Boulder, Commissioner, and Needle islands in lake Chibougamau have a similar northeasterly trend and are composed of drift, whereas the more irregular islands such as Granite and Line islands tend to be rocky. In the northern part of the map-area the form of the lakes is controlled more by the rock structure, but has no doubt been modified by glacial action.

CHAPTER II

GEOLOGY

GENERAL FEATURES

The oldest rocks (*See* table of formations, page 10) are a thick series of altered volcanics and a less extensive group of feldspathic sediments and acid volcanics. The feldspathic rocks are inferred to be in a synclinal structure and to rest conformably on the volcanics. Both groups are steeply inclined and have been very extensively invaded by a great variety of intrusives, ranging from ultrabasic types to granite.

The relative age of many of the basic and ultrabasic intrusive rocks is not known, but they are all, with the exception of olivine diabase dykes and related rocks, older than the granite. It is possible that all have developed progressively from one common magma, except the olivine diabase, which is a much younger rock. The ultrabasic and basic rocks, serpentine, pyroxenite, gabbro, and "diorite," are believed to be a closely related series and form for the most part irregular, sill-like intrusions parallel to the easterly strike of the volcanics. The intrusions are in part very closely spaced and separated only by narrow shreds of the older rocks. The anorthosite and associated gabbros are probably closely related to the other basic rocks. Feldspar porphyry, quartz-feldspar porphyry, and also rhyolite dykes believed to be related to the granite are fairly numerous in certain sections. Narrow "greenstone" dykes, some probably old and related to the volcanics, others definitely later than the granite, are present.

All the intrusive rocks with the exception of very fresh olivine diabase are altered to some extent. The alteration in most cases is great and in some bodies of rock is so intense that their original character is entirely lost. The characteristic alteration is the complete replacement of basic plagioclase by acid plagioclase intimately intermixed with minerals of the epidote-zoisite group and other secondary products and the conversion of the ferromagnesian minerals to secondary amphiboles and chlorite. This alteration was suspected in 1927[1]; but its importance was not then certain and some rocks that were then mapped as acid types are now included in more basic types.

A sedimentary series composed predominantly of coarse clastic rocks is younger than the above rock types except probably the olivine diabase. They are little metamorphosed and lie with gentle dips except along the McKenzie Narrows fault where they are steeply inclined, intensely sheared and altered. The sediments are cut, locally, by quartz veins of igneous origin and it is possible that they pre-date part of the mineralization of economic interest in the district.

1 Geol. Surv., Canada, Sum. Rept. 1927, pt. C, p. 7.

Carbonatization occurs in certain localities where the rocks are intensely sheared and is present to some extent along or near fault zones. Carbonate zones are in some places veined by quartz and accompany certain types of mineralization in the map-area. The latest faulting recognized is in a northeasterly direction and is younger than the coarse clastic sediments.

The present marked relief of Chibougamau district is probably a pre-Pleistocene feature; for there is no reason for postulating excessive erosion by ice during the glacial period, and the denudation since Pleistocene time is negligible.

The general movement of the last Pleistocene ice-sheet in the district is shown by the striæ to be from the northeast. Its plucking effect is shown by cliffs and by blocks on the sides of big hills that are capped by heavily jointed Chibougamau sediments, in the northern hilly belt. The highland areas, where devoid of soil or debris and heavy moss covering, present many smoothed and striated surfaces of fresh rock. Berrigan lake just east of, and over a hundred feet above, lake Antoinette is cirque-like in character, and is flanked on three sides by steep rock cliffs. This small basin was probably cut out by a small glacier during the waning stage of the last ice-sheet.

Unsorted glacial debris or sand is widely present in the valleys and lowland areas. The deposits of sand, which form extensive plains in the northern part of the area, are probably outwash from a retreating ice-sheet and in part were possibly formed in temporary lakes. Lake Noorna and many of the small lakes in these sand-plains are typical pot-holes in appearance; the shape of lake Noorna, however, may be partly controlled by the sand dunes that surround this lake.

The sand dunes, now largely covered by vegetation, muskeg-filled lake basins, and small deltas record the minor importance of erosion and deposition since Pleistocene time.

Recent weathering of the rock surfaces is negligible, but gossan-stained outcrops are present at many of the mineral deposits and carbonated zones. One of these gossan zones, just north of the east end of Berrigan lake, is of interest in suggesting that oxidation has apparently reached a depth of 8 feet since the retreat of the ice and is due to the local configuration of the ground and of the water table.

Table of Formations

Cenozoic	Recent and Pleistocene	Sand, gravel, morainic material, peat
Proterozoic (Late Precambrian)		Olivine diabase and gabbro
	Chibougamau series (Huronian?)	Conglomerate (Rapid river)
		Unconformity (?)
		Conglomerate, arkose, greywacke, quartzite; sericitic and quartzose schist (south of Rapid bay)

Table of Formations—Concluded

Great Unconformity

Archæan (Early Precambrian)		"Greenstone" dykes Oligoclase-albite granite and gneiss, syenite, diorite; feldspar porphyry, quartz-feldspar porphyry, and rhyolite dykes
		Intrusive volcanic breccia
		"Diorite" and related quartz-bearing, highly altered, "dioritic" rocks; anorthosite and associated gabbro and serpentine; serpentine, pyroxenite, gabbro, and altered gabbroic and dioritic rocks
	(Keewatin?)	Feldspathic sediments, breccia and acid volcanics; black slate
		Volcanic flows mostly of intermediate composition, some basic and acid types; some pyroclastics and sediments, and intrusives related to the flows

VOLCANICS

The oldest rocks, the volcanic flows and minor interbedded pyroclastics and sediments, form an altered assemblage that is similar to that termed Keewatin greenstones in other parts of Quebec and Ontario. A rather full discussion of rocks of this character is given in the report on the Rouyn-Harricanaw region[1], and the descriptions presented there depict very well the main features of the old volcanic assemblage in Chibougamau district. The extrusives shortly after their formation were undoubtedly continuous over most, if not all, the territory mapped, but they now occur as narrow bands and shred-like remnants invaded by various intrusives, and occupy not more than 25 per cent of the map-area. They occur only in the northern rocky part of the map-area, north of David, Doré, and Chibougamau lakes. The distribution of the larger masses is shown on the accompanying geological map. A few smaller masses lie within areas mapped as intrusives, particularly gabbroidal and "dioritic" types, from which they are in some cases hard to distinguish, and are indicated by the symbol V. The greenstone belt, shown on the Nottaway sheet No. 190A, Geological Survey, Canada, immediately south of lake Chibougamau, extends northeastward into the southeastern corner of the map-area. The volcanics in this belt are largely displaced by anorthosite and gabbro. They are for the most part schistose and towards the southeast are converted to coarse-grained, garnetiferous amphibole schists.

[1] Cooke, H. C., James, W. F., and Mawdsley, J.B.: Geol. Surv., Canada, Mem. 166, pp. 25-53 (1931).

Highly altered lava flows of intermediate composition, probably andesites, predominate in the volcanic assemblage. They are typical "greenstones." Light-coloured, acid flows, with or without quartz phenocrysts, and of rhyolitic and trachytic composition, are in places important, but basic types and fragmentals are not common. A few, narrow beds of fine to coarse sediments are interbedded in the group. They are apparently waterlain, are probably largely of pyroclastic origin, but may include arkose and conglomerate. The fine-grained sediments are finely laminated with dark and light bands, and closely resemble similar rocks in the overlying feldspathic group.

The volcanics are usually massive, but locally are much sheared particularly where intrusions are numerous. The massive varieties in many places, especially on weathered surfaces, show various structures, such as flow bands; ropy, scoriaceous, and fragmental tops; and amygdules. Pillows of various sizes and degrees of perfection are common in the intermediate types. The grain varies in different flows and even in the same flow from very fine to as coarse as one millimetre. Porphyritic and spherulitic textures are locally present. The weathered surfaces of the volcanic rocks are various shades of greyish green, with the exception of the acid types which are cream to grey. On fresh fractures the colours are similar but darker. The colour generally grades from light to dark according as the rock type varies from acid to basic. The greenish shade is largely due to the development of such secondary minerals as amphibole and chlorite.

Although the structures and textures of many of the volcanic rocks are well preserved, the individual mineral constituents have undergone complete alteration and it is doubtful whether any original minerals remain except in some of the acid types. The chief constituents of the intermediate volcanics are few, but their relative proportions vary considerably in different rocks. They consist of secondary amphiboles, chlorite, minerals of the epidote-zoisite group, sodic plagioclase with minor amounts of quartz, titanite, leucoxene, and carbonate. The form of the original feldspar is well preserved in two rocks studied; a spherulitic type and a diabasic type. In both cases the plagioclase consists of albite with abundant included grains of zoisite, and is interpreted as secondary after the normal basic plagioclase of a basic igneous rock. The acid types have a very fine-grained, quartzo-feldspathic groundmass with a grain of 0·01 mm. and under. They contain well-formed phenocrysts of acid plagioclase, 1·5 mm. long, and in some cases quartz. They usually contain considerable white mica, and lesser amounts of carbonates, epidote-zoisite minerals, and other secondary products.

Coarse fragmentals associated with acid volcanics form an important part of the volcanic assemblage that extends eastward from Portage bay to Taché lake. They consist of subangular to rounded fragments of light grey, acid volcanic material in a fine-grained, green matrix. The fragments are markedly uniform in composition throughout, and average a few inches in size, although some range up to 18 inches. Where the rocks are highly squeezed the fragments are drawn out to many times their original length. Two comparatively narrow bands of fragmentals are inferred to occur north of Bear bay, though they may be parts of the

same band on either side of an isoclinal fold or they may be a series of lenticular deposits. The more northerly band outcrops at two localities west of Valiquette narrows; one, on the east shore of Portage bay 2,000 feet northeast of Meeting island, the other, on the west side of Valiquette narrows immediately south of a gabbro sill. The more southerly band outcrops on the shore 3,000 feet north of Bear bay and was traced due east for nearly a mile to a point where the two bands are separated by about 1,000 feet. At this latter point the northerly band strikes toward the fragmental outcrop on the west side of Valiquette narrows, but was not traced in this direction. Outcrops of fragmentals are well exposed with widths of 100 feet or more in an easterly direction along the strike of the above two bands for a further distance of 1¼ miles, but beyond this point are concealed until the small, narrow lake 4,500 feet northeast of Bag bay is reached. At the northeast corner of this lake fine-grained fragmental rocks occur with a few small, highly squeezed fragments. As they lie on the strike of the fragmental rocks north of Bear bay they probably belong to the same general horizon. They were traced from the small lake for ½ mile east-northeast along the strike, but were not located beyond, that is to the west of the Taché Lake fault, which must cut them off in this direction. East of the Taché Lake fault the fragmental rocks outcrop at two points on the south shore of Taché lake; half a mile east of the western end, and at the eastern end of the lake. The fragmental outcrops on Taché lake probably form the faulted extension of the horizon of fragmentals on the west side of the fault.

FELDSPATHIC SEDIMENTS, BRECCIAS, AND ACID VOLCANICS

The largest area underlain by the feldspathic group is a belt about 3,500 feet wide which extends from the east end of Bourbeau lake to Blondeau lake. The belt narrows progressively eastward from Blondeau lake and terminates at the northwest boundary of the younger sediments a short distance northeast of Rapid bay. The rocks in this belt are flanked to the north by pillowed "greenstones" and to the south by a series of closely spaced basic sills which have a total width of nearly 2 miles. The basic sills are separated from one another by narrow belts of the feldspathic group which were originally part of the larger belt to the north. East of the McKenzie Narrows fault a few, narrow, shred-like remnants of the sediments lie within the intrusive rocks between Rapid river and Roy lake. They may represent the easterly continuation of the group east of the fault. Similar sediments also occur at the outlet of the large irregular lake, 1,000 feet west of the southern end of Taché lake, and in a hill 1 mile west-northwest of this outlet. At one point on the north side of Bourbeau lake opposite the southwesterly bay, and at another near the outlet of this lake, similar sediments occur. They probably represent part of a western extension of the main belt, since the belt, if it continues westward, which is very probable, should underlie a large part of Bourbeau lake.

The feldspathic group are a well-bedded assemblage with a typical sedimentary appearance. They are composed of acid volcanic materials and have a high content of altered feldspar, and a much smaller content of quartz. This peculiar feature of their composition, coupled with their extreme alteration, makes the determination of their original character difficult. It is uncertain to what extent true clastic sediments are included in this group, although some of the rocks are clearly in part waterlain. They are probably for the most part waterlain tuffs and pyroclastics with interbedded acid flows.

In general the rocks of this group, with the exception of dark slates, weather conspicuously white and locally to various shades of grey. Medium to fine-grained types are most common. The former tend to occur in massive beds, some of which are 20 feet or more thick; the fine-grained types are usually well bedded, in beds a few inches to less than an inch thick, and are in part finely banded. The high feldspathic content of the medium-grained types is evident on their weathered surfaces and gives them an arkosic appearance. Dark-coloured slate interbeds are fairly common; some are black and apparently high in carbon. Fragmentals form a small percentage of the group. They consist of subangular to angular fragments of acid volcanics, and fine-grained quartz and feldspar porphyries in a light-coloured matrix. The fragments are fairly uniform in size in any particular bed, range from 1 inch to 1 foot in diameter, and form the greater part of such rocks.

Two types of medium- to fine-grained rocks that are indistinguishable in hand specimens occur in the feldspathic group. They occur in beds ranging from a few inches to 20 feet thick and were considered in the field to be highly altered feldspathic sediments. One type consists of grains of altered, acid plagioclase and a small percentage of quartz embedded in a very fine-grained groundmass of feldspar, quartz, and secondary alteration products of which white mica, calcite, and zoisite are the most important. The plagioclase grains are, as a rule, angular to subangular, but a few have nearly euhedral outlines. They range in size from 1·0 to 5·0 mm., but average about 2·0 mm. and form 50 to 60 per cent of the rock. The quartz grains, which are minor constituents, are angular, in some cases thin and shard-like, and are equivalent in size to the feldspars. The angular character of the plagioclase and the presence of nearly euhedral crystals indicate that the constituents have undergone little attrition by transportation and that they were probably derived from a nearby source. They show no marked degree of sorting as the larger grains in general do not touch one another, but lie surrounded by the fine-grained particles in the groundmass. Their composition and texture are unlike that of a normal arkose, but are comparable with the acid volcanics in the district and for this reason they are inferred to be tuffaceous sediments and pyroclastics. In the highly altered varieties the feldspar grains are a mass of saussuritic material and the original character of such rocks is obliterated. Only very highly altered specimens of the other type were examined with the microscope. They consist of a fine-grained groundmass of quartzo-feldspathic granules, abundant white mica, carbonate, and zoisite, indivdually 0·015 mm. and under, in which are

embedded scattered larger grains of altered plagioclase and quartz, which form 30 per cent or less of the rock. The plagioclase grains are almost completely altered to zoisite, but their original form, which is fairly clearly marked out against the fine-grained groundmass, is as a rule distinctly euhedral. In size they range from 0·5 to 0·75 mm. The quartz grains are less numerous than the plagioclase and average 0·2 mm. in size. They are present in part as definite crystals with hexagonal outlines in thin section and in part as irregular, or narrow, embayed grains. That the hexagonal quartz crystals are primary constituents of these rocks is indicated by: (1) their presence together with other irregularly resorbed quartz grains as an important part of the fine-grained quartz porphyry fragments in the associated breccias; and (2) by the enlargement of one hexagonal grain by secondary quartz, which is clearly distinct from the original grain. The texture of these rocks and the euhedral crystalline form of the larger grains compares much more closely with that found in flows or tuffs than in sediments, and for this reason it is inferred that they were originally either flows or tuffs. Furthermore, in a sediment, feldspar and quartz, which have approximately the same specific gravities, should occur in grains of approximately the same size, and not as in these rocks in which feldspars average 0·5 to 0·75 mm. and quartz 0·2 mm. In tuffs and flows, however, there is no definite relation between the sizes of these two constituents. The distinction between flows and tuffs in such highly altered rocks is difficult, but the flowage structure observed in one rock under the microscope suggests that flows form at least a small part of this group.

The fine-grained feldspathic rocks in this group are white to grey and as a rule well bedded. Only one thin section of a fine-grained type was examined. This rock consists of a very fine-grained aggregate of quartz and feldspar granules arranged in well-defined bands 1·0 to 3·0 mm. wide. It contains small prisms of zoisite throughout, but more particularly in certain bands that carry a little tremolite and actinolite. The rock examined lies close to a large gabbro mass and is partly replaced by a small stringer of pyrrhotite accompanied by fresh albite. The fine-grained, light-coloured types are in many places finely banded with dark parting lines. In certain narrow beds the dark parting lines reveal the presence of fine crossbedding, though the bedded laminæ are too highly squeezed out to be of value in determining the upper surface of the beds.

Bands of fragmentals up to 30 feet wide with fragments up to 8 inches in size are present among the more southerly outcrops of sediments about 1 mile east of Bourbeau lake. They also outcrop here and there in a well-defined narrow belt that extends in an east-southeasterly direction for 1 mile from the north side of the large irregular lake that lies 1½ miles west of Blondeau lake. The fragmentals have a conspicuously white, somewhat chalky appearance and are made up of angular fragments that show little or no rounding. The fragments consist of various types of volcanics and fine-grained quartz and feldspar porphyries, and lie in a matrix that is similar in composition to the associated medium-grained rocks of arkosic appearance.

A breccia, with angular fragments up to 1 inch in size, forms an important member of the belt of fragmentals northwest of Blondeau

lake. The breccia averages 25 feet in thickness and has a steep or vertical dip. It outcrops at two points on the north side of the large, irregular lake, already mentioned, and in a small hill 500 feet west of this lake. At the lake it strikes north 110 degrees east directly towards a similar breccia that outcrops ¾ mile to the east-southeast.

In the small hill west of this lake the north side of the breccia is in contact with a fine-grained, massive rock that is vaguely laminated and has an exposed width of 10 feet. The laminated rock is very highly altered but is inferred to be either a rhyolite flow or tuff on account of its content of euhedral quartz and highly altered feldspar in a very fine-grained quartzo-feldspathic groundmass. Five hundred feet east of the hill and on the northwest side of the irregularly shaped lake, the breccia is in contact to the north with a coarse fragmental rock, 15 feet or more thick, that contains fragments up to 1 foot in size, and to the south with a medium-grained, massive rock composed largely of white feldspar grains and some quartz. The fragments in the coarse fragmental have a white, kaolinized appearance. They consist of fine-grained quartz porphyry with fairly numerous small phenocrysts of quartz and some of feldspar, feldspar porphyry similar in appearance to the quartz porphyry, but with no quartz and abundant lath-like phenocrysts of feldspar, and fine-grained trachytic rocks with a few scattered, green, prismatic amphibole crystals that are fairly conspicuous. The coarse fragmental grades abruptly within a width of 1 foot into the breccia. The breccia contains fragments similar to, though smaller than, those in the coarse fragmental, and also a few, small, angular pieces of grey chert and black slate. The matrix of the breccia forms about 25 per cent of the rock and consists of a fine-grained quartzo-feldspathic aggregate of granules, secondary products, white mica, carbonate, zoisite, etc., together with larger euhedral quartz crystals and highly altered feldspar laths. The composition and texture of the matrix closely resemble that of the laminated volcanic rock with which the breccia is in contact west of the lake, and are also similar to that of the quartz porphyry fragments which it includes, except for a lesser content of quartz. The coarse fragmental, the breccia, and the rhyolite tuff or flow are composed of similar acid volcanic materials, and are closely related rock types. At this locality at least the composition, appearance, and relationship of the fragmental rocks mark them as volcanic products probably explosive in origin. There is a possibility that the breccia may be part of a flow, although definite criteria for its recognition as such is lacking.

The rocks mapped as part of the feldspathic group in the belt about 1,200 feet south of McKenzie bay are of undoubted igneous origin. The continuity of this belt westward and its connexion with a narrow belt of undoubted feldspathic sediments that lie 1,500 feet south of Cumming mountain is open to question owing to the lack of located outcrops in the intervening part of the belt southwest of McKenzie bay. The rocks in the belt south of McKenzie bay are for the most part massive, white weathering, and highly altered, except in the more western part where a few outcrops of banded types are present. The original character of the massive varieties is largely masked by alteration. The less altered types consist of grey, fine-grained, feldspathic material with a few, small,

indistinct phenocrysts of feldspar and occasional prisms of green amphibole or secondary chlorite. In a few instances the feldspar phenocrysts are $\frac{1}{4}$ inch in size. The massive porphyritic rocks may be in part intrusive, but as identical types occur as fragments in the breccias of the feldspathic group it is very unlikely that such intrusives are younger than that group, to which they are closely allied in composition and in appearance. It is more probable that they are the intrusive members of an acid volcanic assemblage and are an integral part of the feldspathic group.

The strikes and dips of the feldspathic group in the area from Bourbeau lake eastward correspond in general to those, so far ascertained, of the greenstone and associated rocks to the north. A peculiar feature of the contact as mapped between the feldspathic group and the greenstones to the north is the narrow tongue of sediments which extends in a west-northwesterly direction into the greenstones northwest of Blondeau lake. If the sediments definitely overlie the greenstones, the sediments in the narrow tongue should either lie in a narrow synclinal fold or be faulted into their present position. Since there is no discernible repetition of beds in this narrow tongue it is unlikely that the structure is synclinal. Furthermore, at the outcrop on the northwest side of the large, irregular lake the sequence, from north to south, is: firstly, coarse fragmentals with fragments 1 foot in size; secondly, breccia with fragments 1 inch or less; and finally, medium-grained strata of arkosic appearance. This sequence suggests that the upper surface of the beds on the south side of the tongue is to the south, which if correct is inconsistent with a synclinal structure. Nor is there any evidence of a fault at this locality, and it would seem, therefore, that the feldspathic group in this narrow tongue is both overlain and underlain by pillowed greenstone. If this interpretation is correct, it implies that the contact between the feldspathic group and the greenstones is not a continuous and definite horizon and that the basal feldspathic strata interfinger to a certain extent with the uppermost greenstone members. Some confirmation for this conception is furnished by the relationship of banded sediments to pillowed lava on the north side of Bourbeau lake opposite the southwestern bay. At this locality banded, light-coloured sediments and black slate, which strike northeastwards, are in contact to the northwest with medium to coarse-grained, dark-coloured intrusive rocks and to the southeast with a pale green lava. The lava is well pillowed. In a section across the lava at right angles to the strike the form of the pillows indicates that the upper surface of the lava faces south and consequently that the lava overlies the sediments. On the other hand, it is possible that a few greenstone members are interbedded with the feldspathic rocks and that this group is entirely separate from the main body of greenstones.

STRUCTURE OF THE VOLCANICS AND FELDSPATHIC SEDIMENTS

The strike of the volcanics and sediments is, wherever determined, generally east or slightly north of east, and the dip steep or vertical. Evidence regarding the true attitude of individual beds obtained here and there between Gwillim lake and the McKenzie Narrows fault suggests

that the remnants of volcanics and sediments that occur in that part of the map-area possess a synclinal structure. Further work may yield evidence indicating that the structure of these bedded rocks is not a simple large fold, and that numerous subsidiary folds are also present. It is also probable in view of the high degree of folding of these rocks and the numerous intrusions they contain that their deformation was accompanied by faulting. If such faults developed parallel to the strike of the rocks, criteria for their recognition and also for their correlation with the periods of folding or of intrusion might be difficult to find.

Only a few good determinations of the attitude of individual flows were made. An excellent determination was obtained $\frac{3}{4}$ mile north of Cedar bay, on lake Doré, at a cliff face developed in four flows. The flows strike east, dip 80 degrees north, and their tops face north. A mile north of the west end of Gilman lake pillowed lavas striking due east outcrop, in which the pillows are considered to indicate definitely that the tops of the flows face north. One mile east of the southeast bay of lake Antoinette a good determination based on the pillow mosaic of an andesite flow indicates that the top of the flow faces north. Poorer determinations in this $1\frac{1}{2}$-mile wide belt of volcanics between lake Antoinette and Doré lake confirm the above evidence and indicate that the tops of all these volcanic strata face north. In the belt of volcanics in the northwestern part of the area, northwest of Gwillim lake and east of the north part of the same lake, no good determinations of flow tops were obtained. They strike due east or slightly north of east, as far as could be ascertained, and dip steeply. Two and one half miles northeast of the east end of Bourbeau lake an excellent determination based on spherulitic pillows of an andesite flow indicates that the flow top faces south. A strike of 20 degrees north of east and a vertical dip were less definitely indicated. Two other flow tops that are inferred to face south were observed in the volcanics north and east of Bourbeau lake; one occurs a few hundred feet northeast of the entrance to Anxiety bay, lake Bourbeau, and the other is exposed on the north side of a sharp hill $\frac{1}{4}$ mile west of the northwestern end of lake Oreille.

Criteria which if interpreted correctly suggest that the feldspathic group between Blondeau and Bourbeau lakes possesses a synclinal structure were obtained at two places; one south of McKenzie bay and the other northwest of lake Blondeau. Finely banded sediments that form part of the more southerly beds of the feldspathic group outcrop 100 feet south of the western extremity of McKenzie bay. They contain structures that were believed in the field to be well-preserved crossbedding and as such to indicate northerly facing beds. But owing to the alteration and fine grain of the rock some doubt exists as to the true nature of the observed structures. At an outcrop on the northwest side of the large, irregular lake $1\frac{1}{2}$ miles northwest of lake Blondeau, the sequence of strata as already mentioned is, from north to south: coarse fragmentals with fragments 1 foot in size; 25 feet of breccia with fragments 1 inch or less; 10 feet or more of medium-grained arkosic strata. This sequence of strata, which occurs in the northerly part of the feldspathic group, suggests that the upper surfaces of the beds are to the south.

The evidence cited suggests that the volcanics, north of Doré lake, and south of a line slightly north of east from lake Antoinette to the north side of McKenzie bay, lake Chibougamau, form the southern limb of a syncline. The line from lake Antoinette to McKenzie bay is considered tentatively to indicate the approximate position of the synclinal axis; and the volcanics north of this line to form part of the northern limb of the fold. If this interpretation is correct the feldspathic sediments east of Bourbeau lake form the central part of a synclinal structure and consequently overlie the volcanics.

The structure of the small remnants of the volcanics and sediments east of the McKenzie Narrows fault is not apparent. They strike in a general easterly direction and have steep dips. Flow tops, one mile northeast of Bear bay, are inferred to face north. A continuation of the inferred synclinal structure east of the McKenzie Narrows fault would be offset to the south. The offset indicated by the displacement of some of the intrusive rocks is about 5,000 feet.

INTRUSIVES

An outstanding feature of the map-area is the variety and extent of the intrusive rocks. They were injected into the Keewatin(?) series of volcanics and the feldspathic sediments prior to the deposition of the Chibougamau (Huronian?) strata. Their areal extent far surpasses that of other rocks and is estimated to be between 60 and 70 per cent of the map-area. The intrusive rocks range from magnesian-rich, ultrabasic types such as serpentine, derived from various olivine rich rocks and pyroxenite, to granite. All the intrusive rocks are altered to some extent. The alteration of the granites and closely related rocks is usually moderate, but that of the more basic types is, in general, intense. They are all characterized by a low potash content which is evidenced by the great rarity of potash feldspar in the thin sections of those rocks studied. In view of their common low potash content and their close geographic relationship in one small area it is possible that they are all genetically related. They can, however, be divided into an older, for the most part basic, group and a younger granitic group. The older group consists of ultrabasic, basic, dioritic, and related intrusives; the younger consists of granite, syenite, diorite, and quartz porphyry and feldspar porphyry dykes. It is possible that some of the rocks grouped in the older division are quite distinct and unrelated to the other members, or possibly have affiliations with the younger group. An intrusive volcanic breccia, not included in either group, forms a restricted and peculiar rock type in the map-area, and is intermediate in age between the older basic group and the younger granites. The basic group occupies a large part of the northern half of the area; the younger group, except for occurrences of small size, is restricted to the southern half.

Ultrabasic, Basic, "Dioritic", and Related Intrusives

The intrusives that comprise this group are serpentine, pyroxenite, gabbro, anorthosite, "diorite", and quartz "diorite." The feldspars of these rocks are, with rare exceptions, either completely altered or comprise sodic

plagioclase that is believed to be secondary. Accordingly the application of such rock names as gabbro and diorite is misleading so far as concerns the actual composition of the rocks. The terms as applied are based largely on field appearance and association with other more readily determined rock types. The intrusive masses of the various rock types are in part distinct, but certain types are either intimately associated or grade insensibly from one to the other, and on this account are difficult to map separately. For this reason the serpentine and pyroxenite were mapped as one unit. A few of the pyroxenite masses grade insensibly into gabbro, and the boundaries between these rock types are, in such cases, arbitrarily drawn. In certain places small areas of one rock type are included in larger areas of another on account of the scale of mapping. Some of the gabbroic and dioritic rocks are more highly sheared and altered than others and it is probable that the rocks grouped together in these rock types as mapping units on the map are of more than one age. The age sequence of the various basic intrusive masses is not at present known. Intrusive relations of certain masses to others have, however, been observed. But in view of the probability that intrusions of similar rock types are not strictly contemporaneous, generalizations from a few observed contacts are unreliable.

A rather characteristic type of alteration prevails throughout all these rocks. In general their original texture and general appearance are preserved to a varying degree of perfection, but the original mineral constituents except in many pyroxenites are as a rule almost completely changed. In the serpentine and in part of the anorthosite even the original textures are lost and in their altered state these rocks tend to be massive and featureless. The preservation of original textures, particularly in the gabbroic and dioritic types, permits an approximate determination of the form of the essential constituents, chiefly ferromagnesian minerals and feldspars, the relationships of these constituents and their characteristic alteration. The pyroxenes characteristically alter to secondary amphiboles, both hornblende and actinolite, and to chlorites. Varying, although usually small, amounts of epidote, carbonate, and even quartz may be mingled with the other secondary minerals. In many of the gabbroic and dioritic rocks the form of the ferromagnesian minerals present has been controlled by the shapes and development of the feldspars. The feldspars have a strong tendency to form narrow, lath-like crystals. In general the lath-like form of the original feldspar is clearly defined by the arrangement of secondary minerals, but the feldspar itself is entirely converted to a mass of secondary minerals. The most common alteration of the feldspar is to a granular mass of zoisite or clinozoisite, in a base determined as albite. Other secondary minerals that may be present in important amounts or that may completely replace the original feldspar are white mica, carbonate, actinolite, epidote, and chlorite; more rarely quartz, and possibly kaolinite, are present. In some cases the feldspars are albite, have a fresh appearance, and possess the textural features typical of medium-grained igneous rocks. Where the other constituents of the rock are little altered it is possible that such albite is primary, but in the profoundly altered rocks its characteristic presence and irregular form and its association with secondary minerals suggest that it has replaced a more basic plagioclase. The complete conversion of what is believed to have been

originally ilmenite to leucoxene is another characteristic alteration in these rocks, particularly in the gabbroic and dioritic types in which large grains of leucoxene are typically present. The leucoxene occurs in grains 1·0 mm. ± in size and contains a lattice-work of black iron ore grains in a rhombic or trigonal pattern. Part of the leucoxene may be a secondary development in titanite. In many of the more highly altered phases of these rocks, with the possible exception of serpentine and pyroxenite, quartz is characteristically present as small, wedge-shaped grains. The grains lie in the angles formed by intersecting feldspar laths, and as a rule are developed in groups that have a common crystallographic orientation; some exhibit micrographic intergrowths with feldspar.

The basic intrusive masses have in general an imperfect tabular form and an east-west trend which is parallel to the strike of the bedding recognized in the neighbouring volcanics and sediments. Exceptions occur; a gabbroic mass in the northwestern corner of the map-area has a northeasterly trend; the form of some intrusives is quite irregular. The boundaries of individual intrusive masses were not in all cases defined clearly. This is partly because traverses were made generally at right angles to the boundaries, which were in few cases actually observed and seldom followed for any distance from the line of traverse; and also because certain masses although mapped as one body on account of general similarity are in reality a composite of several intrusives. Even if the boundaries have more irregularities than are indicated on the map, the larger relationships suggest that the intrusives were injected in general as sheets and irregular sills parallel to the regional folding of the older bedded rocks and to a lesser extent as dykes and other crosscutting bodies. Certain irregularities of trend of the intrusive bodies may be due to later deformation. The inclination of the sheets and sills is probably steep and it is possible that their dip, if it conforms to that of the volcanics and sediments, is in many places toward the north. The intrusives that are injected into well-bedded sediments southwest of McKenzie bay and Asbestos island have apparently a definite northerly dip. Juggler mountain, a prominent knob formed by one of these intrusives, when viewed from the east has the erosional form of a hard, tabular mass that is steeply inclined and that has a barely perceptible dip to the north.

The basic intrusives may be divided into three sub-groups, each subgroup being composed of members that are more closely related by intermediate phases, and in general more closely associated in occurrence with one another than they are with members of the other sub-groups. Certain closely related members form intrusive bodies that are apparently composite parts of one intrusive mass. Others form distinctly separate bodies that in places are intrusive into other members of the same group. The three sub-groups of intrusives that are believed to be composed for the most part of closely related rocks are:

(1) Serpentine, pyroxenite, gabbro, and altered gabbroic and dioritic rocks.
(2) Anorthosite and associated gabbroic and ultrabasic rocks.
(3) Dioritic (and or) diabasic rocks and quartz-rich differentiates.

It is probable that some of the rocks are incorrectly placed as members in these groups. The altered dioritic rocks in group 1 were grouped with

the other gabbroic rocks in mapping for convenience and because of their general similarity. But they may be in part quite distinct and it is quite possible that some may be closely related to the older volcanic assemblage.

Serpentine, Pyroxenite, Gabbro, and Altered Gabbroic and Dioritic Rocks

These intrusives with included narrow bands of the volcanics and older sediments underlie a belt, 3½ to 2 miles wide, that stretches across the northern part of the map-area from Gwillim lake to McKenzie and Rapid bays, on lake Chibougamau. East of Rapid bay the belt is shifted to the south along the McKenzie Narrows fault and extends eastward from either side of Gunn bay. Two fairly large areas underlain by these rocks occur north of the main belt, one north of Bourbeau lake, the other north of Gwillim lake. Smaller occurrences of these rocks, more particularly the altered gabbroic and dioritic types, are present here and there throughout that part of the northern half of the area underlain by volcanic rocks. As a rule these occurrences are too small to map separately and some may be part of the volcanic assemblage rather than the later intrusives.

SERPENTINE, PYROXENITE

Three well-defined intrusions of serpentine and pyroxenite, the Rapid River, the Gunn Bay, and the McKenzie Narrows masses, occur east of the McKenzie Narrows fault. The Rapid River and Gunn Bay masses have sill-like forms, but the McKenzie Narrows mass is a more irregular body. West of the fault, serpentine and pyroxenite masses are developed, apart from minor occurrences, along three principal zones, viz.: the Orielle Lake, the McKenzie Bay, and another, much less perfectly developed one, south of the McKenzie Bay zone. Pyroxenite is well developed in the western part of the Orielle Lake zone, but eastward from this lake either grades into, or gives place to, gabbro, the two rocks apparently forming part of the same sill. This sill was not traced beyond a point 1 mile east of the lake, although isolated occurrences of pyroxenite, and gabbro are present along an easterly extension of this zone as far east as the McKenzie Narrows fault. In the eastern part of the Orielle Lake zone, the sill is probably broken up into short sections by small faults. The most easterly of these short sections occurs on the west side of the narrow lake that lies 2 miles northeast of Rapid bay. The appearance of the rocks in this easterly section of the sill is identical with that of the Rapid River sill, of which it is believed to be a faulted part. Large masses of serpentine and pyroxenite are intruded along the McKenzie Bay zone which comprises the McKenzie Bay mass, the linear mass along the south side of Bourbeau lake, and smaller masses east of the outlet of Antoinette lake. The McKenzie Bay mass is inferred to be an offset part of the Gunn Bay sill. The zone provisionally recognized as lying a short distance south of the McKenzie Bay zone is not a well-defined one. It is best developed at the following localities: ¾ mile south of the head of Sullivan bay, Bourbeau lake; east of "mile one" on the McKenzie-Roy township line; and along

78104
A. Wedge-shaped mass of pyroxenite in serpentine south side of Cran Penché bay, Bourbeau lake.

73900
B. Intrusive volcanic breccia, 1¾ miles northwest of Merrill island, Doré lake; showing a block of gabbroidal, porphyritic anorthosite; vesicular acid blocks; feldspar phenocrysts; and fine-grained, chlorite-rich matrix.

the south side of Antoinette lake. It possibly represents a zone along which intrusions of serpentine and pyroxenite have occurred, that was continuous previous to faulting with the McKenzie Narrows ultrabasic mass.

Serpentine and pyroxenite are as a rule closely associated in occurrence, but where pyroxenite occurs as a local phase of gabbroic masses serpentine may be absent. Pyroxenite characteristically forms a marginal phase along the outer borders of the serpentine-pyroxenite masses, and is seemingly wider on the northern sides of these intrusions. Pyroxenite, *See* Plate III A, also occurs as bluntly terminated, linear masses in the serpentine and as dykes, some of which apparently cut serpentine. In some intrusions pyroxenite is a minor phase in comparison with serpentine, but in others it is the principal rock.

Serpentine

The typical serpentine masses are dark, almost black, rocks with a green cast, and weather white to light brown. The masses have all suffered shearing. The less sheared bodies have a granular texture; the strongly sheared ones have lenses of the granular type, commonly half an inch wide and several times this long, separated by narrow, highly sheared bands of green serpentine. On a weathered surface this structure gives the rock a pebbly appearance, well seen in the mass lying $\frac{3}{4}$ mile southwest of Larone lake, McKenzie township. Slip planes of varying widths are to be found in almost every outcrop and are composed of green serpentine. Very occasionally, veinlets of brittle asbestos cut the serpentine rock and more rarely, veinlets of true asbestos. In all cases noted these veins are less than 1 inch, and usually not more than $\frac{1}{16}$ inch, wide.

The serpentines as seen with a microscope are composed almost exclusively of faint green to colourless serpentine, both fibrous and flaky types, and black iron ore. In slightly sheared types a granular structure is clearly evident, due to a greater concentration of "iron ore" at the margin of the grains. The serpentine fibres, forming the outer layer of the individual grains, are oriented normal to the borders and have a birefringence equal to antigorite. The centre of the grains is composed of similar serpentine with slightly lower indexes of refraction, a very low birefringence, and a zonal structure which is parallel to the margins, and is faintly evident under crossed nichols. Varying amounts of very fine, scattered black "iron ore" are always present. Where well preserved, the grains have a rectangular outline, length about twice the width, and a cross-section resembling a square with the corners truncated. The grains show a seriated size from 0·2 to 1·0 mm. in diameter. Due to the present composition of these grains, their shapes, and the concentration of "iron ore" grains along what were possibly irregular cleavage cracks, it is believed that the original mineral was olivine. Interstitial to these grains is usually a small amount of similar serpentine, grains of black iron oxide, and a little granular titanite, which also occurs in the interior of some grains. A little interstitial penninite is also present. One rock examined contained about 30 per cent diopside and in another a few very small remnants of the mineral were detected. In the first case it is

quite evident that the diopside is interstitial and crystallized later than the inferred olivine as it has an ophitic relationship to these altered grains. The diopside grains are as much as 2·5 millimetres in diameter. They show a partial alteration to antigorite, which in places includes an appreciable proportion of "iron ore" grains. No trace of original plagioclase was seen in any of the sections studied.

Pyroxenite

The pyroxenites are medium to coarse grained. They weather superficially to a rusty brown, but on fresh surfaces are light to dark greyish green, the shiny cleavage faces of pyroxene being clearly apparent. Locally, where well weathered, the uppermost few feet of the pyroxenite is composed of a loose, dark earth of altered pyroxene crystals that may in trenching be mistaken for drift. In places the pyroxenite is strongly sheared and is cut by veinlets of serpentine and to a lesser extent by material resembling picrolite.

The typical pyroxenites examined consist almost solely of diopside and its alteration products, amphibole and chlorite. Sparingly present in some cases are small amounts of serpentine, carbonate, iron ores, talc, probably secondary after olivine, and titanite. The diopside is characteristically fresh and may form as much as 90 per cent of the rock. It occurs in part as an interlocking mosaic and to a lesser extent as well or partly formed crystals, as seen in thin section. Where little altered the diopside grains are bordered by a ragged fringe of secondary amphibole; where highly altered the diopside occurs as small remnants in an irregular aggregate of amphibole and chlorite. Examples occur of all stages from fresh pyroxenite to altered amphibolitic rocks in which only small remnants of diopside are present. This transition suggests that amphibolites composed of a ragged aggregate of secondary hornblende and chlorite and forming local phases of pyroxenite or gabbro masses are altered pyroxenite and not a separate rock type. Phases of the pyroxenite transitional into gabbro contain a little albite, zoisite, and epidote.

The pyroxenite that forms a border phase on either side of the McKenzie Narrows intrusive mass contains a small proportion of brown hornblende. In one case the brown hornblende is clearly later than the diopside about which it has crystallized interstitially in an ophitic texture, and encloses small grains of talc which have a flattened hexagonal outline. The talc is accompanied by carbonate and iron ores and is probably secondary after olivine.

A more restricted type of pyroxenite occurs at McKenzie bay. It is pale grey, in places mottled with green, and on account of its resemblance to altered phases of the anorthosite was classified as such by the Chibougamau Commission. The grey pyroxenite is well exposed on the small island east of Asbestos island. It contains there green, well-formed crystals of chrome garnet, which but for their size, $\frac{1}{25}$ inch, would be of gem quality. The garnets occur in a base of enstatite and diopside, which are present in about equal proportions and form the main constituents of the rock. Similar garnets occur in pyroxenite at Black Rock, eastern townships, Quebec, where they are associated with chromite.

GABBRO AND ALTERED GABBROIC AND DIORITIC ROCKS

Gabbro and similar but more highly altered rocks form intrusive masses that range from bodies of considerable size to quite small masses. One mass midway between Gwillim and Doré lake is 6 miles long and over 2 miles wide; another, of lesser width, which lies immediately north of the McKenzie Bay zone of ultrabasic rocks and the Gunn Bay serpentine-pyroxenite sill, extends in an easterly direction across the map-area. The larger intrusive masses consist to a considerable extent of gabbro that is uniform in character and recognizable as a definite rock type. The gabbro in such masses gives place locally to more highly altered gabbroic and dioritic rocks and in some masses grades insensibly into pyroxenite. The smaller masses, at least in the eastern part of the area, are composed largely of highly altered gabbroic and dioritic rocks and to a lesser extent of more clearly recognizable gabbro, which in many small masses is entirely absent.

The rocks of this group are medium to coarse grained and have a somewhat soapy appearance on fracture. In colour they are finely mottled yellowish green, dark green, greyish green, and grey, although one colour, usually green, locally predominates. Some varieties termed "white gabbro" in the field are green and white in varying proportions. The mottled appearance is due to the alteration of the component minerals, chiefly light-coloured feldspar and green ferromagnesian minerals, which in hand specimens do not appear as sharply bounded crystals but blend one into the other. On fresh surfaces of the less altered varieties the altered feldspar is distinguished by its form and lighter colour from the ferromagnesian minerals. Such rocks are easily distinguished from pyroxenite and serpentine. Some of the more highly altered types, particularly where sheared, are green and massive, and in these the character of original constituents can be barely recognized, if at all.

The gabbroic and associated rock types differ from typical medium-grained phases of the greenstone by much wider uniformity of texture and by having a much more massive structure.

The most prevalent type of gabbro is an even-grained rock with a grain size of 2·0 to 3·0 mm. This type is well developed in the gabbro mass that extends past the north side of McKenzie bay, but grades into a fine-grained phase along the north side of this mass, south of Blondeau lake.

The typical gabbro is composed chiefly of altered diopside and feldspar, with a few large grains of leucoxene and a fine-grained, felted aggregate of chlorite and amphibole interstitial to the other minerals. The altered diopside forms 50 to 60 per cent of the average rock, and is the chief mineral in types transitional into pyroxenite; but local phases occur in which altered feldspar predominates. The diopside is usually present as small remnants surrounded by secondary amphibole interwoven in part with chlorite. The feldspars are entirely replaced by secondary minerals, zoisite, amphibole, chlorite, and albite. The feldspars have developed characteristically in lath-like forms that extend into, and appear to have controlled the development of, the pyroxenes to a large extent. In some cases, however, the altered pyroxenes have euhedral crystal

boundaries. Less than 1 per cent of quartz occurs as small, interstitial, wedge-shaped grains in many of the gabbroic rocks examined from the eastern part of the map-area. In some the quartz is micrographically intergrown with altered feldspar.

A less common rock type grouped with the gabbro has a grain ranging from 5·0 mm. to 1 mm. and a diabasic to granitoid texture. It occurs along the west side, and at a few places on the north side, of the McKenzie Bay serpentine pyroxenite mass, and north of the Gunn Bay-Roy Lake portage. A small mass of this type, 2,000 feet north of the mouth of Rapid bay, consists essentially of fairly fresh albite, dusted with fine, granular alteration products, and pale brownish, partly altered augite, with a little brown hornblende and titanite. Quartz was observed as a constituent of the rock in the field, but not in thin sections. The comparative freshness of the albite, textural relations that are typical of igneous rocks, and the high proportion of unaltered pyroxene suggest that the albite is a primary constituent of the rock and is not secondary after a more basic plagioclase. The rock has the composition of an augite-albite syenite and is believed to be a late differentiate of the gabbro-pyroxenite group. A narrow dyke of this rock type cuts the pyroxenite east of Roy lake; elsewhere its relations to the other rocks were not seen.

The highly altered gabbroic and dioritic rocks, which form many small masses and parts of large gabbro intrusives, are superficially similar to the gabbro and pyroxenite. They have in general a more intense alteration, exhibit a much less perfect preservation of their original textures, and in many cases are finer grained. The field relationships offer the only prospect of determining the true character and significance of rocks of this character. They are composed, with few exceptions, entirely of secondary minerals—essentially amphibole, chlorite, zoisite, epidote, and albite, with minor carbonate, white mica, and in many cases a little interstitial quartz—which are similar to those in the altered gabbro. Some types high in zoisite have a grey rather than green colour. The two main types of the altered rocks are: (1) rocks of gabbroic aspect in which the original ferromagnesian constituents appear to have squat forms; (2) rocks of dioritic aspect in which the original ferromagnesian constituents appear to have been elongate. A restricted dioritic type, present north of Rapid river, is intimately interleaved as narrow tabular bodies in greenstone. It has large amphibole phenocrysts. But the amphibole as seen with a microscope contains small remnants of pyroxene and is no doubt secondary after pyroxene. These porphyritic rocks are possibly highly altered augite porphyrites.

Another exceptional type occurs 1 mile north of the centre of Bourbeau lake in an area of gabbroic rocks. It is a fine-grained diabase with a soapy green colour. Well-formed laths of albite constitute 70 per cent of the rock, the other constituents are actinolite partly altered to chlorite, a little zoisite, leucoxene, and limonite. The albite is partly altered to zoisite and white mica, but its comparative freshness suggests that it may be primary.

The rocks grouped together as highly altered gabbroic and dioritic types are most probably of diverse origin. They probably comprise: (a) altered phases of the gabbro-pyroxenite series; (b) altered phases of

dioritic intrusives with quartz-rich differentiates; (c) members of an entirely distinct group or groups of intrusives. Some of the smaller of these masses that are believed to be intrusive may actually be coarse-grained parts of volcanic flows and would if fully exposed be seen to grade imperceptibly into more typical lava. An apparent gradation from altered gabbro with a grain size of about 2·0 mm. into fine-grained pillow lava across a distance of 6 feet was observed at only one place in the map-area, viz., in a large outcrop one mile northwest of Oreille lake.

Anorthosite, Associated Gabbro, and Serpentine

Two masses of anorthosite occur in the map-area. They are separated from one another by the extensive body of granite that occupies the southern shores and southern part of lake Chibougamau. A few small outcrops of anorthosite visited by H. J. MacLean occur at the northern tip of a small peninsula 2 miles southeast of Yvonne island in the southern part of lake Chibougamau. The extent of the anorthosite at this latter locality is not known. It is apparently surrounded by granite.

The northern mass of anorthosite forms a belt, 2 to 2½ miles wide, that extends in a direction slightly north of east almost continuously across the central part of the map-area from lake David to Nepton bay. Anorthosite is the predominant rock of this belt. The associated gabbro occurs as a narrow marginal phase along the northern side of the anorthosite belt and occurs with serpentine both as marginal phases and as small masses within the anorthosite northeast of lake Chibougamau. The associated gabbro is most widely developed at Caché lake. It underlies a large, irregularly shaped area there and separates the anorthosite at lake David from the main anorthosite mass on lakes Doré and Chibougamau.

The anorthosite mass southeast of lake Chibougamau may have been originally part of the northern mass and have been separated from it by intrusive granite. Gabbroic phases are associated with the anorthosite and are very approximately separated from it on the map. The anorthosite was visited at only two places, 10 miles apart—one, 3 miles southeast of Sunday bay, the other, 2 miles southeast of the Lake Chibougamau shore at a point immediately south of Boulder island. The anorthosite southeast of Sunday bay contains local high concentrations of magnetite, which strongly attract a compass. At one place a vein of magnetite 12 inches wide was followed for 20 feet. The anorthosite at the two localities visited occurs in well-defined ridges trending northeast, and that rise above the low, rolling, drift-covered plain south of lake Chibougamau. Other rocky ridges occur in the country between the ridges that were examined. That the intervening ridges are in part formed of anorthosite is suggested by the distances, ½ and ¾ mile respectively, across which anorthosite was seen where the two traverses were made. The boundaries of the anorthosite were not located at any point and its actual width may be much greater than ¾ mile. The anorthosite southeast of Sunday bay forms a very prominent ridge 300 feet or more above the low ground to the north. From the top of this ridge other rocky ridges are visible, though not visited, a short distance to the southeast. It is possible that the greenstone belt shown immediately

south of lake Chibougamau on the Nottaway sheet, No. 190A, Geological Survey, Canada, extends in an east-northeasterly direction across the southeast corner of the map-area and passes a little to the southeast of the anorthosite. This part of the map-area is difficult of access from lake Chibougamau. A possible route, up the stream entering Girard bay, is impeded beyond a point 1½ miles from its mouth by a succession of rapids, cascades, and falls. A route by way of lakes and portages starts from the southeast shore of lake Chibougamau opposite the south end of Boulder island. A large number of lakes lie southeast of lake Chibougamau; they are probably shallow but offer a possible means of reaching this part of the area from the air.

ANORTHOSITE

Anorthosite is easily distinguished from the other rocks by its white to grey colour and feldspathic appearance. It forms rocky hills of moderate elevation, north of Doré lake, north of Nepton and Finger bays, and also southeast of lake Chibougamau; elsewhere in the map-area it occurs in low-lying areas. In general it is massive and cut by joints 1 to 4 feet apart, but in places it is sheared and schistose. The weathered surface of the anorthosite is white to grey and in places faintly mottled with pale green. On fresh fractures the rock has a similar colour except that the green mottling when present is more distinct. The anorthosite has typically a coarse grain of 1 to 2 cm.; an exceptionally coarse grain up to 4 cm. is developed locally, for instance at the entrance to Cachée bay, lake Doré. But the excessive alteration of the anorthosite largely masks its original coarsely crystalline character and has obliterated any primary cataclastic structures such as are typical of many anorthosite bodies.

The typical anorthosite in the map-area is altered to a mass of secondary minerals that entirely obscure its original composition. Comparatively fresh phases were found only on the north side of Last island in Islands bay and at a locality 3½ miles southeast of Boulder island. The fresh phases consist essentially of labradorite (Ab_{35-32} An_{65-68}) in grains 1 cm ± in size and slightly altered internally to white mica and carbonate. On Last island the labradorite crystals in the anorthosite are broken and traversed by narrow, irregular seams of andesine (about Ab_{69} An_{31}) partly altered to zoisite and epidote; and the rock is cut by narrow veinlets of later quartz and of epidote. The fracturing and veining of the labradorite by andesine, which has grown in crystallographic continuity to the enclosing labradorite, probably developed prior to final consolidation of the rock. The altered phases of the anorthosite are not of uniform composition, although they are superficially similar and give the impression of a high feldspar content. Some consist largely of zoisite, as much as 80 per cent in certain rocks, in grains up to 1 mm. in size. Others consist almost entirely of white mica and carbonate. Present with the zoisite are white mica, in some cases small areas of amphibole and chlorite probably secondary after pyroxene, and up to 10 per cent quartz in grains with crenulated margins. On the south shore of Berthe bay of lake David, and at a few other places quartz is present as large, interstitial, opalescent grains. A little acid oligoclase, as much as 20 per cent in certain rocks, is intimately intermixed with the other secondary

minerals. Two specimens of anorthosite from Cedar bay to lake Doré were examined; a grey variety from the new shaft at an early stage of shaft sinking, and a green variety from one of the mineralized shear zones. The grey variety consists of a fine-grained, felted mass of white mica and carbonate in about equal proportions, with a few small grains of quartz, albite, epidote, zoisite, and leucoxene, and a small amount of chlorite. The green variety is a rather typical phase developed where intense shearing, and in many cases mineralization, has taken place. It contains a high proportion of chlorite, about 60 per cent in the rock examined, with white mica in much larger flakes than in the grey variety, and small, scattered crystals of clinozoisite.

ASSOCIATED GABBRO AND SERPENTINE

Gabbroic rocks composed either in part or entirely of dark ferromagnesian minerals and their alteration products are closely associated with the anorthosite. They are believed to be closely related to the anorthosite in origin and to be of approximately the same age. From Bear bay to the west side of Doré lake gabbroic rocks occur largely as a narrow, marginal phase along the north side of the anorthosite, but west of Doré lake are developed over a wide area within the anorthosite belt. East of Bear bay they occur partly as a narrow, marginal phase along the north border of the anorthosite and partly either as local segregations or as later intrusive masses within the anorthosite.

MARGINAL GABBRO WEST OF BEAR BAY

The associated gabbro marginal to the anorthosite west of Bear bay, in places shows a transition into anorthosite. Away from the anorthosite these rocks for the most part grade into highly altered ones that have little resemblance to the anorthosite and closely resemble rocks described as gabbro, diorite, quartz diorite, and their altered equivalents. Some of the rocks mapped as marginal gabbro that resemble these latter mentioned types may not be closely related to the anorthosite. Some are undoubtedly related to the Cachée Bay quartz dioritic rocks, and in certain places were grouped with these rocks in mapping.

Phases of the marginal gabbro that shows a close genetic relationship to the anorthosite usually occur close to the anorthosite contact, notably, on the northwest shore of David lake; on the portage from the north end of Caché lake to Cachée bay, lake Doré; and on Machin point, on the east shore of Doré lake 1 mile southeast of Cedar bay. At these localities porphyritic bands, a few inches to several feet wide, grade abruptly or gradually into non-porphyritic phases of like widths. The outcrops have a distinctly banded appearance, although the banding lacks regularity and sharp definition. The porphyritic phases range from typical altered anorthosite to an altered porphyritic gabbro with a low percentage of feldspar phenocrysts. The non-porphyritic bands are green, and differ from the porphyritic gabbro only by lack of phenocrysts. Phenocrysts of different sizes occur in the groundmass of the porphyritic varieties, either singly or locked together. The larger usually show comminution, and all

give the impression of having been involved in a pasty matrix subjected to movement under pressure prior to final consolidation. In mineral composition these gabbros are similar to the other highly altered gabbroic and dioritic rocks of the area.

The altered, green, non-porphyritic phases of the gabbro are the characteristic rock type of this group west of Bear bay. In places they show a uniform texture over wide areas; but in many cases an imperfect, discontinuous banding, and irregularly shaped, small segregations, either higher in altered feldspar or coarser in grain than the surrounding rock, give a variegated appearance to large surfaces of this rock type. The banding conforms approximately with the trend of the anorthosite boundary. In places the banded and segregation-rich types closely resemble altered volcanic rocks, but the general uniformity of the bulk of the rock is not a typical characteristic of the varied flow assemblage of the map-area. Small remnants of the older volcanics are, however, present in these rocks, notably in the vicinity of Caché lake.

ASSOCIATED GABBRO AND SERPENTINE EAST OF BEAR BAY

The gabbro, serpentine, and other basic rocks closely associated areally with anorthosite east of Bear bay are of two types. One type is massive to very dark green and is composed either of serpentine or of chlorite and amphibole, the other consists of light and dark minerals in about equal proportions and closely resembles the gabbro previously described that occurs in the northern part of the map-area.

Massive serpentine forms the chief rock of the narrow marginal belt that extends westward from Bag bay along the north side of the anorthosite. The serpentine weathers pale green in places, but is dark green on fracture. It contains abundant grains and irregular pods up to 2 inches in diameter of magnetite, and along the north side of Magnetite bay is traversed by closely spaced, irregular seams up to $\frac{1}{4}$ inch wide of this mineral. The content of iron in a sample taken across 80 feet of these rocks from the hill slope $\frac{1}{4}$ mile north of Magnetite bay is given in the report of the Chibougamau Commission as 35·7 per cent; titanium 0·86 per cent; phosphorus 0·017 per cent (op. cit., page 125). Some of the examined specimens of serpentine from the south side of Sorcerer mountain contain a little diopside or amphibole secondary after this mineral. Apart from their high magnetite content they are similar in all respects to the serpentine associated with pyroxenite in the northern part of the map-area. Serpentine also occurs, as small masses of unknown shape or size, at several places within the anorthosite between the mouth of Magnetite bay and the eastern margin of the map-area. The serpentine in these masses has a high content of magnetite in the form of grains and irregular pods and is in places traversed by tiny veinlets of asbestos. The contact of serpentine with anorthosite is exposed on two small islands in the lake immediately north of Finger bay. On one island a narrow dyke of serpentine cuts across the anorthosite.

The rocks mapped as an associated gabbroic phase, along the northern border of the anorthosite east of the Taché Lake fault, are massive, green rocks composed largely of a fine-grained, felted mass of chlorite and

secondary amphibole. They superficially resemble greenstone of the older volcanic group, but are much more uniformly massive and even-textured. Features that distinguish them from the greenstones are their characteristic content of small, plainly visible, green "phenocrysts" of amphibole and small grains and irregularly shaped pods of magnetite. Massive green rocks of this composition and appearance occur immediately west of Bag bay, apparently interbanded with serpentine in the marginal belt there. They are for the most part basic intrusive rocks, but their extreme alteration, particularly south of the western end of Taché lake near the fault, where they are highly sheared as well, has destroyed their original character. They are inferred to have been pyroxenites and pyroxene-rich gabbros and to be related to the serpentine described above. The relationship is indicated by their similar occurrence marginal to the anorthosite and by the similar development of magnetite in these rocks. As mapped they probably include altered greenstone. A massive, fine-grained diabase lies on the northern border of the belt on the portage south from Taché lake. This rock contains scattered grains of magnetite and a high percentage of apatite. Similar diabase, but free of magnetite and apatite occurs in volcanics on the northern slopes of Sorcerer mountain, and is seemingly related to the volcanics and not to the anorthosite.

Small masses of gabbro occur in the anorthosite along the southeast side of the Taché Lake fault. Judging from the distribution of outcrops they form narrow, tabular bodies parallel to the east-northeast boundary of the anorthosite east of the fault. They are much finer grained than the average anorthosite and except for transitions from altered pyroxene-rich segregations to others consisting of feldspar seen in one large loose block show no evidence of grading into anorthosite. They are medium grained, contain an equal proportion of light and dark-coloured minerals, and weather a light colour. On fresh fractures they are mottled white to grey and dark green. Their composition and texture are similar, except for a greater content of quartz, to that of the typical gabbroic rocks in the northern part of the map-area. The specimen of this gabbro phase that was examined consists essentially of about equal amounts of pyroxene altered to secondary amphibole, and of feldspar entirely saussuritized together with about 5 per cent quartz in graphic intergrowths with altered feldspar. Large grains of leucoxene secondary after ilmenite are present. "Diorite," a little darker in colour but otherwise similar to the gabbros just described, forms the northern tip of Gabbro island, the eastern side of the island to the west of Gabbro island, and part of the point immediately to the north. The original pyroxene or hornblende of the "diorite" on Gabbro island is entirely altered, but the feldspars are andesine ($Ab_{55}An_{45}$). A small percentage of biotite, quartz in graphic intergrowths with feldspar, and large grains of leucoxene secondary after ilmenite are also present. The freshness of the feldspars and the biotite are unusual features in rocks of this type in the area, but are characteristic in the dioritic phases related to the granite on lake Chibougamau. The leucoxene and graphic intergrowths of quartz are, however, typical of the gabbroic and related, highly altered, dioritic rocks that are developed in the northern part of the area, and it is probable that this "diorite" is closely related to the older basic intrusives and not to the granite.

Dioritic and Quartz Dioritic Intrusives

The rocks classed as belonging to dioritic and quartz dioritic types are basic to intermediately basic intrusives with local, quartz-rich differentiates. They are fine to coarse grained, and contain approximately equal developments of altered feldspar and of dark-coloured constituents accompanied by a variable content of quartz. The equal development of light and dark-coloured constituents is quite apparent on weathered, polished surfaces of the fresher varieties, but the more altered phases are dark, to very dark, green and massive. The quartz content, a variability in texture and composition from place to place, and in general a darker colour distinguish these intrusives from those classed as gabbro, and as being part of the gabbro-pyroxenite group, though individual specimens of these two groups may not be distinguishable. Their former nature is masked to a large extent by the alteration of their mineral constituents, particularly the feldspars. For this reason it is difficult to give them a petrographic name that would appropriately indicate their present composition. Nevertheless they do have in general a dioritic appearance, due to the slender, prismatic form of the secondary amphiboles present in the rock. The bulk of these rocks apart from the quartz-rich phases may, however, have been originally diabase or gabbro types.

Intrusives of this type form a narrow belt that extends along the south side of Bourbeau lake and continues eastward to the northern end of Rapid bay; a wider belt lies along the south side of Rapid river; and an irregular-shaped linear mass extends northeastward from Caché bay along the northwestern margin of the anorthosite. Small masses of these rocks occur also as follows: along the north side of the linear mass of gabbroic rocks that extend westward from Proulx bay on Doré lake; in association with other gabbroic rocks in the intrusives one mile north of the centre of Portage bay of lake Chibougamau; and in a, presumably narrow, easterly trending belt immediately north of "mile 4" on the Roy-McKenzie township line.

The dioritic and quartz dioritic rocks in the narrow belt that extends along the south side of Bourbeau lake to Rapid bay apparently form one sill-like mass, parallel to the regional trend of the older bedded rocks. They may in places include narrow shreds of the older rocks, which if schistified could be mistaken for sheared zones in the diorite. The dioritic rocks south of Rapid river, although mapped as one mass, form probably a series of closely spaced, sheet-like intrusive bodies, separated from one another by narrow shreds of the older sediments and volcanics. Narrow bands of the older rocks were observed in these intrusives at several places south of Rapid river, but are largely concealed by drift.

The dioritic rocks that form intrusive bodies along the south side of Bourbeau lake and immediately south of Rapid river vary from a medium to moderately coarse-grained phase to a more restricted phase that is coarse to very coarse grained. The coarse and very coarse-grained phases contain abundant quartz and long, slender prisms of amphibole, up to 2 inches long; some, more rarely, have a high percentage of large amphibole crystals and approach amphibolites in composition. The coarse phases occur as local segregations, and as narrow dykes within the finer grained

phases, or as associated small masses. Their occurrence and association with the finer grained types suggest that they are pegmatitic and quartz-rich differentiates of the latter. The more widespread, medium to moderately coarse-grained phases are green to mottled green on fresh fractures. Some are speckled with yellowish grey, altered feldspars and have a rude diabasic texture; in others the presence of altered feldspars is masked by the development of secondary, green minerals. A small content of quartz is usually visible in all these rocks, in some it is quite apparent even where they are extremely altered and sheared; in the finer grained phases it may be absent or if present occurs as small, scattered blebs. Many of the finer grained phases contain rather abundant, plainly visible grains of magnetite or altered ilmenite and leucoxene. Thin sections of the coarser, medium-grained phases show: a strong development of feldspar in narrow laths, completely altered to a granular mass of epidote, zoisite, actinolite, and chlorite in a base determined as albite; irregular-shaped areas of felted chlorite and secondary amphibole interstitial to the altered feldspar; a plentiful development of slender secondary amphibole crystals with ragged ends, up to 5·0 mm. long and probably secondary after hornblende; 5 per cent ± of quartz with an ophitic texture toward the other minerals and with graphic intergrowths of altered feldspar; and characteristically large grains of leucoxene secondary after ilmenite. The finer, medium-grained phases are of similar composition, but contain a negligible amount of quartz and little, if any, of the slender amphibole crystals.

A contact between the intrusive mass of dioritic and quartz dioritic rocks that lies immediately south of Bourbeau lake, and the gabbro mass to the south of this intrusive, is exposed about 50 feet southeast of the small blacksmith shop on the Noranda vein south of Bourbeau lake. The contact dips 73 degrees north and is exposed for only a few feet. The gabbro has an indistinct flowage banding and a slightly finer grain at the contact; dykes of the quartz- and amphibole-rich phase cut the diorite a short distance north of the contact, but were not observed to cut the gabbro. For these reasons the gabbro is interpreted to be younger than the diorite. Between Bourbeau and Blondeau lakes the quartz diorite is very highly sheared in many places along its contact with the gabbro to the south. The comparatively unsheared character of the gabbro along this contact is also indicative of its probable later age.

The irregularly shaped linear mass of similar dark quartz-bearing rocks that extends northeastward from Cachée bay along the northwest boundary of the anorthosite is a complex composed predominantly of related intrusives that exhibit considerable variability in character and a high degree of alteration. The Cachée Bay mass, herein defined as the Cachée Bay complex, is approximately 4 miles long and half a mile wide. The southern and eastern parts have a high percentage of rock exposures and in general an appreciable elevation above Doré lake. The highest part is in the northeast and includes the hill upon which a fire ranger's observation tower stands. Much of this area and adjacent sections to the north were thoroughly prospected in 1928. Picket lines were run at intervals of 400 feet and all easily accessible rock was stripped.

A coarse-grained rock, rich in blue, opalescent quartz and having the general appearance of a granite or granodiorite, occurs along the eastern margin of the Cachée Bay mass. In 1927 Mawdsley classed this rock as an oligoclase granite and grouped it with other highly altered rock types in one mapping unit. With the exception of this body, north of Cachée bay, the rocks classed in 1927 as oligoclase granite are now regrouped by Mawdsley in the marginal gabbro phase of the anorthosite. The width of this rock type north of Cachée bay is usually a few hundred feet, but in places is much less. Some phases are distinctly porphyritic, others owing to the lath-shaped nature of the feldspar have a diabasic texture. The rock is much altered and in some instances the feldspar is now a mass of alteration products of which the bulk are members of the epidote-zoisite group, with varying amounts of fine white mica and chlorite. Where determined, the plagioclase is an acid oligoclase and is believed to be secondary. It occurs as phenocrysts and interstitially with other minerals. Actinolite, in places partly altered to chlorite, is usually abundant and occurs in large grains, probably secondary after the original ferromagnesian minerals, and also as scattered flakes in other parts of the rock. The quartz is interstitial to the feldspar and forms from 20 to 50 per cent of the rock; it shows strain and is dusted with minute inclusions which very probably give it the opalescent look seen in hand specimens. The accessory minerals, zircon, apatite, and magnetite are present. The last is locally so abundant as to deflect the compass needle. A drift-covered area of pronounced magnetic attraction is present in the vicinity of this rock type, on the point immediately south of Cachée bay, on lake Doré. This rock mineralogically resembles the granites of the area, especially the mass north of lake David. Its contact with anorthosite is hidden, but the two rocks were seen within a few tens of feet of one another. Phases of the anorthosite near this contact contain interstitial grains of quartz similar to the opalescent quartz above described. The coarse, granite-like phase of the Cachée Bay complex intrudes, and is intruded by, the darker phases of the complex. On account of these mutual intrusive relationships, their many mineralogical similarities, and their intimate association with one another, the granite-like and darker phases of the complex are grouped together in one mapping unit, and are believed to be genetically related.

The rest of the complex is predominantly composed of buff-weathering, almost black, highly altered rocks in which dark, shiny grains of quartz are usually visible on a freshly broken surface. The visible quartz varies from about 40 per cent to none. The grain of these rocks varies from $\frac{1}{2}$ to 2 millimetres. The northeastern part of the mass has closely spaced, irregular joints. There does not appear to be a very regular gradation from the quartz-rich to the quartz-poor variety. Near the anorthosite contact the quartz-rich variety is exclusively present. It comprises about a third of the width of the complex, and is coarse grained. Away from the contact, the grain and quartz content varies, but in general the grain is finer and the quartz content less than that in the rocks bordering the anorthosite. The phases in which quartz is not visible to the naked eye resemble altered basic volcanics and would be

mistaken for such if it were not for their close association with the quartz-bearing type and their generally uniform massive nature and lack of all volcanic structures.

The thin sections of the darker phases of the complex that were studied show varying proportions of the same minerals, and indicate that the original rocks have suffered a high degree of alteration. Quartz forms from about 20 to 50 per cent of these rocks, and in one instance 75 per cent. The quartz is in the form of allotriomorphic grains often with crenulated margins, and an appreciable proportion forms micropegmatitic intergrowths with altered feldspars. The intergrowths form 10 or more per cent of the rock and vary in coarseness in different sections. In many cases the micropegmatite quartz and contiguous homogeneous quartz areas are in crystallographic continuity. In the rock containing 75 per cent of this mineral the quartz contains as inclusions the alteration products of the other minerals present and gives the impression that the original rock has been largely replaced by quartz. Euhedral grains of albite are usually present in small quantities. They occur in areas of altered untwinned feldspar that may possibly be orthoclase, or are associated and at times optically continuous with feldspar of the micropegmatite intergrowths. The feldspars contain varying amounts of fine to coarsely granular epidote, and green flakes of chlorite. Large, irregular chlorite aggregates similar to those in the feldspars are common and epidote grains are abundant in these rocks. Epidote usually constitutes 25 per cent of the rock volume. Grains of black iron oxide, in aggregates and small grains, form 1 to 5 per cent of the rock. Small amounts of carbonate, titanite, and colourless mica occur in most of the sections studied.

Outcrops of coarse gabbroidal rocks, in part with a pronounced diabasic texture, though having no essential mineralogical difference from the dark quartz-bearing rocks, as well as coarse amphibolites and phases of the coarse granite-like rock similar to that along the eastern margin of the complex, are sparingly present in the area underlain by the above described dark rocks.

An unusual rock type, resembling some of the marginal gabbro phases of the anorthosite, was noted about 700 feet south of the north contact of the complex, 3,000 feet north and 800 feet west of mile-post 5 on McKenzie-Obalski township line. This rock is porphyritic. Feldspar phenocrysts form 20 per cent of the mass, range from 1 to 4 centimetres in diameter, have rounded corners, are highly altered, and have a soapy green look. The groundmass has a grain of 0·5 mm. and resembles the quartz-rich phase of the black rock type that forms the bulk of the Cachée Bay complex. A small outcrop of conglomerate containing pebbles up to 5 inches in diameter occurs 800 feet west and 400 feet north of mile-post 5 mentioned above. The conglomerate is surrounded by outcrops of the Cachée Bay complex rocks and on this account its age relations to the other bedded rocks of the area are uncertain.

Intrusive Volcanic Breccia

An intrusive volcanic breccia occurs along the northwest side of the central part of the Cachée Bay complex. It occupies the northwest flank of high, rocky ground northwest of Doré lake. Outcrops are few north of

the high, rocky ground and in this direction the exact limits of the mass are difficult to determine. It has a length of about 4,000 feet in a northeasterly direction and an average width of 400 feet. To the north, northwest, and southwest it is in contact with volcanics that contain interbedded volcanic breccia, and exhibit pillows, vesicles, and other volcanic structures and textures.

Along the southern part of its southeast boundary it is in contact with the Cachée Bay complex; and along the northern part with a mass of quartz porphyry or soda granite about ¼ mile in diameter.

The breccia (*See* Plate III B) is peculiar because the fragments are variously composed and show little or no uniformity in size and shape. Irregular, kidney-and bomb-shaped fragments of a feldspar porphyry are very abundant. The phenocrysts in the feldspar porphyry vary in size from 1 to 10 millimetres, are highly altered, have a dark green, soapy appearance, and are white on a weathered surface. The groundmass around the phenocrysts is very fine grained and almost black, has a conchoidal fracture and weathers grey with a purplish cast. Other fragments of like composition lack phenocrysts, and resemble the dense, aphanitic groundmass of the porphyry. On a weathered surface many fragments are scoriaceous due to the weathering out of amygdules that contain carbonates, chlorite, and in some cases quartz. These two types constitute the larger part of the breccia and in places form 80 per cent of its bulk. The size of these fragments is from a fraction of an inch to a foot in diameter. Rounded crystals of altered feldspar, from a few millimetres to 4 centimetres in diameter, are in places common and scattered through the groundmass of the breccia. In their size and nature of alteration they resemble both the feldspar present in the anorthosite and the phenocrysts in the coarse, porphyritic, dark phase of the Cachée Bay complex. A few angular blocks of anorthosite and of anorthositic gabbro, up to 6 feet across, are also present. The altered feldspars in these blocks form about 60 to 90 per cent, show no pronounced crushing, and are up to 4 centimetres in diameter. The feldspar content is lower than in the main mass of the anorthosite bodies of the district, but in degree of alteration, size, and quantity is similar to that in the less feldspathic marginal phases previously described. The northeastern section of the breccia is in places wholly composed of what are possibly angular fragments of volcanics or phases of the black rocks of the Cachée Bay complex. The matrix of the breccia is composed of chloritic material. It is schistose in contrast with the larger fragments it encloses.

A very small mass of the breccia is surrounded by the black, quartz-bearing phase of the Cachée Bay complex, 3,200 feet west and 2,200 feet north of mile-post 5 of the McKenzie-Obalski township line and 200 feet south of the southeast contact of the main mass. Near this mass of breccia, which seems to be definitely engulfed, finer phases of the surrounding intrusive have fine amygdules that make up about 5 per cent of the volume of the rock. This amygdaloidal structure is also found in other outcrops that lie nearer the main body of the breccia. The amygdules are filled with chlorite and in some cases contain quartz as well.

The intrusive nature of the breccia is indicated by narrow tongues that extend from the main mass into the adjacent volcanics and rocks of the Cachée Bay complex. An intrusive contact with a dark green, chloritic

rock, believed to be part of the Cachée Bay complex, is exposed in a large bare outcrop 4,000 feet west and 1,800 feet north of mile-post 5, McKenzie-Obalski township line. The breccia forms the northwest part of the outcrop and contains anorthosite fragments and feldspar crystals to within an inch of its jagged contact with the chloritic rock to the southeast and which is faintly banded due to variations in grain size. At one place it extends as a narrow, irregular tongue, 9 feet long and tapering from 2½ feet to a point, into the chloritic rock. The tongue contains abundant fragments that are typical of the breccia and others that are dislodged pieces from the wall-rock. Four hundred feet northwest of this outcrop there are exposures of amygdaloidal andesite, which is definitely part of a flow. The andesite is cut by narrow dykes derived from the main mass of breccia that lies to the southeast. Similar confirmatory evidence, although less definite, of the intrusive nature of the breccia, was seen at other places.

That the breccia is younger than the (Keewatin?) volcanics of the area is indicated by its much less altered state, and its intrusive relations to these rocks. From the evidence collected it is interpreted to be an intrusive volcanic breccia formed at the locus of an ancient volcanic vent. The blocks of anorthosite and anorthositic gabbro which it has engulfed date it as later than these rocks. The breccia in one place cuts rocks believed to be part of the Cachée Bay complex, in another, breccia is engulfed by rocks of the Cachée Bay complex. It may, therefore, be closely related to these latter rocks. The porphyritic phase of the Cachée Bay complex contains feldspar phenocrysts comparable in size and alteration with those present in the anorthosite and its marginal gabbro phase; similar feldspar phenocrysts occur in the matrix of the breccia. There is, therefore, a possibility that a close relationship exists between all these rocks, but the similarity of the feldspar phenocrysts is not a definite criterion of their affinity.

Granite and Related Intrusives

The distribution of granite and related intrusives in the map-area is shown on the accompanying map (No. 304 A). A large mass occurs on the southern lowland tract and occupies the southeastern shores and southern part of lake Chibougamau. A tongue from this large mass protrudes westward into the anorthosite towards Merrill island and towards the smaller granite body that lies north of lake David. In the northern part of the map-area small bodies of granite or related rocks are present at the following localities: 1½ miles southwest of Gilman lake; near the southwest end of Bourbeau lake; on either side of Portage and Bear bays. Small dykes of granite and feldspar porphyry or feldpar-quartz-porphyry that cut all the older basic intrusives and volcanics are sparingly present in the map-area and are fairly numerous in the districts adjacent to lakes Bourbeau and Doré.

The granite and related rocks are in general altered to some slight extent. In places they are intensely shattered or sheared. They range from light-coloured types high in quartz and feldspar to less common, darker types rich in hornblende and biotite or their alteration products. The feldspars of these rocks are almost exclusively plagioclase. Potash

feldspar, microcline, was noted in very small amounts only in a granite dyke north of Rapid river and in a fine-grained granite that outcrops on a small island ½ mile east of Henry island, lake Chibougamau.

The northern limits of the large granite mass on lake Chibougamau are marked by anorthosite against which it has an intrusive contact that is fairly well exposed on islands in the centre of lake Chibougamau. The southeastern boundary lies 2 to 3 miles southeast of lake Chibougamau, where the granite gives place to altered anorthosite and gabbroic rocks, greenstone, and coarse-grained, garnetiferous amphibole schists. The southwestern extension of the granite towards Merrill lake is largely drift-covered. Granite outcrops lying 1¾ miles northeast of Merrill lake are probably part of the Chibougamau mass. Large boulders of granite on the northeast shore of Merrill lake are probably close to their source and may indicate that the granite extends southwestward to, or nearly to, this vicinity. The Chibougamau Commission's map and the southeastward projection of the contact mapped by Tolman[1] indicate that granite gives place to older altered strata near the southeast corner of the map-area.

The Lake Chibougamau granite mass is composed of two main types. The most widely developed type is light grey granite high in quartz, the more restricted type is a much darker diorite to quartz diorite. The dioritic type forms in places marginal phases of moderate extent to the granite, though it is slightly older and is, in places, cut by granite dykes.

The dioritic phases are developed in the vicinity of Girard bay and northeast of this bay; on islands north of Granite island in the centre of lake Chibougamau; along the shores of the southern part of the Southwest arm; and probably at other places. They are medium grained and vary in composition. Some contain white to colourless feldspar and dark-coloured minerals in about equal proportions and little, if any, quartz. The feldspar in such types is andesine, partly altered to white mica and minerals of the epidote group; the dark-coloured constituents are hornblende and biotite, both partly or largely altered to chlorite. The quartz content in the dioritic phases ranges up to 15 per cent or more and is present as small, clearly visible grains. The feldspar of the quartz-bearing types is also andesine; the hornblende and biotite content is somewhat less than in the quartz-free types. The feldspars of quartz diorite that outcrops on the south side of the large lake east of Club bay, on lake Chibougamau, are very much altered. They are albite or albite-oligoclase, filled with flaky and granular alteration products, and are interpreted to be secondary after andesine, which is the characteristic feldspar of the less altered dioritic types. The diorite and quartz diorite that form local phases of the Lake Chibougamau granite mass are, where fresh, easily distinguished from the older dioritic and quartz dioritic rocks that intrude the volcanics as sill-like bodies in the more northern part of the map-area. Their dark-coloured constituents are fairly fresh hornblende and biotite in contrast with the paler secondary amphiboles and chlorite of the older dioritic rocks, and their constituent feldspars usually show cleavage faces, whereas those in the older rocks are altered to a fine-grained granular aggregate of secondary minerals.

The light-coloured granite that forms the greater part of the Lake Chibougamau mass is grey, locally tinged either with pale green or with

[1] Geol. Surv., Canada, Sum. Rept. 1930, pt. D, p. 22.

red. In places, for instance on Henry island and the adjacent shore of lake Chibougamau, it weathers white and on casual inspection closely resembles anorthosite from which it is distinguished by its finer grain, high quartz contact, and in some cases by its low content of biotite. The latter mineral if altered to chlorite is not conspicuous. The granite varies from medium to very coarse grained; on Alphonse island, in lake Chibougamau, the grain is exceptionally coarse and crenulated biotite flakes, present in the rock there, are ½ inch in diameter. In the eastern part of the mass, south of Eugene island, the granite has an indistinct to definite gneissic structure and a foliation that strikes east-northeastly and dips steeply south. On Eugene and Henry islands the quartz is present as narrow, discontinuous laminæ that weather on the surface into tiny, knife-like ridges. In the southwestern part of lake Chibougamau the granite is locally highly sheared and schistose, but in general has a granulose, shattered appearance, that is very distinct in places, but in others vague. Thin sections were examined of only the granite from the eastern part of the mass south of Eugene island. It contains up to 40 ± per cent of quartz. The feldspars in the phases developed toward the centre of the mass on Sunday bay and near the junction of the two rivers that flow into Girard bay are oligoclase. A little biotite, and in some cases hornblende, is present, but is largely altered to chlorite. The feldspars are broken and faulted to a small extent and are altered, partly or extensively, to white mica and minerals of the epidote-zoisite group; the quartz is converted to a mass of interlocking granules that have a very uneven extinction under crossed nicols. Biotite granite with a high quartz content is the characteristic rock in the southwestern part of the Lake Chibougamau mass. The feldspars in the biotite granite were not examined but probably range from albite to oligoclase as in other granites of the map-area. The report of the Chibougamau Commission (page 150), however, suggests that orthoclase is an important constituent of the biotite granite.

The granite north of lake David is an eastward extension of a mass that lies west of this lake. Its contacts with other rocks in the map-area are covered by drift. Along the western half of its north boundary it is inferred to come in contact with volcanics, and elsewhere with the marginal gabbroic phase of the anorthosite. The characteristic rock of this mass is a medium-grained, light-coloured, albite-oligoclase granite rich in opalescent quartz and poor in ferromagnesian minerals. It is considerably altered. Quartz forms 30 to 60 per cent of the rock, partly interstitial to or penetrating the feldspar and partly as large grains. It is strained, in many cases crushed, and is full of dusty inclusions. The feldspar is acid oligoclase or albite but was probably more basic when fresh. It shows less strain or shattering than the quartz, and is largely altered to a granular aggregate of zoisite, epidote, chlorite, and white mica. The ferromagnesian minerals are green, feathery hornblende partly altered to chlorite, and apparently biotite completely converted to chlorite. Accessory apatite, zircon, magnetite, and titanite are present. Some of the apatite grains are surrounded by pleochroic haloes.

Darker phases of the Lake David mass resemble the light, quartz-rich phases of the Cachée Bay complex and also the coarse-grained, gabbroic phase containing opalescent quartz, that is marginal to the anorthosite northeast of lake David. These dark phases are cut by granite dykes.

Small bodies of green, chloritic granite occur on either side of Portage and Bear bays. It is possible that these bodies, with the probable exception of that on the north side of Portage bay, are part of a larger body beneath the water because the greenstone along the shores of these bays is cut in many places by granite or feldspar porphyry dykes. The granite has a high content of opalescent quartz and a moderate content of chloritized ferromagnesian minerals.

The granite on the north side of Portage island has a shattered appearance, is highly schistose along the northwest side of Hematite point, and is cut in places by glassy, granular quartz that is mineralized with magnetite, pyrite, and chalcopyrite. It is most probably cut off to the west by the McKenzie Narrows fault. That the poorly exposed granite on the north side of Portage bay possibly forms part of its extension west of the fault is suggested by the comparable faulted offset of serpentine-pyroxenite masses.

A pale greenish granite outcrops on the east shore of the bay, ½ mile northeast of Needle island, lake Chibougamau. It is similar in appearance to the granite south of Bear bay but is separated from this granite by 1½ miles of drift-covered country.

A small granite body that is 1½ miles southwest of Gilman lake is composed chiefly of a porphyritic, medium-grained rock, light greenish grey in colour, that contains about 30 per cent quartz. Partly altered albite-oligoclase ($An_{10}\pm$) in euhedral crystals is the most abundant mineral constituent. The quartz shows crushing and occurs in euhedral rhombic grains and also interstitially. Micrographic intergrowths of quartz and feldspar are sparingly present. The original ferromagnesian minerals are chloritized; in some phases they are abundant, in others negligible. Strong shear zones running in an east-west direction and having vertical dips are present in places in this granite. Many of these zones are strongly impregnated with rusty weathering carbonate; others contain an appreciable amount of cubical pyrite. Massive and drusy, quartz veinlets with or without pyrite cut the porphyry and neighbouring wall-rock. In the wall-rock at one locality a similar drusy vein contains euhedral quartz crystals and interstitial chalcopyrite, a type of mineralization encountered in some of the mineral showings of the district. Near the centre of the mass a 1½-foot wide, fine-grained " greenstone " dyke cuts the granite.

The Cachée Bay complex, which lies on the south side of the porphyritic granite, is cut by narrow, satellitic granite dykes from the main body and is, therefore, older than the granite. The relation of the granite to the intrusive volcanic breccia that lies to its west is not clear. Intrusive breccias that are part of the granite itself occur on the southwest and northeast margins of this small porphyritic body. They consist of fragments of chlorite-rich rocks possibly belonging to the Cachée Bay complex, together with a few of feldspar porphyry, all enveloped by a porphyritic granite matrix. The granite shows no chilling effects against the fragments, and the latter show little if any metamorphism. The intrusive breccia phases of the porphyritic granite suggest that the granite is probably related to the intrusive volcanic breccia. The granite is interpreted to be slightly younger in age and to represent the final stage of the intrusion.

The granitic intrusive, which lies 1½ miles southeast of Bourbeau lake on the east side of Line lake, is a small, stock-like body of quartz-poor granite or syenite with feldspar porphyritic phases. Intermittent outcrops of this rock over a distance of 2½ miles in an easterly direction from Line lake suggest that a dyke-like tongue extends eastward from the main body across the southwest arm of Bourbeau lake. The western stock-like part of the syenite mass intrudes volcanics and gabbros; the eastern tongue, which averages about 200 feet wide, cuts serpentine and pyroxenite. The main mass of the rock on the east side of Line lake has a granitoid texture and is medium to coarse-medium grained. The narrow parts of the mass have a tendency to be porphyritic. The phenocrysts in the porphyritic phase are usually exclusively feldspar, but are occasionally quartz. The general colour of the two types is light green where weathered and darker when freshly broken; the feldspar which predominates in this rock has a greenish yellow cast, the ferromagnesian areas being dark grey-green. The feldspar is acid albite in stumpy euhedral to semi-euhedral crystals that are 15 to 70 per cent altered to a fine, flaky, white, mica-like substance accompanied by a very little epidote in grains and veinlets. Actinolite, which is probably secondary, and chlorite are, next to the feldspar, the most important constituents of these rocks. The actinolite crystals are semi-euhedral, show in some cases twinning, and are spottily altered to chlorite. Quartz usually forms a small proportion of this mass. It occurs sparingly as irregularly formed large grains, and characteristically as interstitial particles, or as blebs of like optical orientation penetrating feldspar crystals.

Shearing took place locally in the narrow, dyke-like part of the mass. Where sheared the rock is usually much impregnated with iron carbonate, and weathers deep brown, but is light grey on a freshly broken surface. The constituent feldspar is highly altered, the actinolite is converted to chlorite and epidote, and pyrite particles are common.

Outcrops of granite similar to quartz-rich phases of the Line Lake body occur on the northwest shore of Gwillim lake about 3½ miles west of Line lake and 2½ miles from the west boundary of the map-area. This granite intrudes the volcanics of this section of the area.

Porphyry dykes were observed to cut all the rocks of the map-area, except the intrusive volcanic breccia, the granite, and the Chibougamau sediments. They are fairly numerous in the vicinity of lakes Doré and Bourbeau; elsewhere they are sparingly present or absent. They are usually traceable, owing to drift and moss cover, for not more than a few tens of feet, and are narrow, the majority less than 10 feet wide. On fresh surfaces they are various shades of grey-green, but where weathered are dirty, or yellowish, white. An exceptional type, a pale red variety, cuts the volcanics in the northeastern part of the map-area north of Rapid river. These dykes are usually massive, but many are slightly sheared and others extremely so. Predominantly they are feldspar porphyries with conspicuous feldspar phenocrysts; some contain quartz phenocrysts as well. The narrow ones are typically aphanitic, and resemble rhyolite in appearance and occasionally in texture. In a couple of instances granitoid textures were noted; but even in such the feldspars have a strong

euhedral tendency. The phenocrysts form from about 60 to 20 per cent of the rock and are acid to basic albite. In some cases phenocrysts of quartz are also present, but rarely approach the feldspar in quantity. The diameters of the phenocrysts vary from 5 millimetres to 1 millimetre, and commonly vary in size in the same dyke from 4 to 2 millimetres. The feldspars usually show much alteration like those in the granite. The groundmass of these dykes is usually very fine grained, and is apparently composed of interstitial plagioclase and its alteration products, with varying amounts of actinolite, chlorite, carbonate, magnetite, titanite, sphene, pyrite, and apatite. Many dyke margins are fine grained and resemble the narrow, fine-grained, non-porphyritic dykes that have the conchoidal fracture and appearance of rhyolite.

Strongly sheared types high in chlorite, fine white micaceous material, and at times carbonate, are found. An example of this type is present in the McKenzie mineralized zone, Cedar bay. When studied in 1927[1] it was believed to be a porphyritic rhyolite flow, but stripping since that date conclusively discloses its intrusive nature.

Mineralogically and texturally the above dykes closely resemble one another, and the differences noted do not point to more than one general rock-forming magma as their source. The close areal association of many of these dykes with the granite bodies in the area and the nature of the feldspars in both rocks suggest that the dykes are closely related to the granite.

"Greenstone" Dykes

Dykes closely resembling various intermediate and basic phases of the volcanics, and typically "greenstones" in appearance, were noted cutting all the rock types except the breccia-filled volcanic neck, the porphyry dykes, and the Chibougamau sediments. Some that cut the porphyritic granite neck north of lake Doré are probably younger than the porphyry dykes. They are probably of different ages; some in the areas of volcanics being closely linked in origin with the flows they intrude. Owing to their highly altered nature there is little hope of petrographically distinguishing greenstone dykes of different ages. Although these dykes vary in width, the greater number are narrow, a foot to a few feet wide. They show no particular strike, but are usually vertical or dip steeply. They are a mass of alteration products; the dominant constituents which give them their distinctive appearance are minerals of the chlorite group.

CARBONATE ZONES

Carbonates, for the most part rich in iron, have replaced the rocks in whole or in part at certain localities within the map-area; where the replacement is more or less complete they constitute a separate rock type. All rocks in the map-area have in places undergone this replacement, with the possible exception of the Chibougamau sediments, though even these are cut by carbonate veins. Carbonization occurs quite

[1] Geol. Surv., Canada, Sum. Rept. 1927, pt. C, pp. 15-16.

commonly, though not always, in the mineralized zones. It is particularly prevalent where the rocks are highly sheared and in schistose rocks in zones of intense movement along faults. The carbonated rocks weather to a porous, rusty brown material. They contain, besides carbonates, varying proportions of the original rock mineral; completely replaced rocks consist of carbonate and fine, interstitial quartz. Narrow, barren veins of quartz intergrown with carbonate commonly traverse this rock type. The quartz is either glassy or milky white and in some cases contains sulphides.

The largest single area of carbonated rocks extends westward from the northwest shore of Doré lake and passes ¼ mile north of the head of Cedar bay. It is 3½ miles long and has an average width of ¼ mile. Its western end lies about 2,000 feet south of the southwestern corner of the main part of Gilman lake. Altered volcanics underlie the western half of this area; gabbro, marginal to the anorthosite, and adjacent volcanics underlie the eastern half. Strong shear zones having an easterly strike and steep dips extend for considerable distances within this area. Narrow quartz veins are common where the shearing was intense and they strike and dip concordantly with the shear zone.

The belt of volcanics and associated rocks ¾ mile wide, that lies along the north side of Portage bay, is also in places highly carbonated. The carbonatization in this belt is developed irregularly and does not apparently form a definite zone. It is present particularly in that part that lies north and northwest of Meeting island. Narrow but intensely carbonated zones occur also on the south side of Portage bay, between Hematite point and the lake in the centre of Portage island.

CHIBOUGAMAU SERIES

Remnants of a sedimentary series, consisting chiefly of conglomerate and arkose that are little metamorphosed, occur in the northern part of the map-area and to the north of the map-area along the shores of lake Wakonichi. They are separated by a great angular unconformity from the underlying (Keewatin?) volcanics and sediments and most, if not all, the basic and granitic intrusives. A similar unconformity is, as pointed out by the Chibougamau Commission, developed beneath the Huronian strata of eastern Ontario; strata that in many ways are similar lithologically to those of Chibougamau district. It is possible that the Chibougamau sediments are of Cobalt age as suggested by the Chibougamau Commission and by Retty. In view, however, of the doubt that may always exist as to the accuracy of such a correlation, the clastic sediments, of possibly Huronian age, in Chibougamau district, will herein be defined as the Chibougamau series. Further work may show that the strata of the Chibougamau series are of more than one age. It is possible, for instance, that the relatively undeformed sediments west of Bourbeau lake are younger than the tilted and sheared strata at McKenzie and Rapid bays. Evidence, given below, suggests that an unconformity occurs within the Chibougamau series southeast of Rapid bay; but little importance is, at present, attributed to the evidence on account of the very small thickness and poorly exposed character of the beds overlying this suggested unconformity.

The Chibougamau sediments are preserved in the map-area as small remnants that cap higher hills of the Bourbeau Lake hilly belt west of Bourbeau lake, and also occur in a down-faulted block that lies between McKenzie and Gunn bays in the northeastern corner of lake Chibougamau. The hills capped by these sediments west of Bourbeau lake are evenly spaced along a line 7 miles long and trending a little south of west from the southwest bay of the lake. With the exception of the knob-like mass east of Antoinette lake the areas underlain by sediments in these hills are lens-shaped and elongate in the direction of the belt. They range from ½ to 1½ miles long and from ¼ to ½ mile wide. The down-faulted block southeast of McKenzie bay is nearly 6 miles long and 1 mile wide.

The sediments southwest of Bourbeau lake are conglomerate and finer sediments in nearly equal amounts. West of Antoinette lake the basal part is fine material, whereas east of this lake it is conglomerate. In the next hill to the east conglomerate again forms the basal member, but in the third or easternmost hill a few tens of feet of fine sediment are apparently basal and underlie conglomerate at some places.

The conglomerate is coarse, ill sorted, and made up of fragments of every size up to 18 inches in diameter, embedded in a varying matrix of coarse arkose, grit, and greywacke [1]. The pebbles and boulders are rounded to subangular and consist of volcanics and basic intrusives, such as are found in the map-area, and also of a pink granite. Anorthosite boulders were not found in the conglomerate; their absence may indicate that the sediments were derived from the north. In some exposures the pebbles and boulders form a small percentage; the matrix greatly predominating.

The finer sediments closely resemble the matrix of the conglomerate. The exposures west of Antoinette lake show a considerable thickness of fine-grained, unstratified grit with occasional pebbles 1 inch in diameter. The grit gives place above to a conglomerate with a high percentage of granite pebbles up to 6 inches in diameter. Elsewhere, fine and coarse, impure quartzites, grits, arkoses, and greywackes were seen. Pronounced stratification in these finer sediments was noticed at three widely separated localities.

Both the conglomerate and fine-grained rocks have their components strongly cemented so that a joint or fracture plane traverses boulders, pebbles, and finer grains alike. No other metamorphism seems to have taken place and no squeezing or shearing of the constituents of the rocks is evident.

The greatest thickness of these clastics is exposed on the west side of lake Antoinette, where the basal contact dips below the level of this lake, and the highest point in the exposed strata is at least 200 feet above the lake. The sediments, and the surface upon which they rest, dip from a little east of south to southwest at an angle of about 10 degrees. This was determined by measurements on banded quartzite in two separate hills, and by the position of the basal-contact surfaces in all the hills.

1 "Essentially a sandstone compounded by quartz and miscellaneous rock particles of diverse origin, the latter often in excess of the detrital quartz. The very mixed character of these rocks is usually discernible at a glance, while the grey, green, or dark colour is common. Often highly micaceous, well bedded, usually void of recognizable organic remains."
Milner, H. B.; Sedimentary Petrology, T. Murby and Co., 1929.

The elevation of the floor on which the sediments rest is generally progressively higher in an easterly direction and indicates that no pronounced dislocation separates the outcrops. The preservation of these sediments in a linear belt may be due not only to their resistance to erosion but in some measure also to down faulting.

The contact of the sediments with older rocks is exposed a short distance northeast of lake Antoinette, south of Larone lake, and east of Line lake. On the north face of the hill east of lake Antoinette a coarse, unsorted conglomerate rests on a gently undulating surface of serpentine. The serpentine immediately below this surface shows no evidence of weathering and is identical with the serpentine found elsewhere in the map-area. Three thousand feet due south of the eastern end of Larone lake, on a north-south picket line, conglomerate is in contact with pyroxenite. The contact dips 80 degrees south and strikes east. Eight hundred feet west of this point another contact between conglomerate and pyroxenite is exposed. It is undulating and dips 45 degrees south. Some slipping took place along these two contacts, but was unaccompanied by brecciation and the contacts are sharper than might be expected if due to faulting. Yet faulting may have occurred along the contact-plane, for 900 feet to the southeast the sediments dip only 10 degrees southeast. A contact between conglomerate and syenite is exposed 2,200 feet east and 800 feet north of the southeast end of Line lake. The syenite is coarse-grained and fresh at the contact; the conglomerate shows faint bedding planes that dip about 5 degrees southeast. The contact is a distinctly undulating erosion surface and is approximately parallel to the bedding of the conglomerate. Although the contact between the sediments and older rocks is rarely exposed, its position can nearly always be inferred by the cliff-like margins of the areas of sediments. The cliff-like features are due to strong vertical jointing in the sediments and the plucking action of the Pleistocene ice-sheet.

The sediments southeast of McKenzie bay form a wedge-shaped block about 1 mile wide that extends for about 6 miles along the strike in a northeasterly direction, parallel to the McKenzie Narrows fault. The strata dip at angles ranging from 30 to 50 degrees or more southeast towards the fault, which has brought up older rocks against the sediments. The total thickness of sediments across the widest part of this area, assuming no repetition or omission of strata and a constant dip of 50 degrees, would be 3,400 feet. They consist in ascending order of a basal conglomerate member; a thick group of massive arkoses; and a thin upper conglomerate. This sequence is not exposed uninterruptedly at any one place and may have been misinterpreted.

The basal conglomerate is well exposed on the northwest side of the area of sediments, between the head of Rapid bay and Contact bay. The extension of this basal conglomerate northeast of Rapid bay is exposed about 1 mile northeast of the lake. The conglomerate is similar in composition to that southwest of Bourbeau lake. It contains subangular to rounded boulders ranging up to 18 inches in size; an exceptionally large boulder, 3 feet in diameter, occurs on a small point on the south side of McKenzie bay. The boulders are largely granite but include other more basic igneous rocks and volcanics. The matrix is either reddish and

arkosic or green and composed of fine-grained detrital material in which a few, scattered, broken pieces of feldspars and quartz stand out conspicuously. The conglomerate on the north side of Contact bay is massive, shows little indication of bedding, and contains here and there small, much contorted lenses of sandstone and grit. One lens of well-bedded sandstone and grit, with small fragments and cobbles up to 2 inches, occurs in the conglomerate at a locality due north of the centre of Contact bay; it has a well-marked channel structure, the upper layer cutting down into, and truncating, lower layers that have a crossbedded structure. On the south side of McKenzie bay and between the mouth of this bay and Conglomerate island, the conglomerate in bands of 20 to 50 feet thick is interbedded with bands of finer grained sediments of like thickness. The finer grained sediments are well bedded, greyish green to grey in colour, and consist of impure, sandy material with a few fragments of feldspar and quartz. They contain narrow bands of very fine-grained, silty composition as well as bands of coarse-grained grit with small cobbles; the coarser phases at a few points channel into immediately underlying layers. The exposed thickness of the conglomerate member at this locality is estimated to be 100 to 200 feet, but an accurate determination is not possible. The angular unconformity of the conglomerate to the underlying rocks is indicated by the great discordance between the northeasterly strike of the conglomerate and the easterly trend of the older bedded rocks and the intrusive bodies that have invaded them. Only one contact between the conglomerate and older rocks was observed. It is exposed on the south side of McKenzie bay, about 1,500 feet west of its mouth. At this point a basal, dark-coloured arkose grades without perceptible break into medium-grained "diorite."

The massive arkosic strata that overlie the basal conglomerate are exposed on the south shore of Rapid bay, in ridges between the bay and the fault, and on small islands south of the mouth of Rapid bay. Along the south side of Rapid bay the arkose is massive, greenish grey to light brown, and without conspicuous bedding. It is medium to coarse grained, and contains a high proportion of red feldspars and quartz in fine-grained, sericitic, interstitial material. Occasional small interbeds of grey, arenaceous shales or dark slate are present in the arkose. The arkose loses its massive character southeast of Rapid bay and becomes progressively more highly sheared and schistose in this direction. Eight hundred feet inland from the shore, at a locality 4,000 feet northeast of the mouth of Rapid bay, the arkose, although massive, shows considerable shearing with sericitization of the feldspar and squeezing of the constituent grains. One thousand feet inland and in the ridges which lie northwest and north of the large lake southeast of Rapid bay, the arkose is sheared into a highly schistose, brown to grey, silvery rock. The feldspars in this rock are almost completely altered to sericite, but retain vague outlines of their original detrital character. Some phases in the zone of sheared rock near Rapid river are schistose quartzite with a high content of quartz in clearly visible grains.

The thin, upper conglomerate member lies between the concealed fault and the highly sheared and schistose phases of the arkosic strata. It is exposed 900 feet southwest of Rapid river, and along the northwest side of the narrow lake that drains into Rapid river ½ mile east of its mouth.

The conglomerate southwest of Rapid river outcrops only in one very small knob rising above low-lying ground, and is nearly 100 feet from the nearest outcrop of quartzite, which lies to the northwest. The conglomerate is definitely stratified, the beds striking north 45 degrees east and dipping 75 degrees southeast towards the McKenzie Narrows fault. The neighbouring quartzite shows only cleavage planes, which strike north 55 degrees east and dip vertically to steeply south. The field relationships suggest that the conglomerate and rocks associated with it rest unconformably on the schistose quartzite and that they are faulted down against older rocks that lie on the southeast side of the fault. The conglomerate shows little indication of shear and in this respect is in strong contrast with the quartzite. Furthermore, the arenaceous matrix of the conglomerate is not highly indurated and the constituent quartz grains stand out in the sugary textured, weathered surface, whereas the quartzite is highly indurated and fractures readily in any direction across the constituent grains of quartz. About 20 feet, only, of the conglomerate is exposed. It contains rather numerous, angular fragments, $\frac{1}{2}$ inch to 6 inches long of granite, diorite, volcanics, red chert, and quartzite. Specular hematite in pebble-like pods is also present in the conglomerate, but may have been introduced after deposition of the rock. The quartzite pebbles in the conglomerate are indistinguishable in composition, texture, and sheared structure from fragments broken from the neighbouring schistose quartzite.

The conglomerate exposed on the narrow lake that drains into Rapid river is 50 feet $\pm$ thick and forms a small ridge parallel to the lake. A small outcrop of schistose arkose occurs at lake level, a short distance north of the conglomerate. It apparently flanks the northwest side of the conglomerate, but the contact is concealed. The conglomerate on this lake lies along the strike of the conglomerate that outcrops $\pm$ 900 feet southwest of Rapid river, and contains similar pebbles as well as irregular stringers and pods of specular hematite. The two outcrops, therefore, are along the same general horizon, although the rock now in question is more highly sheared than that to the southwest. It contains at one point a thin interbed of slickensided and brecciated arkose, and is bordered on its south side at another point by a small thickness of fine-grained, fissile sediments.

If the conglomerate actually rests unconformably on the schistose quartzite to the northwest, as facts obtained would indicate, there was probably more than one period of movement along the McKenzie Narrows fault. An unconformity would seem to imply a sequence of events as follows: an earlier movement along the fault during which older rocks were thrust northwestward against the arkosic and quartzose sediments which were thereby sheared and rendered schistose in a zone along the fault; deposition of the conglomerate containing pebbles of the schistose sediments; finally, a later movement along the fault whereby the conglomerate was tilted to its present position. It is true that lack of continuous outcrops from Rapid bay southeastward prevents conclusive proof that the schistose quartzite northwest of the conglomerate is definitely part of the Chibougamau series and that it underlies the conglomerate unconformably. The outcrops available, however, do furnish evidence that shearing was progressively more intense in a southeasterly direction from Rapid bay and there is good reason to believe on that account that the schistose quartzite is

actually a part of the Chibougamau series. Even so it may be faulted against the conglomerate and not lie unconformably beneath it.

The suggested correlation [1] of the Chibougamau series with the Cobalt series of eastern Ontario and western Quebec lends credence to the belief that part at least of the Chibougamau sediments may have formed during a period of continental glaciation. At the present time conclusive evidence for this belief is lacking, although the clastic sediments west of Bourbeau lake apparently contain no features that are in conflict with the glacial theory, and a striated boulder is reported to have been found in the conglomerate there. In the northeastern part of the map-area north of Contact bay the basal conglomerate contains contorted lenses of sandy material and grit, some of which are crossbedded and indicative of deposition by stream action. The fine-grained, well-bedded sediments interbedded with the conglomerate on the western shores of the lake north of Conglomerate island also clearly point to deposition in water. These sedimentary structures do not rule out the possibility that glacial conditions obtained during this period, but they do suggest that stream action and deposition in water were important events leading to the accumulation of these rocks.

OLIVINE DIABASE AND GABBRO

Olivine diabase and gabbro, remarkable for their freshness in a district characterized by highly altered basic rocks, occur at a few localities in the southern part of the map-area. The olivine diabase is exposed on islands in the western part of lake Chibougamau; at one point on the southern shore of Doré lake; and at a few other places on Doré lake mentioned in the Chibougamau Commission report (page 125). The gabbro occurs between lakes Caché and Gladstone. The nearest outcrop of olivine diabase at present known, that on Doré lake, lies 4¼ miles distant from the gabbro. Although separated thus they have like mineral compositions and this in conjunction with their fresh character suggests that they are genetically related. They form, however, intrusive masses of unequal size, the gabbro mass being larger than any of the occurrences of diabase, and consequently the two masses are dissimilar in certain features.

The alinement of olivine diabase outcrops in the western part of lake Chibougamau indicates that the diabase occurs as a dyke or dykes cutting the granite. These dykes are probably narrow and less than 100 feet wide.

Outcrops of olivine diabase occur on two small islands, ½ mile apart, that lie 1½ miles north-northwest of Devlin peninsula. It is probable that these outcrops are part of one dyke that strikes north 60 degrees east. That the dyke continues along this strike in an easterly direction is suggested by outcrops of medium-grained olivine diabase on the southern part of the small island that lies 3,500 feet southwest of the western tip of Line island and by olivine diabase dykes on the north side of the centre of Line island. The latter are very fine grained and may be offshoots from the main dyke. If the olivine diabase dyke northwest of Devlin peninsula maintains its

[1] Retty, J. A.: Township of McKenzie, Chibougamau Region, Que.; Que. Bureau of Mines, Ann. Rept. 1929, pt. D, p. 58.

strike in a southwesterly direction, it would pass ½ mile north of the diabase outcrop on the south side of Doré lake. The latter may accordingly be part of a separate dyke.

The olivine diabase is dark grey and almost black where very fine grained. Characteristic phases have a grain size of 1·0± mm. and an even texture; some have a slightly coarser grain; others a microporphyritic structure produced by minute, clearly recognizable feldspar phenocrysts in a black, aphanitic groundmass. On weathered surfaces the diabasic texture is quite apparent; where freshly broken the constituent feldspars show up well as very small, glassy laths, with shining cleavage faces, in a dark groundmass. The diabase is easily distinguished from fine-grained, dioritic phases of the granite mass. The dark-coloured constituents of the latter have a greenish tinge that pervades the whole rock; those in the diabase have a distinct brownish tinge under a magnifying glass. The estimated composition of the diabase is as follows: labradorite, 50 per cent; augite, 25 to 20 per cent; olivine, 20 to 15 per cent; brown biotite and iron ores, 5 to 10 per cent. A little brown hornblende is present also. The labradorite is zoned, is approximately $Ab_{50}An_{50}$, and is characteristically unaltered. The augite is pale violet-brown, is interstitial or ophitic to labradorite, and in the finer-grained phases contains numerous Schiller inclusions; it is altered in rare cases to uralitic hornblende and chlorite. The olivine occurs as remarkably fresh, irregular grains and as euhedral crystals, a few of which are altered to felted flakes of antigorite or of talc.

The olivine diabase is definitely younger than the granite and related intrusives of the map-area. It does not come in contact with the Chibougamau sediments but is inferred to be also younger than these rocks. This inference is based on the following: (1) the freshness of the diabase in contrast with the highly indurated and more altered state of the sediments; (2) the absence of any known shearing or schistosity in the diabase, whereas the sediments are intensely sheared and altered in a wide belt along the McKenzie Narrows fault; (3) the inferred parallelism of the dykes to the southwesterly extension of the McKenzie Narrows fault across the north side of Portage island. Such parallelism suggests that northeasterly faulting, which is later than the sediments, contributed to the formation of fractures along which the diabase was able to ascend.

The gabbro, which is believed on account of its freshness and mineral composition to be genetically related to the olivine diabase, occurs along the portage between Gladstone and Caché lakes. It forms an intrusive body, at least ¾ mile long in a north and south direction and ⅓ mile wide, within an area underlain by rocks classed as gabbro marginal to the anorthosite. It outcrops as high ridges surrounded by drift that conceals the contact with the marginal gabbro or with small masses of greenstone that are included in that intrusive. The fresh gabbro varies in appearance and texture in different outcrops. Its description as given by Mawdsley [1] in 1927 is as follows:

"The southwestern outcrops are of a gabbro having a granitoid texture and grain of 5 millimetres. The weathered surfaces are a dark, rusty brown. The freshly broken rock is greenish black and the shining faces

[1] Geol. Surv., Canada, Sum. Rept. 1927, pt. C, p. 10.

of the fresh feldspar, which are slightly lighter than the rest of the rock, are easily recognizable. Feldspar forms 50 to 60 per cent of the rock and under the microscope is seen to be labradorite ($Ab_{45}An_{55}$) occurring in an interlocking mosaic of various-sized grains. The crystals are dusted, especially towards their centre, with minute inclusions, usually dark, having a maximum diameter of 0·01 millimetre. These inclusions are apparently primary. The feldspars show a slight alteration which generally occurs in irregular patches and consists of epidote, zoisite, and carbonate in fine grains. Secondary green hornblende in feathery aggregates traverses the crystals of feldspar along cracks and boundaries between crystals. Light sepia-coloured augite forms about 25 per cent of the rock. Occasional crystal faces are present, but on the whole it crystallized contemporaneously with the feldspar and in grains of like size. The augite crystals are dusted with stumpy, dark Schiller rods up to 0·1 millimetre in length, which within each crystal are orientated in the same direction. The augite crystals around their edges have changed to a flaky, secondary, blue-green hornblende. Associated with this hornblende are grains of iron ore, probably magnetite. In some parts apatite in large grains forms 5 per cent of the rock.

"Some of the northern outcrops of the mass contain fine as well as coarse-grained phases, grading into one another in short distances and without any definite arrangement. The coarse variety is 5 millimetres in grain and in this and its granitoid texture resembles the gabbro of the southern outcrops. The colour of the rocks of the northern outcrops is lighter and the feldspar more abundant than in the rocks in the southern outcrops. In the field the rock looks like the dioritic phase of a granite. This impression is heightened by the fine phases that form irregular patches of the rock. The feldspar has the same development as that of the rocks farther to the south, but is slightly more acid, and is a basic andesine ($Ab_{55}An_{45}$). It shows the same alteration, but to a greater extent, since 50 per cent is affected. Secondary chlorite occurs in irregular patches and has replaced not only ferromagnesian minerals but also feldspar. Hornblende occurs both as the flaky green variety and as crystals that may or may not be secondary after augite. Accessory apatite and iron ore are scattered throughout the rock. A little quartz occurs and is generally associated with the chlorite."

CHAPTER III

NORTHEASTERLY FAULT SYSTEM

Two parallel faults of large displacement strike in a northeasterly direction across the northeastern part of the map-area. They are 3¼ miles apart and are inferred to belong to one system of thrust faulting toward the northwest. These two faults are the McKenzie Narrows and Taché Lake faults, so-named after important physical features along which they lie. The McKenzie Narrows fault disrupts the Chibougamau sediments. The Taché Lake fault lies at a distance from these sediments but is believed to have formed during the same period of deformation as the McKenzie Narrows fault. Indications of faulting in rocks older than the Chibougamau strata are present at many places; such faulting is in part probably older than these sediments, but in certain cases is inferred to be subsidiary to movement along the northeasterly faults. A third major fault with a northeasterly trend may be along Gwillim lake. Its presence is suggested by the shape of the lake and by northeasterly shearing of the rocks at places along the lake shore.

The age of the northeasterly faulting relative to the period or periods of mineralization is not definitely known. The Taché Lake fault offsets the northern margin of the anorthosite and along this marginal part of the anorthosite massive sulphide mineralization, typified by the Bear Bay and Taché Lake deposits, has occurred. On account of this offset and the local, intense shearing of sulphides in the western part of the Taché Lake sulphide deposit the northeasterly faulting is believed to be later than this type of mineralization. It is possible that the northeasterly faulting is later than the massive copper sulphide mineralization on Doré lake, but its later age is not yet established. Because of the probable importance of the faulting in mining developments, and the possible southwesterly extension of faulting across Doré Lake, the two faults are described in detail.

McKENZIE NARROWS FAULT

The McKenzie Narrows fault lies along McKenzie narrows in the northeastern part of the map-area. It extends northeastwards from the narrows across Rapid river, and along the chain of narrow lakes that empty into the river half a mile east of its mouth. Southwestward from the narrows the fault is inferred to extend southwestward across Contact and Portage bays. Southwest of Portage bay the criteria for delimiting the fault are less reliable than to the northeast, but many features rather strongly suggest that the fault crosses the northwest part of Portage island. Whether the fault continues southwestward from Portage island along the length of Doré lake, or branches in other directions, is not at present known.

Northeast of Portage bay the approximate position of the fault is rather closely defined by McKenzie narrows, and the chain of narrow

lakes northeast of Rapid river. Between Rapid river and the large lake southeast of Rapid bay, the fault lies in a broad, muskeg-filled depression that is partly faced on both sides by low rock ridges.

The most important geological features that indicate the presence of the fault are the structures developed in the Chibougamau sediments and the abrupt termination and offsetting of the basic intrusive masses along the line of faulting. The only suggestion of disturbance in the greenstone is the change in strike of its planes of schistosity. The schistosity or cleavage planes developed in these rocks strike generally in an easterly direction, but close to the fault they more or less parallel the fault.

The most marked effect produced by the fault on the Chibougamau strata is the development southeast of Rapid bay of a deformed zone about 1,200 feet wide in the arkosic and quartzose sediments. The rocks in this zone are intensely sheared and cleaved. The constituent feldspars are squeezed out and flattened, and are largely altered to sericite. The cleavage strikes north 50 to 60 degrees east and dips either vertically or steeply south. The conglomerate along the northwest side of McKenzie narrows shows little shearing but is cut in places by well-defined vertical joints that strike nearly parallel to the fault. The finer grained lenses in the conglomerate, however, are much contorted.

The general succession of rocks, older than the Chibougamau sediments, from north to south, on the west side of the fault, is rather perfectly matched by that on the east side; but the succession on the east side is shifted southward. Differences in detail occur, but these may be ascribed to the fact that the rocks on the east side of the fault have been moved upwards relative to those on the west side and, therefore, belong to a much deeper horizon than those west of the fault.

The Rapid River sill has been offset 5,000 feet by the fault and other distinctive rock masses have been offset about the same distance. Criteria for determining the amount of the vertical displacement of the rocks are lacking; but the displacement is probably great. The fault is not exposed at any place, but the intense shearing impressed on the sediments in a wide zone southeast of Rapid bay, and the steep southerly to vertical dip of the cleavage developed in these rocks suggest that the fault dips vertically or steeply southeast, and that the rocks to the southeast are thrust against those to the northwest.

Certain small faults and joints are apparently subsidiary to the McKenzie Narrows fault. A fault of this type is inferred to branch from the main fault along the northern bay of the narrow lake ¾ mile east of Rapid bay and to form the northeastern boundary of the Chibougamau strata. Its presence is suggested by the relative position of sediments and volcanics at the entrance to this bay; the sediments that outcrop on the west side strike in a northeasterly direction towards the volcanics 500 feet distant on the east side of the bay. The fault is also inferred from the lack of continuity of rock types across the assumed fault line north of the bay and by scarp-like topographic features. Other faults with a northeasterly strike are present in the greenstone north and northeast of Rapid bay, but their magnitude is not apparent. One such fault situated 1 mile north-northwest of the head of Rapid bay is marked by a distinct trench about 30 feet wide that affords an outlet for a small lake. The

surface of the greenstone on the northwest side of this trench is smooth and polished, dips 45 degrees southeast, and may represent the approximate dip of the fault. The greenstone on the southeast side stands up in a jagged, irregular cliff 15 feet high and is sheared along a direction striking north 75 degrees east.

Joints trending in an easterly or east-northeasterly direction are locally present in the conglomerate and schistose sediments along the northwest side of the McKenzie Narrows fault. They are also developed across the schistosity of the greenstone along the east side of the fault northeast of Rapid bay. Movement along fractures trending in this direction is indicated by displacement of the basal Chibougamau conglomerate on the south side of McKenzie bay. The basal conglomerate on the northwest side of Rapid bay dips about 30 degrees southeast and strikes in a southwesterly direction. It is exposed in a direct line along this strike on islands in the lake and on the south shore of McKenzie bay, southeast of Asbestos island, without any indication of disruption. On the south shore of McKenzie bay the conglomerate dips 60 degrees south; farther to the southwest it is cut off by older rocks and is offset about 3,000 feet to the east. This offset indicates that a fault runs in a general easterly direction along the south side of McKenzie bay, probably an upthrust of the rocks to the south against those to the north. Northwest of McKenzie narrows the sediments are apparently compressed into narrow folds striking northeast, but they may also be sliced by minor faults in this direction.

The McKenzie Narrows fault is not a well-defined feature south of Contact bay; but its probable location on Portage island is indicated on the geological map. That the fault does not deviate to the south at McKenzie narrows is indicated by the continuity of rock types and their boundaries from Valiquette narrows to Portage bay. The assumed fault line on Portage island follows a depression, 600 feet wide, that in places is very distinct and extends south 62 degrees west in general alinement with Contact bay. Pillowed lavas with a vertical dip and striking in general slightly north of east outcrop northwest of the fault in low, hummocky hills, separated from one another by steep-sided gullies. The gullies parallel a very pronounced system of joints that are present in the lavas, trend north 20 to 40 degrees east, and may indicate faults with this trend. The lavas are massive, but in places are sheared along planes that strike north 55 degrees east and dip steeply south. The lava in the most southeasterly outcrops is considerably sheared, is cut by narrow carbonate veinlets, and is in places pyritized.

The rocks immediately southeast of the assumed fault line are best exposed on the south shore of Portage bay and in a high hill present between the bay and the small lake in the centre of the island. They consist of granite along the bay and massive to schistose chloritic rocks southwest of the granite. Zones of intense shearing striking north 50 to 70 degrees east and dipping steeply are present in many places not only in the chloritic rocks but also in the granite. They are accompanied in places by almost complete carbonization of the rock and in certain cases by impregnation with sulphides. The granite has everywhere a shattered appearance and west of Hematite point is intensely sheared in a northeasterly direction.

The strike and magnitude of the McKenzie Narrows fault in the northeastern part of the map-area suggest that this fault may extend southwestward across Doré lake and along the straight, narrow arm of this lake that receives the drainage from Caché lake. A fault line occurs along the stream beside the first portage from Doré to Caché lake and is in accord with a possible continuation of the McKenzie Narrows fault to this locality. The fault line is indicated by the narrow trench, trending north 30 degrees east, through which the stream descends into Doré lake, and also by the intense shattering of the rocks along the walls and centre of the trench. Abundant evidence of deformation is presented by both shear zones and joints in the rocks around Doré lake, but their correlation with any system of faulting cannot be made from the information obtained up to the present.

A sheared and brecciated zone is exposed on the south side of Bateman bay, 1,000 feet east, and again 500 feet west, of the portage into Chibougamau lake. It has an exposed width of about 30 feet and consists of knotted, irregular fragments of chlorite schist impregnated and veined with carbonates. The rocks along the south side of the bay east of the breccia are fine-grained diabasic and chloritic rocks, some of which are probably of volcanic origin. It is probable that the brecciated zone indicates a fault separating the rocks mentioned above from the anorthosite on the north side of the bay. The breccia on Bateman bay strikes about south 60 degrees west towards a similar but wider zone of intense shearing and brecciation lying 1 mile west on the south side of Doré lake where it is exposed for a length of 3,000 feet. The zone on Doré lake has a general east-northeasterly trend, but is intersected in places by shears trending northwesterly. The two brecciated zones may intersect at an acute angle or may be parts of a single zone. The Doré Lake zone may be a part of the McKenzie Narrows fault.

Shear zones and joints in the anorthosite on Doré lake have an economic importance, sulphide mineralization having occurred along such fractures which in many places form three intersecting sets. The most prevalent direction of shearing between Cachée bay and the narrows on Doré lake, near Cedar bay, is northwesterly. Shear zones with this trend occur at the following localities: Cachée bay; Kokko creek; ½ mile northeast of Kokko bay; the north side of Merrill island; Cedar bay; and the narrows on Doré lake. These northwesterly shear zones are up to 30 or more feet wide. Many occur alongside quartz porphyry or rhyolite dykes that cut the anorthosite in this direction. The three intersecting sets of fractures are typically present at Kokko creek immediately north of Merrill island. The mineralized shear zone at this locality strikes north 41 degrees west and has a maximum width of about 40 feet in the trench that crosses the zone immediately west of the stream. One hundred feet northwest of this trench and in the country beyond, the rocks are cut by a very definite set of joints that strike north 20 to 40 degrees east and dip steeply north and along which shearing has in places developed. Another set of joints strike from north 75 to 110 degrees west. One or more of these three sets of fracturing, generalized as northwesterly, northeasterly, and easterly, are characteristically present in the rocks on Doré

lake, particularly the first and third sets, which form the joint system of the massive, undeformed anorthosite east of Merrill island. At McKenzie's showing, ½ mile northeast of Kokko creek, a northwesterly mineralized shear zone is cut by a small fault that offsets the east side 4 feet to the north. This fault strikes north 7 degrees east and dips steeply west.

The zone of carbonated and sheared rocks that extends westward for 3½ miles from the northern part of Doré lake and passes ¼ mile north of the head of Cedar bay, forms an important part of the rock structure near Doré lake. It may be a zone of faulting, but its relation to other zones of shearing and faulting on Doré lake is not known.

TACHÉ LAKE FAULT

The Taché Lake fault is a clearly defined structure between Taché lake and Bag bay on lake Chibougamau. This portion of the fault parallels the McKenzie Narrows fault lying 3¼ miles to the northwest. The Taché Lake fault probably extends in a northeasterly direction across and beyond Taché lake, passing out of the lake at the head of the small bay 1,000 feet west of the township line. Its northern extension, however, is not marked by any well-defined fractures, except possibly the alinement of Taché lake. South of Bag bay the fault is concealed by drift and by lake Chibougamau.

Southwest from Taché lake, for 1 mile, the fault lies in a trench that narrows at one place to a width of 50 feet. This narrow part has rock walls 10 to 15 feet high that stand vertically or slightly overhang on the southeast side of the trench and that dip 45 degrees toward the trench on the northwest side. West of the trench a series of low greenstone ridges parallel the schistosity of these rocks and trend north 60 degrees east. When viewed from the air they are clearly separated by the trench from the much higher and sharply ridged ground that lies east of the trench and is underlain by gabbro and anorthosite.

The gabbro and anorthosite along the east side of the trench although massive are highly mashed and sheared parallel to the fault; the shear planes dip 45 to 65 degrees east. At a distance from the fault these rocks are comparatively undeformed except for zones of intense shearing. The most highly sheared rocks occur between the northern boundary of the anorthosite and associated gabbros, and the southern end of Taché lake. They apparently consist of schistose greenstone intruded by coarse-grained gabbroic rocks, but the latter are intensely sheared and foliated. Highly schistose rocks, greenstone and agglomerate, outcrop on the east side of Taché lake 1,000 to 2,000 feet north of its southwestern corner. The cleavage of greenstone on the northwest side of the trench deviates to the northeast from its more general easterly trend, but the rocks show in general no greater deformation than similar greenstones farther west along the northern boundary of the anorthosite.

The northern boundary of the anorthosite is offset 6,000 to 7,000 feet north on the east side of the fault. The position of a very definite horizon of agglomerates in the greenstone on either side of the fault points to an offset in a similar direction and of equivalent magnitude (*See* pages

12, 13). The offset of the Gunn Bay pyroxenite-serpentine sill or dyke on the east side of the fault is apparently quite inconsistent with the offset of the anorthosite. The Gunn Bay mass was traced eastward from Gunn bay to the square-shaped lake on the township line 2,000 feet north of Taché lake. Throughout this distance it shows no disruption by major faulting. From Gunn bay to the east side of Roy lake it extends in an easterly direction; east of this lake it swings to the east-northeast, roughly parallel to the strike of the schistosity planes in the greenstone west of the fault. A short distance east of the square-shaped lake the serpentine-pyroxenite mass is apparently shifted about 1,000 feet to the south. This offset may indicate the location of the northeasterly extension of the Taché Lake fault which if it continues in a northeasterly direction should cross this basic mass a short distance east of the square-shaped lake. That the serpentine-pyroxenite mass east of the inferred location of the fault is part of the Gunn Bay intrusive is suggested by its continuing for several miles east-northeastward as a tabular mass very like the Gunn Bay body in size and form.

The dip of the shear planes in the anorthosite and gabbro along the trench southwest of Taché lake indicates that the fault is probably a thrust from the southeast and that the fault plane probably dips between 45 and 65 degrees in this direction. The displacement indicated by the offset of the anorthosite boundary is great, but its magnitude and direction are unknown. Assuming that the anorthosite body dips about 65 degrees north, as indicated at Sorcerer mountain by drilling, a vertical displacement of about 3 miles unaccompanied by any lateral movement would effect the observed offset; but lateral displacement and irregularities in the form and attitude of the anorthosite mass might, if known and taken into account, markedly decrease the calculated vertical displacement.

The offset along the east side of Taché Lake fault is northeasterly, whereas the offset along the east side of the McKenzie Narrows fault is southwesterly. These offsets afford no means at present of calculating the vertical displacement which in both cases is inferred to have been produced by upthrusts from the southeast. The southerly offsets of the serpentine-pyroxenite and other associated rock and the northerly offset of the anorthosite might be explained by assuming that these masses converge towards one another downwards in accordance with the theory that they are differentiated phases derived from one magma. A similar effect would be produced by the upfaulting of a synclinal structure.

A smaller fault lies 1,000 feet east of the Taché Lake fault near the southwestern corner of Taché lake. This fault is roughly parallel to the larger fault, but it shifts the rocks in the opposite direction, the offset being about 500 feet to the south on the east side of the fault. It is shown by the position of the sulphide mineralized zone along the northern margin of the altered anorthositic gabbros on the portage south from Taché lake, relative to that of the same mineralized zone in the high hill west of the portage. The fault cuts across the most western trench on the mineralized zone that extends westward from the portage. In the north side of this trench highly sheared and slickensided anorthosite is exposed and marks the proximity of the fault which must lie between these exposures and the mineralized zone

that occurs 20 feet to the south. The fault is also indicated by a narrow draw that runs northeasterly from the trench. This small fault shows rather clearly that the northeasterly system of faulting as represented by the Taché Lake and McKenzie Narrows faults is younger than part at least of the sulphide mineralization in the map-area.

Very little is known of the geology east of lake Chibougamau. Figure 1 presents the general distribution of rock types in McCorkill township which adjoins Chibougamau map-area to the east. In this township the general trend of the anorthosite, greenstone, and associated basic intrusives is about north 60 degrees east, in contrast with their nearly easterly trend in Chibougamau map-area. Faulting, northeast of lake Chibougamau, in a northeasterly or north-northeasterly direction is suggested by a straight, narrow waterway, several miles in length, that was seen from the air on the east side of Bignell township, about 5 or 6 miles southeast of lake Wakonichi. If the thrust faulting from the southeast, as displayed in Chibougamau map-area, extends in a northeasterly or north-northeasterly direction, it would pass south of the Mistassini limestones on Mistassini lake. Such faults may lie along the southeast side of these limestones and account for their preservation in this part of the Canadian Shield.

It is probable that faulting in a northeasterly direction extends southwest from Chibougamau district, as the McKenzie Narrows and Taché Lake faults are evidence of large crustal movements. The possibility that such faults may be present southwest of lake Chibougamau, however, does not in itself necessarily offer an inducement to prospecting in that section of the country unless it can be proved that mineralization of economic value is associated with this type of faulting.

CHAPTER IV

ECONOMIC GEOLOGY

INTRODUCTION

Numerous mineral occurrences of copper and gold have been discovered in Chibougamau map-area. This is notable because the district has been difficult to prospect both on account of the heavy moss that conceals much of the rock and its distance from the railway. That the area will receive much further investigation is certain, and that some of this work will result in the uncovering of deposits of economic importance is probable. Although asbestos was one of the minerals in the area that first attracted interest, it has not been found in important deposits; a full account of the character of the asbestos and the early workings on deposits of this mineral are given in the Chibougamau Commission report (pages 181-193). Appreciable concentrations of magnetite, probably all of a titaniferous variety, are present in the rocks in certain parts of the area; the most important so far known being those in serpentine on the north side of Magnetite bay (*See* page 30). None so far discovered contains sufficient iron for commercial ore.

The mineralization bearing copper, or copper and gold, or gold, is not restricted to any one type of rock or structure. It occurs in the older sediments and volcanics, the anorthosite, the basic intrusives, and also in some intrusives rich in quartz. No copper or gold-bearing deposits have as yet been discovered in the Chibougamau sediments which seem unfavourable for prospecting though they may pre-date mineralization of economic interest and are cut by barren quartz veins and irregular veinlets of specular hematite at Rapid bay. The granite or rocks closely akin to granite are in places mineralized—for instance, on part of the Obalski property north of Cachée bay, and at Knoll island.

The deposits vary in composition within certain limits. They are composed essentially of certain combinations of pyrite, pyrrhotite, chalcopyrite, and quartz, or of quartz with only a small percentage of sulphides. The order of succession of the minerals is not simple, since at least in some of the deposits evidence suggests that more than one generation of the various minerals is present. The following tentative classification of the principal types of mineralization is offered.

A. *Sulphide Quartz Mineralization*

(1). Massive sulphides with little quartz:

Consisting chiefly of pyrrhotite and pyrite with small amounts of chalcopyrite and more rarely sphalerite, and occurring as replacements in greenstone or sediments along or near the contact with basic intrusive rocks. Examples: Bear bay, Taché lake.

(2). Sulphides and quartz:

Consisting of chalcopyrite, pyrrhotite, and, or, pyrite, with important amounts of quartz vein material and more rarely tracts of sphalerite, and occurring as

replacements along shear zones or closely spaced fractures, particularly in the anorthosite on Doré lake. Many deposits of this class are wide, lenticular masses, but where quartz predominates they have the characteristics of veins.

B. *Quartz Veins*

Consisting essentially of quartz, in part fractured and possibly of more than one generation, with small amounts of arsenopyrite and pyrite and rare traces of chalcopyrite and pyrrhotite. Examples: Noranda and Sharpe veins.

The massive sulphide deposits (A (1)) are typified by the deposit at Bear bay. It lies along the contact of greenstone with serpentine on the northern border of an anorthosite body. The sulphides present are principally pyrrhotite with which is associated a little chalcopyrite and pyrite. The iron sulphides occur in more or less separate masses, either as massive lenses or disseminated and occur more particularly in greenstone but also in the serpentine. In some places actinolite is present with the sulphides in important amounts. Drilling indicates that at depth to at least the level of the lake the sulphide mineralization is confined to the neighbourhood of the greenstone serpentine. The deposit at Taché lake lies close to the outer edge of basic rocks that form a narrow marginal phase along the northern border of the anorthosite. As compared with the Bear Bay deposit, it contains a slightly higher proportion of chalcopyrite and probably of quartz, and this may imply a relationship between this type and those of class A (2) in the anorthosite on Doré lake. Deposits somewhat like the Bear Bay deposit and developed in sediments or greenstone along or near their contact with basic intrusive rocks, occur on the north shore of Bourbeau lake, $\frac{3}{4}$ mile south of the east end of Bourbeau lake (Bourbeau Lake mines); and on Rapid river. Mineralization of this type on a small scale occurs along the contact of sediments and basic intrusives between Juggler mountain and McKenzie bay on lake Chibougamau. Other unrecorded occurrences of this type are probably present. The deposits of this type have, to the writer's knowledge, yielded only traces of gold or very low gold values.

Sulphide-quartz deposits of class A2 occur at Merrill island, Kokko creek, Cedar bay, and at other places along the northwest side of Doré lake. The majority lie along shear zones in anorthosite, some, however, as at the Obalski deposit, are in "dioritic" or even quartz-rich, granite-like intrusive rocks. The anorthosite in the mineralized shear zones is dark green and chloritic. The sulphides are disseminated in the sheared rock and occur also in nearly pure, vein-like lenses up to about 2 feet wide. Chalcopyrite occurs with the iron sulphides; in some instances, as at the Obalski property north of Cachée bay, it forms almost pure, irregular lenses. It also occurs with or without iron sulphides in short, ramifying veinlets in quartz. In the lenticular deposits, as at Kokko creek where mineralization has considerable width in comparison with length, the quartz occurs in irregular, vein-like masses 2 or 3 feet wide, that branch and coalesce in an irregular fashion and are difficult to follow for any length. At the Obalski property a quartz-rich variety of this type has more nearly the character of a tabular vein and can be traced for several hundred feet. The deposits of this type (Class A2) contain important concentrations of copper, and in places carry very attractive values in gold and also some silver. No gold was seen in polished surfaces of this type of mineralization,

possibly because it is in a finely divided state but not necessarily submicroscopic. The gold does not seem to be associated with any particular mineral because samples of pyrrhotite, others of chalcopyrite, and still others of pyrite are all reported to have yielded gold.

Only a few occurrences of quartz veins of class B—those in the Noranda property and at the Sharpe showing—have been discovered up to the present. They apparently represent a type quite distinct from the sulphide-rich deposits. They are characterized by their definite vein structure, and the low content of sulphides. The most conspicuous sulphide is arsenopyrite and it occurs in part as fine veinlets or bands near the walls of the vein and in part as well-formed crystals. In veins on the Sharpe showing gold was observed along fractures in arsenopyrite and in the quartz. No gold was seen in polished specimens of the quartz from the Noranda vein, but it is present in considerable amounts in rusty pockets in the quartz in one of the more southerly of the trenches on this vein.

In view of the great number of deposits that occur in shear zones in anorthosite or associated rocks close to the shores of Doré lake it is reasonable to suppose that some occur under the lake. To locate such deposits or others in drift-covered areas adjoining the lakes, systematic mapping, on a large scale, of all exposed areas of rock and of shear zones and dykes, would be a desirable initial step. When feasible, shear zones and dykes should be carefully traced, for they may lead to places of mineralization, judging by evidence obtained at Cedar bay, Kokko creek, and on McKenzie's claim a short distance northeast of Kokko creek. A further step would be geophysical surveys by magnetic and electrical methods. The effects of the known deposits should furnish some basis for interpreting the results obtained in areas of concealed rock on land or under water.

MINERAL OCCURRENCES

Gwillim Lake

A block of thirty-five mineral claims was staked by T. Devanney and D. Paquin, along the west boundary of McKenzie township. The northwest corner of the group is ½ mile north of mile-post 5, on the township line, or about ¾ mile north of the north shore of Gwillim lake. The southwest corner of the block is on the northwest shore of Boundary lake, about ¼ mile south of mile-post 4. The group has a width of four claims, or approximately a mile. North of Gwillim lake the group is underlain by volcanics and minor amounts of intrusive gabbroidal rocks, and in places porphyry dykes are present. South of the lake, gabbro and diorite rocks predominate. The southern part of the claims include areas underlain by the Chibougamau sediments.

Most of the work done up to August, 1930, is confined to an area immediately northeast of mile-post 5 and is reached by a short trail from Gwillim lake. This work consists of four trenches aggregating about 240 feet in length and partly discloses bedrock over an east-west distance of about 300 feet.

The two westernmost trenches are 30 feet apart. They disclose a width of about 45 feet of shattered porphyry containing scattered phenocrysts of quartz and altered feldspar, and mineralized with disseminated sulphides that form from 1 to 5 per cent of the volume of the rock. These consist of 70 per cent pyrrhotite, 25 per cent pyrite, and 5 per cent chalcopyrite. Calcite veinlets bearing chalcopyrite are also present.

The two eastern trenches are 40 feet apart; that to the west is 30 feet and the other 130 feet long; they strike about 40 degrees west of north; the northwest end of the eastern trench is 30 feet north of the end of the western trench. The northern part of the western trench for a length of 20 feet discloses a massive, altered diorite or gabbro, to the south of which shattered porphyry similar to that in the trenches to the west is exposed for 10 feet. An 8-inch wide zone in this trench is impregnated with about 30 per cent of fine to coarse-grained pyrite. Another irregular zone of like width is richer in pyrite and contains a little chalcopyrite. In the eastern trench, the rocks as exposed from north to south and for the lengths indicated, are: 25 feet, massive, altered diorite of which the southeastern 10 feet are sheared; 2 feet, shattered porphyry probably an east-northeast continuation of the porphyry in the trench to the west; 2 feet, chlorite schist containing lenses that consist of chalcopyrite and pyrite in about equal proportion, form about 15 per cent of the rock, strike east-northeast, and have a vertical dip; 15 feet, shattered, basic greenstones; 85 feet, fairly massive greenstone and diorite.

In the high, rough country near the contact of the Chibougamau sediments, in a dark, altered quartz diorite-like rock, $\frac{3}{5}$ mile east of mile-post 4, is a poorly exposed quartz vein, 2 to 4 feet wide. It is traceable for a few feet, has a strike of about north 60 degrees east, and dips steeply to the south. The glassy quartz varies from white to bluish and contains a little disseminated pyrite and chalcopyrite.

In this general locality there is a bed of steeply dipping, cherty, and arkosic sediments containing a little disseminated pyrite and chalcopyrite. These poorly exposed sediments are believed to be intruded by the neighbouring gabbroidal rocks and to be older than the nearby Chibougamau sediments.

Part of the ground described above was restaked in 1934 on account of a find made $\frac{1}{2}$ mile east of the Barlow-McKenzie township line and 2,000 feet northwest of the northwest shore of Gwillim lake. The main showing at this point is disclosed in three trenches 30 to 50 feet long, and consists of a sheared zone in massive, fine-grained greenstone. Fine-grained quartz to quartz feldspar porphyry dykes that weather white similar to anorthosite occur near the showing. The rocks in the most western trench only were visible when visited in September, 1935. The chloritic schists, which form part of the shear zone in this trench, contain a few small quartz veins 1 foot or less wide, irregular carbonate stringers, and one vein-like mass of carbonate 3 feet wide.

Pyrite, chalcopyrite, and a little sphalerite are present in the quartz and occur to some extent disseminated in the chlorite schists. The length of the shear zone proved by trenching is at least 175 feet: its width ranges from 20 to 11 feet. The gold values are not uniform across these widths

and are reported to range upwards to 0·5 ounce to the ton. The mineral zone was tested by drilling in 1935 by the McIntyre Porcupine Mines, Limited.

Berrigan Lake

A mineralized zone, staked in 1929 by D. Berrigan and F. Larone, lies along the northeast shore of lake Berrigan and immediately east, in the west part of McKenzie township, about 1 mile northeast of Antoinette lake. During the summer of 1930 this property was under option to the Consolidated Mining and Smelting Company of Canada who carried out a program of systematic exploration involving much stripping and rock trenching, and some diamond drilling. The trenching disclosed several mineralized zones.

The mineralization uncovered is in peridotite serpentine and associated narrow bodies of volcanics. The volcanics where less altered are recognizable as fine tuffs and rhyolite porphyries. The relatively unaltered volcanics are present in small amounts only. The highly altered rhyolite has the same colour as the peridotite and can only be recognized by its conchoidal fracture and occasional, small quartz phenocrysts. The rocks of many places in the mineralized zones and adjacent to them are impregnated by a high percentage of iron carbonate, and the gossan cappings of these sections are in places deep. In other places iron carbonate is lacking or present only in scattered grains.

Post-glacial weathering of the iron carbonate to a depth of 8 feet is indicated in a trench about 60 feet northeast of the northeast end of Berrigan lake. This trench is at a considerable height above the lake and crosses an undulating, glaciated surface. The low points of this surface are peridotite; one of the highest parts is a strongly iron-carbonated band weathered to a rusty, soft mass of gossan, to a depth of 8 feet. A projecting point of such soft material could not have survived glaciation and, therefore, the weathering must have taken place since the glacial period.

The main zone investigated is apparently sinuous, but has a general trend of north 70 degrees east. Its west end extends along the northeast part of the lake for about 250 feet. The zone has been crossed by trenches at intervals over a distance of about 1,200 feet. The trenches average 80 feet apart and expose widths of about 80 feet across the zone. The rocks exposed are in general considerably shattered and in narrow widths are sheared vertically in the direction of the zone. The bulk of the rock is now iron carbonate or a gossan. These materials grade rapidly or gradually into serpentinized peridotite or into somewhat silicified carbonate rock. The latter is in part highly altered rhyolite but silicification has probably occurred in the peridotite also. Varying widths of the above rock types alternate with one another. Dark, glassy quartz veins are sparingly present, and for the most part occur where the rock is silicified. In some cases silicification extends outward from the quartz veins and gives the definite impression that quartz has replaced the carbonate rock. Some of the quartz veins contain calcite, and others both calcite and sphalerite. Calcite veins are also present. Dark schist that is heavily sheared, and may be somewhat carbonated peridotite, contains appreciable

amounts of pyrite. Sparsely distributed through the strongly silicified parts of the zone and also the carbonate are narrow stringers and lenses of one or more of the sulphides, pyrrhotite, sphalerite, and chalcopyrite. One specimen disclosed quartz, veined and replaced by pyrrhotite and sphalerite. The sulphide mineralization is generally heavier at the western end of the exposed zone, but even there appreciable concentrations are lacking.

About 180 feet from the west end of the above zone, near its north margin, are narrow, tongue-like intrusions of quartz porphyry somewhat coarser than the rhyolite porphyry (believed to be of flow origin). The narrow bodies of porphyry have a north-northeasterly strike. One hundred feet in this direction, stripping discloses heavily carbonated and silicified rock traversed in a northeast direction by an 8-foot zone mineralized with irregular veinlets of dark quartz forming as much as 10 per cent of the zone. Varying but small amounts of sphalerite, pyrite, pyrrhotite, and chalcopyrite are present. Trenching to a point 200 feet east of the above discloses little mineralization and a variety of altered rocks, of which the predominant types are a gabbro phase of the peridotite and cherty to basic tuffs.

About 600 feet east of the east end of the main zone is the west end of a trenched area that extends eastward for about 300 feet and discloses heavily carbonated rocks having a width of 10 to 30 feet, and peridotite and rhyolite porphyry.

Bourbeau Lake

A sulphide zone was uncovered during 1929, by S. McBurnie and H. Brown, on the north shore of Bourbeau lake, about 500 feet east of the western tip of the long peninsula south of Anxiety bay. Consolidated Chibougamau Goldfields, Limited, in 1934, explored this zone for a distance of 1,100 feet. Their work consists of fifteen trenches that are up to 80 feet in length and are spaced at intervals of 50 feet or more along the zone.

A thickness of about 200 feet of finely banded to massive sediments, cherty to arkosic in appearance, with at one place interbeds of black slate, are exposed in the trenches. They strike north 50 degrees east and dip vertically to 85 degrees south. They are in contact to the northwest with dark-coloured, altered "diorite" in which pegmatitic phases, rich in quartz and long needles of amphibole, are common. A small thickness of lava flanks the southeast side of the sediments in the most eastern trench. The lava has well-developed pillows which suggest that the lower surface of the flow faces northwest and is in contact with the sediments.

The mineralization consists almost entirely of pyrite, and lies in the sediments near the "diorite" contact. It occurs principally along the bedding planes and replacing the rock adjacent to such planes, but also occurs in desseminated form throughout and along joints. A few bands 1 inch to 1 foot wide are nearly 100 per cent replaced by pyrite, but the average content of the highly mineralized part of the zone, 10 to 20 feet in width, is much less. A little chalcopyrite with pyrrhotite and quartz forms tiny veinlets cutting the pyrite. Assay returns are not encouraging

A selected sample of the sulphides collected in 1934 did not yield a trace of gold when assayed by the Mines Branch, Ottawa.

HAILEYBURY MINING SYNDICATE

A small but interesting showing occurs at the right-angled bend ½ mile from the head of the southwest bay of Bourbeau lake, on claims held in 1934 by the International Mining Corporation. A little work had been done on the showing prior to 1930 by the Haileybury Mining Syndicate. During 1934 the open-cut, in which the mineralization is displayed near the lake at the base of a steep hill, was extended for a few feet, the face of the cut being now 28 feet back from the shore.

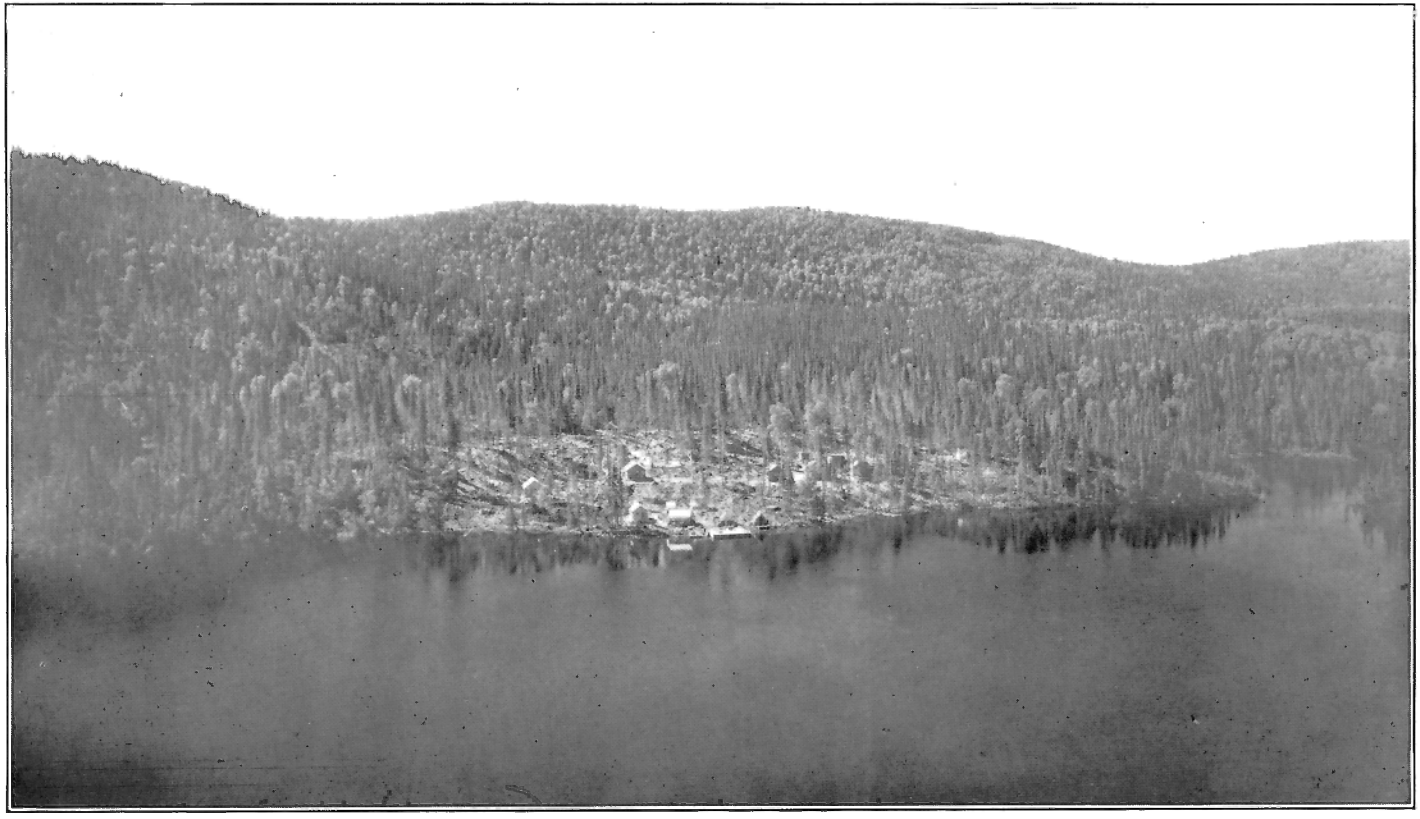
The cut exposes a narrow tongue of massive sulphides that extends in a northerly direction across serpentine which forms the country rock. The tongue averages 18 inches wide, at one place forks out to a width of 3 feet, but wedges out completely 4 feet from the face of the cut. There is a possibility that it is pinched off by movement in the surrounding slickensided serpentine.

The sulphides consist of pyrrhotite with a few irregular grains and seams of chalcopyrite and sphalerite, and a fair percentage of microscopic, well-formed crystals of pyrite. A sample collected in 1934 from an 18-inch width across the centre of the tongue was furnished to the Mines Branch, Ottawa, for assay, and yielded 0·82 ounce (Troy) of silver and 1·15 ounces (Troy) of gold, to the ton. Similar high assay values are reported to have been obtained from this showing.

NORTHERN CHIBOUGAMAU MINES, LIMITED

Northern Chibougamau Mines, Limited, in 1934 trenched and stripped considerable areas of rock on claim Q14009 which lies on the south side of Bourbeau lake immediately west of Cran Penché bay. The rocks on this claim consist of pyroxenite and serpentine intruded by one large dyke and many smaller ones of feldspar and quartz-feldspar porphyry. The rocks, both acid and basic, are cut by two or three small quartz veins that range from a few inches to 26 inches in width, strike in general a few degrees west of north, and dip vertically to steeply east. The quartz is mineralized with chalcopyrite, pyrite, small amounts of pyrrhotite, and in places molybdenite, and is reported to have unimportant values in gold. On the west side of the 26-inch vein the pyroxenite is silicified and mineralized with sulphides for 2 feet, but in general shows little alteration near the veins. The 26-inch vein occurs about 3 chains east of the west boundary of the claim and 10 chains south of the lake. On the claim line west of this vein the pyroxenite is cut by a narrow quartz porphyry dyke that strikes north and has been broken into numerous short sections by small east-west faults. Many of the faults are mineralized with narrow seams of quartz and sulphides.

The rocks on claim Q14009 are fairly well exposed in natural outcrops and in stripped surfaces. If the gold-bearing quartz vein on the Noranda property on the north side of Cran Penché bay extended southward across the bay, it could hardly have escaped detection as a result of the stripping and trenching done on this claim.



A. 4737-53 R.C.A.F.
Aerial view looking south across the Noranda camp on the south side of Bourbeau lake. (Photo by Royal Canadian Air Force.)

78103

Looking east along deep valley from the west side of Cran Penché bay, Bourbeau lake.

NORANDA PROPERTY, BOURBEAU LAKE

A gold-bearing quartz vein or vein system was discovered in 1930 by H. F. Gilligan and W. D. Mahoney on claims held by Gilligan, Mahoney, and Coffin on the south side of Bourbeau lake, immediately north of Cran Penché bay. Noranda Mines, Limited, optioned these claims in 1933 and since that date, by systematic trenching and drilling, have disclosed a deposit of considerable economic interest.

The vein follows a general southwesterly course from a point near the south shore of Bourbeau lake about 1,800 feet east of the entry to the southwest bay of the lake; and lies along the eastern edge of comparatively low, rough ground. The ground rises steeply from the east side of the vein to form a high ridge along the south side of Bourbeau lake (*See* Plate IV). The ridge trends in an easterly direction and is several hundred feet in elevation above the lake. Its southern flank slopes at a very steep angle towards a deep east-west depression (*See* Plate V) that parallels the ridge from the head of Cran Penché bay to the southern end of Sullivan bay.

The vein as disclosed in the trenches cuts across easterly-trending, basic, sill-like intrusive masses that have invaded the older volcanics and sediments about Bourbeau lake. The succession of rocks from the lake, southwards, on the east side of the vein, is as follows: altered, dark-coloured " diorite " with quartz-rich pegmatitic phases, 800 to 900 feet; altered gabbro, 750± feet; serpentine and pyroxenite, poorly exposed. The gabbro includes two bands, 100 feet or so wide, of dark-coloured schistose rocks that are converted to graphitic or sericitic schists in the zone of shearing and mineralization along the vein. One of these bands lies about 200 feet south of the gabbro-" diorite " contact, the other near the southern limit of the gabbro. The latter band is exposed in trenches spaced in an easterly direction at right angles to the vein at the southern end of the trenched ground, and passes a few hundred feet east of these trenches into well-banded, probably tuffaceous, sediments. The first band is highly altered and sericitic near the vein, but is probably derived from similar rocks. One mile to the east, along the general strike of these bands on the west side of Sullivan bay, a 400-foot wide band of fine-grained sediments, mostly of slaty composition, is bordered on either side by gabbro. Similar narrow bands of sediments, some highly carbonaceous and slate-like, are of common occurrence as narrow, rather persistent, shreds within the basic intrusives between Bourbeau lake and McKenzie bay, lake Chibougamau. A wider belt of sediments lies between the east end of Bourbeau lake and Blondeau lake. The topography, the continuity of other rock types, and the presence of a small thickness of sediments at one place on the north side of Bourbeau lake suggest that this belt of sediments extends westward under the lake.

The rocks on the west side of the shear zone in which the vein occurs are apparently shifted a few hundred feet to the south. The offset is indicated by the dark green, altered " dioritic " rocks in the trench that lies close to the west side of the vein, 300 feet south of the " diorite "-gabbro contact on the east side. That no major movement has occurred either along the shear zone or in the bay to the west can be inferred

from the close correspondence in the succession of the rocks from north to south on either side of the bay.

Whether faults with easterly trend pass across the southwest bay of Bourbeau lake is not certain. A very pronounced depression, very striking from the air, extends westward from the right-angled bend ½ mile from the head of the bay. Mineralized shears along the side of this depression, and the vertical cliffs that border its northern side near Bourbeau lake suggest that it marks the location of a fault. Such a fault if persistent eastward would extend along the narrow arm of the southwest bay of the lake, and possibly pass out of the lake from Cran Penché bay at a point not far south of the southern trenches in the vein.

The Noranda vein or vein system strikes in a general direction of 30 degrees east of north. It has been trenched for a distance of 1,300 feet, the most northerly trench being 325 feet south of the lake. The character and continuity of the northern part of the vein are well disclosed in cuts 25 to 50 feet apart for a distance of 700 feet and the vein has been thoroughly explored by drilling at regularly spaced intervals, practically all the drilling done on the property being confined to this section. This part of the vein extends northward from the band of dark-coloured schist that lies on the east side of the vein 200 feet south of the " diorite " gabbro contact. The walls of the vein in the southern 600 feet of the trenched ground are dark-coloured schists. The southern trenches are more widely spaced and yield less certain information as to the continuity of the vein. Important widths of dark grey quartz, containing in places considerable free gold, are present in closely spaced trenches for a distance of 120 feet in the southern part of the 600-foot section; but they are separated by a 425-foot interval of low ground, across which only one trench has been dug, from the 700-foot, closely trenched section of the vein.

The vein as displayed in the closely spaced trenches along the northern 700-foot section varies from 8 to 2·5 feet in width and dips 50 to 55 degrees southeast. It consists of almost pure quartz, greasy, mottled grey, and considerably fractured. The few sulphides present are a little pyrite, small prismatic rods or tiny veinlets of arsenopyrite, and more rarely traces of pyrrhotite and chalcopyrite. The sulphides occur, where observed in one trench, particularly along the foot-wall. Numerous, small, branching offshoots of quartz extend out on either side of the vein into the wall-rocks, and contain, at one place, small amounts of chalcopyrite and pyrrhotite. The wall-rocks along the vein are considerably sheared and carbonated, particularly in the foot-wall. Where well exposed in one trench the foot-wall rocks are highly carbonated for 20 feet and to some extent for 80 feet from the vein. The hanging-wall is carbonated for a few feet only. The wall-rocks are impregnated with pyrite, particularly those in the foot-wall.

A total of 15,000 feet of drilling, distributed in forty-five holes, has been done on the property to test the northern part of the vein. This work, according to information secured from the company, outlines an ore shoot 800 feet in length, the depth so far determined being 500 feet. The average thickness is given as 4½ feet and the average value as 0·35 ounce of gold a ton.

Another quartz vein was discovered during 1934, 1,500 feet east of the main vein and 900 feet south of the lake, and was traced to the eastern boundary of the Noranda property. In all essential megascopic characters it is similar to the main vein and also to veins on the Sharpe showing, 3,000 feet to the east. A series of trenches 100 to 25 feet apart have been dug across the strike of the vein for a distance of 775 feet. When visited by the writer in September, 1934, the vein was disclosed at four places, for 200 feet in the eastern half of the trenched ground, the maximum exposed thickness being about 3 feet. It dips steeply south, and strikes almost due east in line with the similar veins present on the Sharpe showing. The quartz is mottled dark to light grey and contains near its walls small amounts of arsenopyrite and pyrite, and at one place a trace of sphalerite. Free gold is said to occur in the vein but was not seen by the writer. The wall-rocks are "diorite" with quartz-rich pegmatitic phases and are somewhat sheared and carbonated near the vein.

SHARPE SHOWING

A series of short, connected, lenticular quartz veins that are alined one after the other in an easterly direction occur about 900 feet southeast of the point on the west side of Sullivan bay, Bourbeau lake, half a mile northwest of the portage to Doré lake. They are similar in character to those on the Noranda property to the west. The veins were staked in 1929 by S. Sharpe, but are now (1934) held by the International Mining Corporation and were rather thoroughly trenched during 1934.

The veins lie along a moderate shear within the "diorite" that flanks the south side of Bourbeau lake, and have been trenched at intervals of about 30 feet for a distance of 750 feet along the strike. The most easterly vein (No. 1) strikes about south 82 degrees west and is about 275 feet long. It is a lenticular mass, with a width of about 8 feet near the centre, but tapering at either end to negligible thicknesses. Small branching offshoots from the main vein form a stockwork 9 feet wide along part of its length. At the western end the vein either tapers out entirely or is connected by narrow stringers of quartz to the adjoining vein (No. 2) which lies 120 feet to the west along the same shear zone.

Vein No. 2 strikes north 82 degrees west for 150 feet and then swings 25 degrees south of west for 130 feet. At the point where the strike changes the vein is 10 feet wide and consists of a stockwork of quartz veins and 50 per cent included blocks of wall-rock. East and west of this point it tapers quickly to a width of 5 feet, consisting of quartz vein material and included rocks. About 155 feet west of the southerly bend of vein No. 2 the shear zone and vein either swing 60 degrees northwards or a third vein 30 to 36 inches wide is present. The third (?) vein has apparently been traced for 50 feet or so but rusty-weathering rocks in a stripping west of the most western trench suggest that it may continue in that direction. The veins dip steeply south in general but local dips of 45 degrees suggest rolls.

The quartz in these veins is mottled grey, dark grey to white, and in places has a shattered structure indicative of deformation. It contains a little scattered pyrite in crystalline form, smears of black, fine-grained

tourmaline and chlorite, and in places a little chalcopyrite. Arsenopyrite is present, particularly in the more western trenches, as narrow, fine-grained bands near the walls of the vein and less commonly as scattered, well-formed crystals up to ¼ inch long in the quartz. The wall-rocks, and particularly the blocks included in a stockwork of quartz, are pyritized, in places heavily so. Carbonatization of the wall-rocks (and in places chloritization) has occurred but is not intense, except in some of the included blocks in the veins. The rocks away from the vein have a dioritic appearance and contain local segregations rich in quartz and in long, amphibole crystals.

Free gold is visible in quartz in the most western trench. Under the microscope, the gold in polished specimens of the vein quartz from this trench is very conspicuous. It occurs chiefly as small grains and narrow plates along fractures in arsenopyrite, and to a much smaller extent in the quartz. The arsenopyrite that encloses the gold occurs as narrow, shattered bands in the quartz, the bands being broken up into a series of short, separate segments. In one instance a pyrite crystal is traversed by a veinlet of arsenopyrite. Gold is present in the arsenopyrite veinlet, but is not visible in the surrounding pyrite.

The rather spectacular occurrence of gold in the polished specimens examined from the westernmost trench warrants further exploration on these veins and along the shear zone in which they occur, although to the writer's knowledge no high gold values have been obtained from these veins up to the present. A promising feature of the veins is their almost perfect alinement with the similar vein, reported to contain free gold, 3,000 feet to the west on the Noranda property.

About 400 feet due south of the centre of the vein system described above and near the southern margin of the " diorite," is a vein of almost black quartz that contains no visible mineralization. This body is exposed for a length of 15 feet, has a strike north 85 degrees west, and a vertical dip. At the east end of the exposure it is 2 feet wide, but narrows to 6 inches at the west end.

About 1,000 feet south of the Sharpe vein system, on the top of the hill present in this locality, stripping has exposed an east-west belt, about 400 feet wide, of fine-grained clastics. These are mostly slaty in composition, but a little arkose-like material is present. They have an east-west strike and vertical dip and are believed to be waterlain tuffs. They are definitely intruded by gabbro present on both sides of them. A little disseminated pyrite and chalcopyrite were noted in them at one point, but no vein quartz is present. Near and south of the south margin of these sediments an outcrop of highly altered feldspar porphyry was noted, and is probably part of a narrow dyke of this rock.

BOURBEAU LAKE MINES, LIMITED

On claims held by this company, south and east of the eastern end of Bourbeau lake, some mineralization was uncovered in 1934. One occurrence of disseminated pyrite and small stringers of this sulphide in banded sediments was exposed by trenching at a locality 25 chains south of the southern tip of Sullivan bay. The highest gold values reported are $1.70 a

ton. Other massive to disseminated sulphide replacements consisting of either pyrite or of pyrrhotite with a little pyrite and chalcopyrite occur in the volcanics close to the south side of the pyroxenite gabbro mass that lies 4,000 feet south of Sullivan bay. The replacements lie 3,000 to 2,000 feet west of the lake on the Bourbeau-Doré Lake portage and have been stripped and trenched at a few places. Only a trace of gold is reported to have been obtained from assays of these sulphides.

During the winter of 1934-35 the company is reported to have located an easterly extension of the main vein outcropping at the Sharpe showing, by drilling through the ice at Sullivan bay.

OTHER MINERAL OCCURRENCES NEAR BOURBEAU LAKE

In 1934 Prospectors Airways, Limited, and the International Mining Corporation explored their claims that lie between Line lake and the southwest bay of Bourbeau lake. A little sulphide mineralization—pyrrhotite, pyrite, and a little chalcopyrite in places—was disclosed by this work, chiefly along the sides of narrow, trench-like valleys that probably mark the location of faults, but no encouraging gold values were obtained. Some of this mineralization occurs in narrow shear zones that branch out from the trench-like valleys, nearly at right angles.

David Lake

The mineralization described in 1927[1], which occurs a mile north of lake David and about one-half mile east of the more westerly creek that flows south into this lake, was then believed to be near the north boundary of the granite present in this locality; subsequent stripping and mapping show that this boundary lies a quarter of a mile farther north. The stripping and trenching in the vicinity of the original find disclose altered, fine-grained, black, quartz-bearing rock similar to the Cachée Bay complex type, followed to the north by a heavily sheared serpentine schist, in places containing lenticular bodies, up to ¼ inch across, of iron carbonate and lesser amounts of granular quartz. These lenses seem to owe their shape, at least in part, to later shearing. Neighbouring outcrops north and south of these workings are granite, more or less sheared and carbonated. Narrow dykes of carbonated granite cut the above, black, quartz-bearing rock. The shear zone at the workings strikes north 87 degrees west and dips 72 degrees to the north. The bands of carbonate present in the trenches have irregular and ill-defined borders, and in places definitely strike at a small angle across the shearing planes. In the dark quartz-bearing rock, a zone of 2 feet, rich in carbonate, contains four stringers rich in sphalerite. The total width of the stringers is 6 inches, the widest being 2½ inches. A few, very narrow veinlets are also present in the neighbouring uncarbonated rock. The veins are somewhat sinuous. Their general strike is about north 50 degrees east, and they dip 80 degrees to the northwest. They are apparently later than the

[1] Geol. Surv., Canada, Sum. Rept. 1927, pt. C, p. 20.

main shearing and carbonatization. The veins probably contain: 5 per cent pyrite, usually cubical and in greater amounts near the walls; 70 per cent light-coloured sphalerite, containing minute particles of chalcopyrite; and 25± per cent white granular quartz. The pyrite crystals are in places fractured and traversed by quartz veinlets.

On the north end of the long point on the south shore of David lake, west of the entrance of Chibougamau river, and on the west margin of the map-sheet, is a poorly exposed complex of chloritized anorthosite, sheared gabbroidal phases of the anorthosite, and an altered, quartz-bearing, diorite-like rock similar to phases of the Cachée Bay complex type. Stringers and small lenses of quartz cutting these rocks contain much chlorite and very little sulphides. Several stringers, up to 1 inch wide, of magnetite, were also noted.

Gilman Lake

A mineralized zone, about ¼ mile south and ¼ mile west of the east end of Gilman lake, was trenched in 1929 by the Vega Finance Corporation. It lies in greenstone that forms part of the extensive iron-carbonated zone present in this part of the area north of the anorthosite. Over a length of about 350 feet in a direction north 80 degrees east, and a width of 180 to 230 feet, four north-south trenches disclose the bedrock. North of this zone the ground is low and the rock is drift-covered. The workings expose rusty weathering, heavily carbonated rocks, believed to be volcanics, and some of which have the appearance of volcanic fragmentals. Shearing is usually pronounced, the planes having a strike varying from 10 degrees north to 10 degrees south of east, and a vertical dip.

Steeply dipping lenses or bands rich in fine pyrite are sparingly present. They are 3 inches to 3 feet wide and strike in an easterly direction. A little quartz is present in one of the pyrite bands and occurs also in a flat, glassy, white vein in the northwest part of the zone, but is otherwise rare. One irregular veinlet shows a parallel fibrous structure, at right angles to the vein wall, due to the alternate presence of quartz and carbonate. The quartz, in the main, however, veins the carbonate, and is in part at least contemporaneous with the pyrite.

Doré Lake

OBALSKI PROPERTY

Considerable work has been done on a group of forty claims aggregating 1,670 acres. Most of the ground is north of Cachée bay, lake Doré, but some lies south and west of the bay. One claim lies north of the Obalski-McKenzie township line. The north boundary of the block formed by the other claims is approximately the township line from a point about ¼ mile east of mile-post 8 to a point about ¼ mile west of mile-post 6. Work was done on this group in 1928 by the Chibougamau Mining Company, and was continued by its successor the Obalski Mining Corporation. During the summer of 1929 the ground was systematically prospected

by R. W. Howe, under the direction of W. F. James and J. E. Gill. At this time about 40 miles of picket lines were run at intervals of 400 feet; all rock along these lines and 50 feet to each side was examined and mapped and zones of interest were explored. Stripping, rock trenching, and diamond drilling were also done to determine the value of the mineral showings. The company kindly supplied Mawdsley in 1930 with two reports on this work, prepared by Gill, and the detailed maps accompanying them.

High, rocky ground is present in the centre of the group, and it is in this locality that the greatest amount of work has been done. High, rocky ground is also present along the south boundary, immediately south of Cachée bay. The point enclosing the eastern end of the bay is low, but its surface is almost continuous rock outcrop. Elsewhere, rock outcrops are relatively few.

The southeastern two-sevenths of the group is underlain by anorthosite. The western boundary of this rock is slightly sinuous, but has a general trend of 15 degrees east of north. Coarse-grained and porphyritic phases approaching a feldspar-rich type of gabbro are sparingly present. Near the boundary of the anorthosite a small amount of altered amphibolitic rocks occurs. In general characteristics these rocks are typical of the anorthosite mass in this map-area. Along the west side of the anorthosite is an irregular band of the quartz-rich phase of the Cachée Bay complex, averaging about 1,000 feet in width. The quartz is generally pronouncedly blue and opalescent and the rock has the appearance of a dark granite or granodiorite. The northern part of this quartz-rich phase is flanked to the west by the darker, diorite-like type of the Cachée Bay complex. The latter averages 1,300 feet wide on the property and its northwest boundary trends southwest. The Cachée Bay complex rocks are cut by a few, altered, narrow diabase dykes.

Gabbro marginal to the anorthosite underlies the southwestern part of the block of claims and lies immediately west and south of the Cachée Bay complex. Banded, porphyritic anorthosite forms local phases in the gabbro, notably on the portage from Cachée bay to Caché lake. The banding parallels the north-south contact of these rocks with the granitic rocks immediately to the east.

The northwest corners of the group of claims, about one-fifth of its total area, is underlain by volcanics, not well exposed. They are predominantly andesitic in composition.

"Greenstone" dykes cut all the above rock types and the quartz and sulphide mineralization present is later than them all.

Shattering is not uncommon in the rock masses on these claims, but wide shear zones are not in evidence. Narrow, persistent shears are present and have played a prominent part in the localization of carbonate, quartz, and sulphide-bearing mineralization. In the main showings the shearing follows three general directions, namely: north 83 degrees east, south 65 to 70 degrees east, and south 40 degrees east, the shearing in this direction being probably youngest. Some of the directions of shearing parallel the strikes of narrow greenstone dykes, and all the shearing has been influenced in whole or in part by contacts between dissimilar rock masses or between

different phases of the same type of rock. The sheared and mineralized zones are generally sinuous and in places branch. Shearings along two directions exist in places along a single zone.

Five main zones have been found. They lie in an area that is 3,700 feet long, strikes north 70 degrees west, and has a maximum width of about 900 feet. The east end of this area is 500 feet north of the northeast end of Cachée bay. The northwesternmost zone (zone No. 1) strikes north 80 degrees east and has been explored over a length of 600 feet by nine cross trenches. In the western trenches the zone is 3 to 4 feet wide and consists of sheared diorite heavily gossaned and containing small, narrow lenses of quartz. The adjacent diorite contains a little pyrite in skeleton crystals. The easternmost trench and a trench 220 feet west of it disclose stronger mineralization of like widths and character. In two intermediate trenches, now caved, this mineralization may also be present. In the easternmost trench a greenstone dyke apparently crosses the zone. It strikes south 40 degrees east. Along its edge the diorite is sheared but unmineralized. The mineralized zone in the easternmost trench strikes north 85 degrees east and is vertical. The zone is 1½ feet wide, and consists of about 30 per cent irregular quartz lenses, 30 per cent pyrite, and 40 per cent heavily chloritized, sheared diorite. The quartz contains some pyrite and small masses of chlorite and is cut by fractures bearing thin seams of chalcopyrite. The chalcopyrite forms less than 1 per cent of the zone. The zone is bordered by relatively massive rock which across widths nowhere exceeding 1½ feet contains about 10 per cent of pyrite in cubes and small stringers.

A second zone (No. 2) starts at the west end of zone No. 1, strikes south 65 degrees east, and is disclosed in eight trenches spaced over a distance of 800 feet. Drift conceals the rock for 1,000 feet southeast of these trenches. The drift-covered part has been explored by diamond drilling, but with what results is not known to the writers. The No. 2 zone is in the diorite-like phase of the Cachée Bay complex and the drift-covered area, except in the extreme northwest, is apparently in the dark, granite-like phase. Shearing, trending with the zone and dipping steeply to the south, is disclosed in the trenches, and in places quartz stringers cut across this structure. The westernmost trenches disclose little of interest except gossan-stained material that occurs in widths of 2 or 3 feet and that contains a little disseminated sulphides but usually no quartz. The eastern trenches expose narrow lenses of quartz forming a mineralized zone having an average width of, probably, 3 feet. This zone and the wall-rock alteration that accompanies it are like that of zone 1 except for a lower sulphide content. The sulphides—pyrrhotite was recognized—and the quartz, in one case containing pyrite and chalcopyrite, are traversed by veinlets of fine-grained pyrite. In the easternmost trench, the quartz lens there forming the zone is 60 feet long and has a maximum width of about 4 feet.

About 400 feet south of the west part of zone 2 are a few trenches that disclose a little quartz, striking southeasterly and cutting the diorite.

The westernmost trench on zone No. 3 lies 300 feet north 55 degrees east from the southeasternmost trench on zone No. 2. Zone No. 3 is the longest and most important zone. The western part is 1,500 feet long,

strikes south 70 degrees east, and extends across "diorite" and the "granite" that lies east of the "diorite," to the anorthosite contact. The western part is well exposed in trenches some of which follow, and others cross, its strike. It has also been explored by diamond drills. The eastern part of the zone starts at the anorthosite contact, 55 feet beyond the southeast end of the western part. This section has a sinuous trend. It lies in the anorthosite and is exposed in six trenches spaced at intervals over a distance of 850 feet along a line trending about south 65 degrees east.

The western end of the western part of zone 3 is uncovered for 260 feet along the strike by a narrow trench with connected cross trenches and two prospect pits. The trenches disclose a sinuous, quartz-rich zone of variable thickness that divides into two sections in the eastern part of the workings, and has minor, slightly diverging offshoots elsewhere. The southeast wall of a pit in the centre of the workings, west of the forking of the mineralized zone, exposes a good cross-section of the zone and wall-rocks. Pronounced shearing planes strike parallel to the zone and dip 80 degrees north. The foot-wall, on the southwest side of the zone, is massive, altered diorite. The mineralized zone is a 3-foot wide band rich in grey and in white, greasy quartz, both markedly fractured. The band is highly stained with iron oxides which may indicate the original presence of pyrrhotite. It contains varying amounts of chalcopyrite in dendritic masses, and some pyrite. The 3-foot mineralized band is bounded on the north side by 1 foot of shattered, unmineralized diorite followed by an 8-inch section consisting of 60 per cent chalcopyrite and 40 per cent quartz, beyond which lies a breadth of 9 feet of shattered, altered diorite forming the northern wall of the zone. The diorite in this wall contains skeleton crystals of pyrite and is traversed by veinlets of pyrite and quartz, the sulphides forming 10 to 15 per cent of the rock. Some of the pyrite veinlets have a narrow selvedge of chlorite. Gold can be panned from the heavily gossaned parts of the zone, and assay returns of interest are reported.

Westward from the described section exposed in the pit, mineralization decreases and is quite narrow at the west end of the trench. Eastward, the southern branch of the quartz vein decreases rapidly in width and dies away before the eastern end of the exposure is reached. The northern branch is separated from the southern by, on the average, 4 feet of fairly massive rock. It continues to the eastern end of the exposure and swells and pinches from almost nothing to a width of 3 feet. It finally passes under the drift at the east end with a width of about 1 foot.

The eastern workings on the western part of zone No. 3 are separated from those described above by 450 feet of covered ground. They reveal widths of quartz varying from 1½ to 3 feet. The mineralization is like that present farther west in this zone, but the proportion of sulphides is less.

The eastern part of zone No. 3 in the anorthosite has narrow widths and relatively low concentrations of sulphides as compared with the western part.

The east end of zone No. 4 lies about 50 feet south of the northwest end of the eastern section of zone 3. Zone 4 is ill defined, and is exposed in eight trenches, spaced over a distance of 700 feet in a direction south

85 degrees west. The westernmost working on zone No. 4 is on the strike of zone No. 2, but is separated from the easternmost exposure of that zone by 1,000 feet of drift-covered territory. The wall-rocks along zone No. 4 vary, but are chiefly a black, quartz-bearing, diorite-like rock that in places contains large phenocrysts of feldspar. The mineralization resembles that of the previously described zones but is irregular, and none of it so far disclosed has dimensions or mineral content of particular interest. The shearing along this zone is not pronounced and stringers diverging sharply from the general trend of the zone are common.

Zone No. 5 is sinuous with a general strike of south 40 degrees east, and is exposed in nine, irregularly spaced trenches distributed over a distance of 920 feet. The westernmost exposure lies 350 feet northeast of a point on the eastern part of zone No. 3 about 200 feet east of its western end. The most southeasterly stripping on zone No. 5 is 500 feet in a north-northwesterly direction from the extreme northeast corner of Cachée bay. This zone is in the anorthosite. At three points along it, greenstone dykelets lie along and parallel to the mineralized section. The mineralization is irregular and no lengths of particular interest were noted, though widths up to 10 feet of gossan-stained rock are present. The gossan is due to the weathering of iron carbonate and pyrite. Quartz is sparingly present and occurs in lenses. The quartz is usually mottled, grey or blue-grey and white. At one locality a quartz lens contains chalcopyrite and pyrite and the wall-rock is strongly impregnated with pyrite, but contains no visible chalcopyrite. Elsewhere on the property minor amounts of mineralization have been uncovered.

Another small shear zone in the anorthosite and containing grey to dark quartz mineralized with chalcopyrite and pyrrhotite, occurs on the north side of Doré lake 500 feet east of the Obalski cabins. The quartz is a lenticular mass 30 feet long and at the centre, 3 feet wide. It narrows southward to 1 foot and in the opposite direction to small stringers. The wall-rock on the west side is slightly carbonated and contains disseminated sulphides. The lens has nearly the same strike as, and occurs on the strike of, zone No. 5, the nearest exposure of which lies 3,000 feet to the northwest. A general claim map of the district indicates that the lenticular quartz body lies in the Gilman group of claims adjoining the east side of the Obalski property.

MERRILL ISLAND

Considerable work has been done on a mineralized zone on the north shore of Merrill island, Doré lake. The part of the bed of the lake adjacent to and on the strike of this showing has been drilled.

Block C, a patented claim held under mining concession 136, comprises most of the east end of this island. It was formerly owned by the Blake Development Company, Limited, but in 1934 was held by the Northern Investment and Mining Company. The work done on this property by the former company has been described by one of the present writers. [1] During 1928 the latter company did much further trenching and lengthened and deepened some of the previously existing trenches, bringing to light some facts not previously known regarding the nature of the occurrence.

[1] Geol. Surv., Canada, Sum. Rept. 1927, pt. C, p. 18.

Merrill island is underlain by anorthosite. Its southeast shore is just northwest of the end of a northwesterly trending projection of granite from a much larger mass to the south. The showing is on the north shore and is about ¾ mile from the granite-anorthosite contact. This mineralized zone is on the point that lies immediately east of the prominent bay on the northwest shore of the island. It strikes north 45 to 60 degrees west and has a vertical dip. Nine rock trenches, spaced at intervals of 100 feet, run approximately at right angles to this strike and disclose the bedrock intermittently for a distance of 800 feet southeastward from the shore and for a width of 100 to 180 feet. Stripping and a test pit disclose the rock completely in the vicinity of the shore. Good values in copper and gold have been reported from the showing.

The part of the zone exhibiting the greatest shearing and the heaviest sulphide mineralization occurs in the shore stripping and is about 45 feet wide. Pyrrhotite, pyrite, and chalcopyrite together average about 10 per cent of the rock across this width, pyrrhotite slightly predominating. The mineralization starts rather abruptly at the southwestern margin of this zone and for 12 feet in a northeasterly direction across the zone the sulphides form 30 to 50 per cent of the rock. Beyond this they gradually decrease in amount to the northeast margin, where they are very sparingly present and the zone is bounded by unmineralized, sheared, chloritized anorthosite. The sulphides occur in massive, vein-like bodies, in irregular veinlets, and as disseminations. Solid masses of sulphide, 1 to 3 feet wide and composed of pyrrhotite, chalcopyrite, and sparse amounts of pyrite, are present in the 12-foot southwestern section. Glassy and opalescent quartz veins are sparingly present, though more common in the sulphide-rich section. Iron carbonate is present in parts rich in sulphides, but is almost absent where sulphides are scattered. Sphalerite and a trace of galena are associated with other sulphides, a short distance from the shore on the west side of the draw that passes along the east side of the trenches.

In the various rock trenches southeast of the lake shore, there is evidence of progressive decrease, away from the lake, in the intensity of shearing and mineralization. In the trench located 300 feet from the lake the anorthosite exhibits merely a blocky shattering, and mineralization has ceased to be important. Where present it is mostly pyrite or pyrrhotite disseminated in small amounts, or takes the form of small, chalcopyrite-rich veinlets in narrow, irregular fractures, in otherwise massive anorthosite. In the trenches farther to the southeast mineralization becomes even less until in the last two trenches it is practically absent.

In each of three trenches, located 200, 400, and 600 feet, respectively, southeast of the lake shore, fresh-looking quartz porphyry with phenocrysts 4 mm. in diameter is exposed. The greatest observed width of porphyry was 5 feet. Shear zones and shattered zones made it difficult to determine the relationships of these separate exposures of porphyry, but they are probably not parts of one dyke.

The exposures along the mineralized zone clearly show a connexion between mineralization, shearing, and chloritic alteration of the anorthosite. Where one of these phenomena is well developed, the other two are likely to be prominent also.

The gradual increase in the amount of mineralization that takes place as the north shore of the island is approached possibly indicates the presence of an ore-body beneath the lake. During the winter of 1928-29 and part of the summer of 1929, Chibougamau Prospectors, Limited, explored the ground under the lake north of Merrill island by means of diamond drills operated from the ice and from a scow. Although the writers are unacquainted with the exact results obtained, it is known that mineralization instead of increasing under the lake was found to exist in no greater quantity than where exposed on the shore and that none was encountered in holes drilled a few hundred feet northeast of the shore. Retty [1], who studied some of the mineralized cores obtained from this drilling, notes that the mineralization consists of chalcopyrite, pyrite, pyrrhotite, and quartz and that it contains appreciable gold values. This association is similar to that found in the trenches on the shore.

KOKKO CREEK

The Kokko Creek deposit lies near the head of a small bay on the northwest side of Doré lake, immediately north of the centre of Merrill island. It is a shear zone, mineralized with pyrrhotite, chalcopyrite, pyrite, and quartz and lies in anorthosite along the southwest side of a fine-grained quartz porphyry dyke. The anorthosite is massive and grey except in the sheared zone where it is schistose, green, and chloritic. The zone strikes north 41 degrees west and dips vertically to steeply northeast. It has been trenched and stripped at intervals over a distance of 550 feet and has been opened up in two pits. The greater part of the development work was done in 1929 by the Northern Investment and Mining Company, but some dates back to 1906-1907 when the deposit was discovered by John Kokko.

The most intense mineralization occurs in a trench on the west side of the creek and the section from the quartz porphyry dyke southwestward is as follows:

	Feet
Quartz porphyry dyke	
White to dark grey quartz with chalcopyrite and pyrrhotite	2·5 to 3
Sheared anorthosite with scant mineralization	10·7
Massive pyrrhotite with 10 or more per cent chalcopyrite	1·7
Quartz with scattered chalcopyrite and pyrrhotite	3·8
Schistose anorthosite with sparsely disseminated sulphides, small stringers of massive sulphides, and small lenses of mineralized quartz	16·7
Anorthosite, very slightly mineralized	11·5
Massive sulphides	0·5
Massive anorthosite.	

The mineralization is progressively less intense northwestward from this trench and is practically lacking in the last trench in this direction—275 feet away. The anorthosite in the last trench but one contains sparsely disseminated chalcopyrite, pyrrhotite, and pyrite, and small stringers of these sulphides across a width of 20 feet with one heavily mineralized section, 1 foot wide, along the southwest edge of the zone. In a pit about 25 feet northwest of the first described trench the

[1] Bureau of Mines, Quebec, Ann. Rept. 1929, pt. D, p. 63.

mineralization is like that in the first described trench. The bands of solid sulphides or of quartz and sulphides present in these trenches branch and die away irregularly.

About 125 feet southeast from the first described trench, a breadth about 32 feet of green, chloritic anorthosite is exposed in a trench. The rock is less sheared than the rock in the trench to the northwest, but contains disseminated sulphides and a 2-foot wide lens of quartz containing chalcopyrite. Massive anorthosite is exposed at the northeast end of this trench and also southeast of the southwest end of the trench. In a trench about 100 feet farther southeast, 6 feet of green schistose anorthosite is exposed at the south end of the trench. It contains a little mineralized quartz and a moderate content of disseminated sulphides. Quartz porphyry is exposed on the east side of the anorthosite in this trench and possibly is part of the dyke exposed on the northeast side of the zone west of the creek. A small depression lies 100 feet south of the southeasternmost trench and is bordered by massive anorthosite on its southwest side. The depression parallels the mineralized zone and may indicate the location of a zone of shearing.

According to the Chibougamau Commission's report (page 208) samples taken from the Kokko Creek deposit assayed as follows: general sample from the dump—gold 0·04 ounce and silver 2·10 ounces a ton, copper 4·82 per cent; selected pyritous material—gold 0·03 ounce, silver 5·16 ounces, copper 10·44 per cent. More recent assays indicate that certain parts of this mineralized zone carry appreciable values in gold.

Two hundred feet north of Doré lake, near Mr. Bordeleau's cabin, or 1,200 feet southeast of the last-described trench, two trenches 75 and 90 feet long, respectively, have been cut across anorthosite on the strike of the Kokko Creek mineralized zone. The anorthosite contains a little chalcopyrite, pyrite, and quartz located along narrow shear zones that strike north 55 degrees west. More intensely sheared zones, a few feet wide, striking north 55 to 42 degrees west, and bearing slight traces of mineralization, are developed in anorthosite on the small island 2,000 feet southeast of Mr. Bordeleau's cabin. They also lie nearly on the strike of the Kokko Creek zone. The alinement of the zones of shearing at these three places indicates that shear zones in the anorthosite if traced along their strike may lead to mineral deposits. A similar condition to that of the Kokko Creek locality exists at Cedar bay, where a shear zone that is heavily mineralized on the point at the entrance to the bay passes into an unmineralized shear zone northeastwards.

MCKENZIE'S CLAIMS

A narrow, mineralized shear zone in anorthosite occurs 600 feet inland from the northwest shore of Doré lake, 1 mile southwest of the entrance to Cedar bay. The zone strikes north 58 degrees west. Exploratory work on this zone consists of: a large pit at the southeastern extremity of the rock exposures; stripping for 300 feet northwest of the pit; and a drill hole put down on the west side of the showing. The results obtained by drilling are unknown to the writers. Southeast of the pit the zone passes under drift.

The section exposed along the northwest face of the pit, from east to west, is as follows:

	Feet
Very fine-grained quartz porphyry (rhyolite dyke)	16
Green, chloritized anorthosite with a little disseminated pyrite, small veinlets of pyrite, and occasional veinlets of quartz and chalcopyrite	4
Quartz with stringers and solid masses of chalcopyrite up to 3 inches wide	2
Green, chloritized anorthosite with a little disseminated pyrite, small veinlets of pyrite, and occasional veinlets of quartz and chalcopyrite	7

The quartz porphyry is highly schistose, the cleavage planes strike about north 65 degrees west and dip 75 degrees east.

The 2-foot wide body of quartz wedges out 12 feet northwest of the pit. The quartz occurs as a series of small stringers a few inches wide that coalesce in places to form more solid masses of quartz and sulphides. The mineralization exposed in the pit continues in the adjoining stripping, but tapers to a point at a place 120 feet northwest of the pit. Farther northwest the anorthosite is quite highly sheared but contains little sulphide. A fault (striking north 7 degrees east, dipping 50 to 60 degrees west) occurs in the pit; the quartz body is offset 4 feet to the east on the south side of the fault. A zone, about 2 inches wide, of shattered rock containing chalcopyrite lies along the fault between two sharply defined smooth surfaces. That the fault is younger than the mineralization is indicated by the slickensided surface of the quartz body on the south side of the fault, and by the restriction of chalcopyrite to that part of the shattered zone that lies between the two offset sections of the vein.

A well-defined scarp facing northeast is present 120 feet east of the pit. It strikes north 56 degrees west. The rocks along the scarp are schistose, medium to very fine-grained quartz porphyry, and in part probably altered anorthosite; in places they are carbonated and iron-stained. The scarp probably marks the location of a fault or shear zone.

CEDAR BAY, DORÉ LAKE

Four mineral occurrences have been opened in the vicinity of Cedar bay. The most important is the McKenzie showing and lies on the point that projects eastward partly across the entrance to Cedar bay. This occurrence was being developed in 1935 by the Consolidated Mining and Smelting Company of Canada. Two of the other three mineral occurrences are on or near the shore of Cedar bay, ½ mile from its head; one on the east side, the other on the west. The fourth occurrence is about ½ mile north of Cedar bay, and was explored in 1929 by the Chibougamau Prospectors, Limited.

Cedar Bay Property (Consolidated Mining and Smelting Company of Canada)

The Cedar Bay property, *See* Plate I—the McKenzie showing—was initially opened up to a certain extent by Chibougamau McKenzie Mines, Limited. It was taken over by Consolidated Chibougamau Goldfields,

Limited, during the winter of 1933-34. Work by this company during 1934 disclosed very promising mineralization with high gold values, and in September, 1934, the property was optioned to the Consolidated Mining and Smelting Company of Canada.

The showing consists of a series of shear zones developed in anorthosite and mineralized with quartz, chalcopyrite, and pyrite. The early work, done prior to 1927, and described by Mawdsley[1], exposed bedrock for 200 feet east and west and 130 feet north and south. In this area one shear zone, about 40 feet wide, strikes north 58 degrees west along the southwest side of a quartz-feldspar porphyry and was trenched and stripped. A second zone, 50 feet south of the first, strikes slightly north of east, and was explored by a shallow prospect shaft. The porphyry is described in the 1927 report as a rhyolite volcanic, but more extensive stripping has proved it to be a dyke about 15 feet wide and similar to many others that cut the anorthosite on Doré lake. The porphyry is less sheared in some of the more recent trenches and in them grades from quartz porphyry to quartz-feldspar porphyry. The walls of the dyke are irregular. A narrow, fine-grained dyke of the same type of rock occurs within 4 feet of its south edge.

The anorthosite in the 40-foot wide, northwesterly striking shear zone bordering the southwest side of the porphyry dyke is dark green, is cut by numerous, narrow, quartz veins, and is mineralized with sulphides. It resembles greenstone, and is difficult to distinguish from greenstone dykes that cut the anorthosite in the vicinity of the mineral showings. The sheared anorthosite is now composed of aggregates, in many cases with fairly regular boundaries, and veinlets of chlorite, of patches composed almost entirely of fine, flaky white mica, and of areas of the two minerals intermixed. A small percentage of fine-grained carbonate is scattered throughout. The alteration exhibited by the anorthosite is attributed to mineralizing solutions that were associated with the dark quartz veins and the disseminated sulphides. The sulphides are pyrite and chalcopyrite. A little cobalt bloom was collected, but the cobalt or cobalt nickel mineral of which it is a weathering product has not been identified. In two minor zones, respectively 7 feet and 3 feet wide, the quartz veins form 40 to 60 per cent of the rock mass, but in other parts the quartz veins form a much smaller proportion. In the 7-foot zone the sulphides form 10 per cent of the mass, but in places form as much as 50 per cent. The mineralization is usually closely associated with the dark vein quartz which in places shows shattering. Narrow stringers of sulphide and disseminated particles of sulphide are present in the dark chloritized country rock. The sulphides are in places largely pyrite and in other places largely chalcopyrite. It is believed that the quartz and sulphide mineralization is contemporaneous, although the evidence from a study of polished surfaces of the ore is conflicting. One specimen shows a vein of pyrite 1 inch wide cutting across dark quartz. The pyrite and quartz are shattered and dark quartz fills the cracks in pyrite. A little chalcopyrite is scattered in grains within the crystals of pyrite composing

[1] Geol. Surv., Canada, Sum. Rept. 1927, pt. C, pp. 15-17.

the vein and is also associated with the quartz filling the cracks in the pyrite. Chalcopyrite and pyrite are found along the fracture zones in the adjacent dark quartz.

Light green anorthosite is exposed for 70 feet south from the 40-foot mineralized shear zone. Within this rock 50 feet south of its north edge is a prospect shaft sunk on a mineralized zone 70 feet long, striking north 80 degrees east and dipping vertically. The width of this zone varies from nothing to 6 feet. Some shearing continues from the two extremities of the zone, but is unmineralized. The mineralization in the zone is roughly banded. In the shaft, within a few feet of the surface, it consists of 2 feet of dark glossy quartz containing up to 80 per cent of chalcopyrite, followed on the north by 3 feet of black, chloritized, sheared anorthosite with disseminated pyrite and chalcopyrite. When visited in 1927 the shaft was filled with water to within 8 feet of the surface. Down to water-level the mineralized zone was seen to widen slightly. It is understood that this slight widening continues to the bottom of the 26-foot shaft where the width is stated to be 6½ feet. Polished sections of material from the shaft show that the relationships of the sulphide minerals and the dark quartz are much the same as in the mineralized zone to the north. The pyrite, chalcopyrite, and quartz are believed to be essentially contemporaneous, although chalcopyrite is slightly the latest.

The Quebec Bureau of Mines report for 1928 (page 42) states that "a series of eight samples taken near the bottom of the shaft in 1928 by Capt. J. G. Ross gave an average value across a width of 6 feet of $12.10 in gold and silver, and a total average value of $19.14 per ton for gold, silver, and copper."

Consolidated Chibougamau Goldfields, Limited, in 1934, stripped the anorthosite southwards from the old prospect shaft and disclosed a third extensively mineralized zone about 75 feet south of the shaft. This third zone extends in an easterly direction parallel for a part of its length to the shaft zone, but swings southward and converges with the main northwesterly-striking shear zone, which extends at an angle across the whole width of the point of land at the entrance to Cedar bay. The point of convergence of the two zones lies 250 to 275 feet east-southeast of the old shaft. The main shears in the third zone trend easterly, though joints and small shears cross the main shearing almost at right angles. The third zone has been stripped and trenched for about 600 feet. The mineralization diminishes to negligible proportions at either end of the 600-foot section. The mineralization in the third zone is like that in the other zones but is heavier. The most important parts of this zone lie south and southeast of the old shaft where widths of 25 feet or more heavily mineralized with pyrite, chalcopyrite, and quartz occur. The rock between the shaft and the zone is also mineralized along numerous fractures. Some samples taken across this zone are reported to carry much higher, and others lower, gold values than the samples from the old shaft.

A small shear zone, mineralized in places with bunches of nearly pure chalcopyrite carrying large, perfectly formed crystals of pyrite, has been uncovered near the eastern end of the point about 140 feet northeast

of the main, northwesterly trending shear zone. This shear zone strikes north 60 degrees west approximately parallel to the main shear zone. The gold values in this zone are reported to be negligible.

Other stripping and trenching have been done on the northwest side of the bay that lies north of the point on which the main showings occur. These trenches disclose the extension of the main northwesterly shear zone at two points 875 and 975 feet northwest of the old shaft, and show that the zone continues along the same strike for at least this distance northwestwards. When visited the trenches were filled with water, but the sheared rocks are reported to be practically unmineralized. The trenches also disclose another small shear zone 130 feet southwest of the main zone and parallel to it. In the southwestern end of the trench that lies 875 feet northwest of the old shaft, the smaller shear zone is mineralized across a width of 4 feet; similar mineralization is present in a pit 50 feet southeast. It consists of quartz stringers and small amounts of chalcopyrite, a little pyrrhotite, and probably pyrite; mineralization extends along narrow fractures from the 4-foot width into the adjacent wall-rocks.

Immediately on taking over the property in September, 1934, the Consolidated Mining and Smelting Company started to sink a 500-foot prospect shaft, at a point 100 feet west of the old shaft.

Chibougamau Prospectors, Limited

Chibougamau Prospectors, Limited, in the summer of 1929, uncovered chalcopyrite and other mineralization on a group of claims held by them north of Cedar bay, lake Doré. The showings are about ½ mile due north of the head of the bay, in, and just north of, the anorthosite. They occur at the southern margin of the wide belt of carbonated rocks that extends westward from Doré lake. They are best reached by a trail ¼ mile long, which leads northeast from the Doré-Gilman Lakes portage at a point ⅝ mile from Doré lake.

In the southeastern part of the explored area a chalcopyrite showing is disclosed by 350 feet of stripping and trenching in a direction north 20 degrees east, by a test pit 60 feet from the north end of these workings, and by some nearby rock trenches and strippings. The rocks exposed 100 feet south-southwest of the pit are anorthosite or anorthositic gabbro, somewhat crushed and altered to chlorite. They are cut by a narrow "greenstone" dyke that strikes south 80 degrees east and dips vertically and is displaced by small cross faults. The rocks at this point are also cut by a 5 to 12-inch wide, magnetite-rich vein containing a little chlorite. The vein strikes about north 35 degrees east, dips vertically, and is also displaced by small cross faults like the dyke. The rocks north of the anorthosite and associated rocks to the end of the workings 60 feet north of the pit are heavily carbonated, but are believed to have been a phase of the anorthosite. From a point 90 feet south-southwest of the pit to a second point 30 feet north-northeast of it, discontinuous, narrow lenses, or wedges, of sulphides having a general strike of north 10 to 18 degrees east are partly exposed. In the southwestern half of this zone they are 6 to 15 inches wide, dip about 60 degrees to the west, and contain about

50 per cent fairly coarse pyrite. Two larger lenses, composed of about 40 per cent pyrite, 30 per cent chalcopyrite, and 30 per cent calcite, occur near the pit. One, lying a few feet east of the pit, is 12 feet long and 3 feet wide, ends abruptly to the north, and passes under drift to the south. The foot-wall is apparently a slip plane striking north 18 degrees east and dipping 55 degrees to the west. A curving slip plane with a more easterly strike but a similar dip occurs in the hanging-wall and may account for the ending of the sulphide body. The second larger lens is 15 feet north of the pit and about 8 feet west of the strike of the first one. It is a wedge-shaped body about 12 feet long and 2 feet wide. The north end is pointed and the south end hidden by drift. It strikes in the same direction as the other larger lens; its foot-wall dips 65 degrees to the west. Just west of the second described lens are slip planes in the rocks that strike north 40 degrees east and dip 85 degrees to the east. Forty feet south of the pit the mineralized zone is crossed by shatter planes along which there is no appreciable displacement. They strike north 85 degrees east and dip vertically. Sixty feet south from the pit a vein 6 inches wide and bearing pyrite and chalcopyrite joins the main mineralized zone from the southwest. This vein has a length of 35 feet, strikes north 55 degrees east, and dips vertically.

The shapes of the sulphide bodies in the main zone are in large measure due to sinuous fault planes that apparently parallel the various sulphide lenses. It is known that short drill holes, sunk close to the test pit, did not pick up ore. The northern part of the exposed zone appears to be the more promising section, but to determine the locality most favourable to the possible occurrence of bodies of value still requires much careful work on the probable strike, dip, and pitch of the original sulphide bodies, and the direction of the subsequent fault movements. Such work involves careful exploration and mapping. It has not yet been demonstrated that the wedge-shaped mineralized bodies now exposed are faulted sections of a large body or bodies, but those in the main zone are probably parts of one original body. Some of the evidence suggests that at least the chalcopyrite-rich mineralization is later than the approximately east-west shattering and shearing that affected the rocks in this locality.

Seventy-five feet north of the test pit is the south end of a 500-foot trench that trends north 25 degrees west. Bedrock is exposed over most of its length, and with the exception of a 3-foot width of what appears to be an altered feldspar porphyry dyke, consists of iron carbonated rocks. These along the south part of the trench are believed to have been originally phases of the anorthosite, whereas those to the north are thought to have been volcanics. One hundred feet from the north end of the trench is a 4-foot wide zone containing 70 per cent of fine to coarse pyrite, and striking about south 70 degrees west and dipping vertically. To the westward on the strike of this zone five short cross trenches were dug at intervals over a length of 400 feet. In the first three trenches this zone is not present. Its possible continuation may be indicated by a 6-foot wide pyritized zone (80 per cent pyrite) in the fourth trench 350 feet west, and by a 20-foot wide pyritized zone (20 per cent pyrite) in the fifth trench, 400 feet west of the 500-foot trench. If

these two zones are parts of a single, unfaulted body, its strike is east-west. Fifty feet south of the fifth trench is the north end of a trench 100 feet long and trending south 50 degrees east. The rock across a 50-foot width in the north part of this trench contains about 30 per cent pyrite, occurring both disseminated and in veinlets. Siderite veinlets are also common. In these trenches the country rock appears to be highly carbonated (iron carbonate) volcanics. In the last three trenches strong east-west shears with a vertical dip are common, and it is possible that the sulphides uncovered in them are parts of one faulted body.

Consolidated Mining and Smelting Company of Canada

On the shore and a short distance back of the shore, on the west side of Cedar bay about ½ mile from its head, trenching was carried out in 1930 by the Consolidated Mining and Smelting Company of Canada, on a mineralized shear zone that strikes 25 degrees south of east. Much carbonate is disclosed and veinlets rich in chalcopyrite are sparingly present over narrow widths. In the workings 300 feet west of the shore the carbonization and mineralization are much less intense than in the trenches close to the shore. A little vein quartz is present, though the chalcopyrite here is apparently associated with calcite. The veins appear to be later than the siderite that has impregnated the wall-rock. The wall-rock is an altered phase of the gabbro marginal to the anorthosite.

Dumonde's Showing

The Dumonde showing on the middle of the east side of Cedar bay was studied by Mawdsley in 1927. The rocks that were believed at that date to be volcanics engulfed in anorthosite are now considered to be altered gabbro phases of the anorthosite, and altered fine-grained diorite dykes ("greenstone" dykes). Later work has not disclosed anything new regarding the amount or nature of the sulphide mineralization present.

Bedrock is exposed in a 120-foot trench along the water's edge. In detail from north to south the rocks exposed are: 6 feet of anorthosite; 1 foot of dark, chloritized anorthosite; 3 feet of similar rock slightly mineralized, the mineralization being similar to, but less intense than, that in the main mineral zone; a "greenstone" dyke 27 feet wide, containing near its south margin a few, small gash-veins of quartz, some of which are mineralized with a little, coarse pyrite and epidote; 6 feet of dark green, chloritized rock (anorthosite) cut by quartz-sulphide veinlets; 6 feet of a similar chloritic rock containing imperfectly banded quartz, calcite, siderite, chlorite, a little magnetite, and an average of 20 per cent of pyrite and chalcopyrite and constituting the main mineralized zone. This zone strikes 35 degrees south of east and dips, apparently, 75 degrees southwest. The mineral zone is flanked on the south by 36 feet of green, chloritic rocks that are cut by a few barren quartz veinlets and that exhibit at one place structures similar to those of volcanic rocks. These chloritic rocks are believed to be altered anorthosite and anorthositic gabbro cut by a narrow greenstone dyke. They give place to altered anorthosite in the southern part of the trench.

6674—7½

About 300 feet southeast of the shore, a trench 150 feet long and trending southwest, not seen in 1927, was examined in 1930. The northeastern 60 feet is probably on the strike of the mineralization on the shore but was filled with water and debris. The rest of the trench discloses a dark, dioritic-looking rock, occasionally containing knots of altered feldspar phenocrysts. It is undoubtedly the anorthositic gabbro. Part of this rock is heavily impregnated with siderite. A horizontal vein of glassy quartz, a few inches wide, was seen, but no sulphides were noted.

PROULX BAY, DORÉ LAKE

The Steel-Fortune Mining Syndicate worked a group of eleven claims just northwest of Proulx bay, lake Doré, near the east boundary of McKenzie township. The first work was done in 1926. Various small mineral showings are present, though so far no assays of interest have been obtained.[1]

The rocks have been trenched for 20 feet and stripped on claims Q1412, near the northeast corner of the group, a little over ½ mile northwest of the head of Proulx bay, on the high, rocky area west of the portage between Doré and Bourbeau lakes. The trench is approximately 500 feet north of a band of basic intrusives, which at this point has a width of about 3,000 feet. The rock in the workings exhibits structures that vaguely resemble those of a rock having poorly developed pillows, and is probably a fine-grained trachyte. It is highly altered to epidote or zoisite that in places forms about 90 per cent of the rock.

The rock is cut by narrow veins and veinlets of glassy quartz containing sulphides, and the sulphides also occur in the wall-rocks. Across the whole width of mineralized rock the sulphides total between 5 and 10 per cent. They consist of pyrite and chalcopyrite distributed in varying relative amounts, but the total amount of pyrite exceeds that of chalcopyrite. A little magnetite in the form of small octahedrons and also occasional flakes of mica are present. The glassy nature of the quartz and the occasional presence of mica indicate a high temperature type of deposit. In the immediate vicinity there are a few dykes of quartz-feldspar porphyry, most of which are narrow, although one is known to be 20 feet wide.

About a half mile west of this showing, a series of workings on claim Q1393 consist of widely spaced pits and strippings. These expose volcanics over a north-south length of 500 feet and what appears to be a single zone of mineralization. In the southern showing, a width of 8 feet of the volcanics is cut by ramifying veinlets of glassy quartz that form 50 per cent of the rock. One hundred feet farther north a similar zone, 2½ feet wide, dips vertically. In these two places some calcite, pyrrhotite, chalcopyrite, and sphalerite are present with the quartz. Farther north the mineralization consists of narrow widths of barren or almost barren quartz.

On the southeasternmost claim, Q1402, 2,000 feet south of the southernmost exposure of the 500-foot zone described above, a north-south trench, 25 feet long, cuts across a gossan-covered outcrop. The southern

[1] Bureau of Mines, Quebec, Ann. Rept., pt. A, pp. 67-69 (1929).

10 feet of the section exposed in the trench appears to consist of a basic andesite that contains a small percentage of pyrite. The andesite is followed on the north by a vertical bed of volcanic fragmental, 5 feet wide and striking a little north of west. The matrix is replaced by fine-grained pyrite that forms 30 to 70 per cent of the total rock mass. The rest of the trench is in drift and gossan-stained rock. A few calcite stringers and what appear to be fine silicified stringers cut the outcrop.

SOME OTHER MINERAL SHOWINGS ON DORÉ LAKE

On the northwest shore of lake Doré, 3,000 feet southwest of the point where the McKenzie-Obalski township line crosses the lake, work was done in 1929 by the Northern Investment and Mining Company on some sulphide mineralization. This mineralization was presumably first uncovered by John Kokko in 1906-7 and was examined by the Chibougamau Commission.[1] The country rock is somewhat shattered anorthosite in contact on the west with a fine-grained "greenstone," presumably part of a dyke. The contact between these two rocks strikes north 15 degrees west and dips 65 degrees to the west. In the anorthosite 3 inches from this contact and paralleling it, is a pyrite-rich stringer 1 inch wide. About 15 feet to the east is the northwest end of a lenticular area of mineralized anorthosite that strikes southeast, dips 80 degrees to the northeast, is about 40 feet long, and is 6 feet wide in its thickest, central part. The lenticular area consists of sheared, chloritized anorthosite in which there are bands running rich in chalcopyrite and pyrite and containing minor amounts of pyrrhotite and colourless, granular quartz. Irregular calcite veinlets carrying some chalcopyrite fill fractures in the above material. One of three assays of material from this showing as reported by the Chibougamau Commission gave the following results: 0·32 ounce gold and 4 ounces silver to the ton, and 6·72 per cent copper.

Knoll island lies off the southwest end of Merrill island, is about 50 feet in diameter, and is so low that it is awash during high water stages. The somewhat sheared, chloritized, dark granite that makes up the island is cut by an irregular mass of glassy quartz from which there are a few, short offshoots. This mass trends northerly, is 50 feet long, and, where best developed, 12 feet wide. A little pyrite, chalcopyrite, and tourmaline are associated with the quartz. Although an unpromising looking showing, assays by three independent parties have shown high values in gold.[2] It was drilled through the ice by Prospectors Airways during the winter of 1933. The results obtained were disappointing. Islands to the south of Knoll island are formed of granite and those to the north of anorthosite. The mineral deposit is near the northern apex of a northward extension of the large body of granite to the southeast.

Two, large, loose blocks of glassy, white quartz lie on the north shore of a small island, about 3 miles south-southwest of Knoll island, near the west shore of lake Doré, in range V, Obalski township. They are 40 feet apart. Each is 8 to 10 feet in diameter. The quartz holds scattered

[1] Chibougamau Mining Commission Report, 1911, p. 207.
[2] Chibougamau Mining Commission Report, 1911, p. 210.
Mineral Resources, Can. Nat. Rys. 1926, p. 32.

masses of chalcopyrite and a little pyrite. Near the blocks at least six other pieces of similar quartz more than a foot in diameter were seen. The southwesterly moving Pleistocene ice-sheet probably moved these blocks from a vein that lies to the northeast, possibly beneath the lake. The outcrops near these blocks are of anorthosite.

The point, known as Machin, or Block A, point, and the adjacent ground on the east side of Doré lake, ¾ mile east of the mouth of Cedar bay, was explored under the supervision of Capt. H. A. C. Machin, in the early days of prospecting in the district. Breadths of a few inches of vein quartz and schist carrying chalcopyrite and pyrite, believed to be parts of one zone of mineralization, were uncovered in various short trenches spaced over a distance of 400 feet along the shore southward from the point. Some work was also done 600 feet east of the point, on the shore and for a short distance inland. Recent work in this locality has been concentrated at this latter place, and consists of stripping and trenching that intermittently expose an area 600 feet long in an east-northeast direction and 200 feet wide where widest. Nothing of economic importance has yet been uncovered.

The rocks underlying Machin point are chiefly recognizable phases of the altered gabbro marginal to the anorthosite. Some of the rocks contain as much as 80 per cent of feldspar crystals and approach anorthosite in composition. Others have the appearance of greenstone and may be in part dykes and in part fine-grained phases of the gabbro. Their original characters are masked by shearing that has a general strike of south 30 degrees east and by secondary iron carbonate.

Just north of the extreme northeast end of Doré lake, about ⅓ mile north of the northernmost of the two streams that discharge lake Chibougamau into lake Doré, work was done in 1906-7 by Capt. H. A. C. Machin on some quartz-sulphide mineralization, on the surveyed claim designated as Block H. The workings are now caved and little can be seen. Originally, strippings and two pits disclosed vein quartz and schist carrying sulphides, over widths of as much as 12 feet. Assays of these materials made for the Chibougamau Commission yielded low values.[1]

Prospecting by E. Taylor, in 1934, 1 mile north-northwest of the mouth of Kokko creek, disclosed sulphide mineralization and a quartz vein in greenstone. The gold values present are reported to be unimportant.

PORTAGE ISLAND

Mineralization, consisting either of sulphides, or of quartz, or of both together, is present at several locations on Portage island. It is exposed in natural outcrops along the north and southwestern shores of the island and in trenches, stripping, and other workings in the interior.

On the north shore of the island, 1 mile west of Northeast point, a mineral zone, 4 feet wide, occurs in the volcanics on the north side of a deep bay, immediately south of granite outcrops. The zone strikes easterly, dips vertically, and consists largely of magnetite and dark chloritized material, but also contains small lenses of glassy, granular quartz, and

[1] Chibougamau Mining Commission Report, 1911, pp. 204-5.

veinlets of chalcopyrite and pyrite. Between the deep bay and Northeast point, the greenstone is cut at a few places by narrow veins of calcite with a little quartz, and by others of pyrite with quartz and specularite.

From Northeast point southwestward along the southeast shore of the island, the rocks for a distance of 1,800 feet are highly altered but appear to be volcanics. Altered gabbro and related rocks are exposed for 3,000 feet southwestwards from the volcanics. This 4,800-foot section of volcanics, gabbro, etc., exhibits at a few places narrow zones mineralized with pyrite and magnetite; more rarely narrow veinlets of quartz occur.

At Copper point anorthosite is shattered and mineralized with chalcopyrite, pyrrhotite, and pyrite. The sulphides occur in veinlets and also disseminated in the rocks adjacent to the veinlets. The mineralization is exposed by stripping and trenching over an area approximately 30 feet in diameter. It is irregularly distributed, lacks any definite trend, and nowhere is it concentrated in amounts of economic importance. The relative amounts of the three sulphides vary. Some veinlets are almost pure chalcopyrite with a very little granular quartz. The Chibougamau Commission report that selected samples of chalcopyrite assayed 0·12 ounce of gold and 1·34 ounces of silver a ton; and that selected samples of pyrrhotite carried gold 0·06 ounce and silver 0·33 ounce a ton, and nickel 0·48 per cent.

Workings generally referred to as the McKenzie gold mine lie a little north of west and at a distance of about 1,500 feet from Copper point. The deposit at this place was discovered by Peter McKenzie in 1904, and is the oldest recorded gold discovery in the district. Work on this property, consisting of twenty-five cuts and pits and a shaft 35 feet deep, was completed prior to 1910 and no further work has been done. Caving of the workings and vegetation has concealed much of the vein material and enclosing wall-rocks visible in 1910 at the time the property was examined by the Chibougamau Commission and described in their report. The workings lie on the south slope of the high ground that forms the northern part of the island and are 125 feet above lake Chibougamau. Rocks in the vicinity of the workings are altered gabbroic rocks that are marginal to anorthosite. Along the borders of the quartzose deposits occurring on the property the rock is sheared to a schist that in places is contorted, though in general the schistosity conforms in strike with the mineralized zone and dips steeply. The schist in places is high in chlorite; in others it is heavily impregnated with iron carbonate and weathers to a rusty gossan; and in still other places it contains an appreciable amount of pyrite, occasionally with some chalcopyrite. The original nature of the schist is in doubt, the rock probably has been derived from a basic intrusive rock but possibly was a volcanic. The quartz occurs in lenses, spurs from the lenses, and stringers. It is a white to light grey, and holds fragments of schist, and varying amounts of pyrite and chalcopyrite. The amount of chalcopyrite is usually low, the pyrite predominating. Specks of free gold have been noted in the quartz and gold has been panned from weathered sections of the sulphide-bearing parts. A bulk sample from this deposit, assayed by the commission, yielded 0·07 ounce of gold to the ton, 47 per cent of which was free-

milling. One selected sample of granular pyrite from cells in quartz ran as much as 2·0 ounces in gold to the ton, but various other samples gave much lower returns. A little silver, as well as copper, is also present.

About ¾ mile west of the McKenzie mine and about 1,300 feet east-southeast of the middle of the southeast shore of the small lake in the middle of the island, is the westernmost working on a zone that has been trenched and stripped at intervals over a length of about 1,500 feet along an east-northeasterly direction. This work was done by the Obalski Mining Corporation and has uncovered some heavy pyrite mineralization in highly altered rocks carrying iron carbonates. These rocks are probably in part volcanics and in part altered gabbro. Feldspar porphyry, probably part of a dyke, outcrops northwest of the workings. The westernmost trench is 125 feet long and extends south 35 degrees east. The rock on the northeast side of this trench for a length of 25 feet from the northwest end of the trench is heavily impregnated with pyrite; the mineralization is much less intense on the southwest side of the trench. A little disseminated pyrite and a few quartz carbonate stringers that strike north 70 degrees east occur in the trench southeast of this pyrite-bearing zone. Other trenches dug at intervals along a stretch of about 1,000 feet extending northeast from this trench also expose pyritized rocks, some of which carry a little calcite and magnetite. In one of the more easterly of these trenches a band about 20 feet wide consists in part of massive pyrite and in part of country rock carrying disseminated pyrite. Small masses of chloritized material are also present.

Another mineralized zone lies about 2,000 feet a little south of east of the above workings and about 2,000 feet north of the camp site on the southeast shore of the island. It strikes 10 degrees south of east and is exposed for 300 feet in cross trenches at 50-foot intervals. The country rock is for the most part massive and dark and resembles phases of the Cachée Bay complex. The three westernmost trenches disclose no mineralization. In the trench 150 feet east of the west end of the zone, a wedge-shaped body of quartz with a maximum width of 1½ feet is poorly exposed. It contains a little calcite and chalcopyrite. In the trench 50 feet farther east, a quartz vein carrying less chalcopyrite strikes east, dips 20 degrees south, and has a width of a foot. It is cut off to the west by a slip striking 40 degrees south of east and dipping 10 degrees southwest. In the same trench, at a point 23 feet farther south, another quartz vein with the same width and mineral content as the northern of the two veins strikes east 60 degrees south and dips about 10 degrees southwest. The three quartz bodies in these two trenches may be parts of one faulted vein.

BEAR BAY

A sulphide replacement deposit consisting of masses of pyrrhotite with a little chalcopyrite and pyrite occurs along the contact of the volcanics and serpentine 2,000 feet south of Bear bay, on claims held in 1934 by Noranda Mines, Limited, and Consolidated Chibougamau Goldfields. The deposit was thoroughly explored by trenching and drilling in 1929-30 by Dome Mines, Limited.

The volcanics consist largely of massive to schistose greenstone, but include finely banded, silicified "rhyolite," fine-grained, highly altered diabase, and, more rarely, thin bands of fragmental rocks. They strike easterly approximately parallel to their contact with the serpentine and dip steeply north. The serpentine forms a marginal zone about 1,000 feet wide along the north side of the anorthosite mass. It contains abundant, small, irregular pods and veinlets of magnetite. The contact between the volcanics and the serpentine lies on the south side of the crest of Sorcerer mountain. This mountain or ridge rises abruptly from the south shore of Bear bay to an elevation of 500 feet above the lake. The precise location of the contact is obscured by mineralization. The volcanics and probably the serpentine are cut off westward by granite that is exposed along the lake shore for 2,000 feet southward from the mouth of Bear bay and for 500 feet inland. The mineralized zone seems to end abruptly at the granite, although small stringers of pyrite are present in porphyritic phases of the granite near the apparent western termination of the zone. A narrow quartz porphyry dyke, striking northeasterly, cuts the volcanics on the bare, highest knob of Sorcerer mountain but stops at the serpentine contact. Narrow, mineralized fractures cross the dyke in an easterly direction parallel to the mineralized zone. It is probable that faults striking northeasterly disrupt the volcanic-serpentine contact. Their presence is suggested by the following features: depressions across the ridge 500 feet east and 1,500 feet west of the bare, high knob, mentioned above; an apparent slight offset of the contact near these depressions; and slickensided fractures apparent in the sulphides in some of the trenches and in drill cores from this zone.

The mineralized zone has been uncovered in eight trenches, each 100 feet or more long, and spaced over a distance of about 1,700 feet extending eastward from the edge of the body of granite. The most westerly trench lies 500 feet inland at the base of the western slope of Sorcerer mountain; the succeeding trenches to the east lie along the centre of the ridge and the most easterly trench is almost due south of the head of Bear bay. The deposit has been tested by drilling five holes, ranging in length from 377 to 1,073 feet, on the north side of the ridge. Brown, heavily rust-covered outcrops indicate that the mineralization extends eastward from the trenches for a further distance of ½ mile, the total length of the mineralized zone being at least 4,000 feet and possibly more. The mineralization is not of uniform intensity throughout the zone, since the sulphide replacement is bunched in lenses separated by sparsely mineralized intervals.

A section across a pyrrhotite-rich part of the zone is exposed in one of the most easterly trenches, about 850 feet west of the high, bare knob on the ridge. It consists from north to south as follows:

	Feet
Greenstone with sparsely disseminated pyrrhotite, some pyrite, and a little chalcopyrite; cut by narrow, irregular seams of pyrrhotite and chalcopyrite; and containing occasional bands, 1 to 3 inches wide, of pyrite. Dip 65 to 85 degrees north	30·0
Greenstone containing 25± per cent disseminated pyrrhotite, and bands, 1 to 4 feet wide, of nearly pure pyrrhotite with large pyrite cubes; in places, considerable actinolite and a little chalcopyrite are present	20·5
Pyrrhotite, containing in places 25 per cent greenstone and a little chalcopyrite	19·0
Serpentine and greenstone with 25 to 50 per cent disseminated pyrrhotite and pyrite	30·5
Concealed	18·0
Serpentine and magnetite, partly replaced by pyrrhotite	31·0
Concealed	5·0
Serpentine and magnetite	30·0

The chalcopyrite content of the mineralized zone is low everywhere and in the trench section described above probably does not average more than 1 to 2 per cent across any appreciable width. A little sphalerite accompanies the other sulphides in a few places. Very little if any quartz appears to have been introduced with the sulphides, although 1,100 feet east of the trench on top of the high bare knob a small quartz vein, 1 foot wide, lies along the strike of the mineralized zone. The more characteristic mineral introduced with the sulphides is actinolite.

Drill cores exhibit the same general type of mineralization at depth along the volcanic-serpentine contact as is seen at the surface. They show clearly that the mineralization is not confined to the volcanics, but occurs also in the serpentine for many feet away from the contact. In drill hole No. 5 the volcanic-serpentine contact was reached between 569 and 571 feet. Between depths of 500 and 602 feet in this hole the rocks are pyritized. The pyrite occurs, in disseminated form, comprising up to 25 per cent of the rock, and occasionally as nearly pure bands 2 feet or more wide. Pyrite in disseminated form and as a bed 3 to 4 feet or more wide, occurs in the most western trench near the granite. The pyrite-bearing rock in this trench probably belongs to the pyritized zone cut in drill hole No. 5, which was put down a short distance north of this trench.

A sample taken from this deposit is stated in the report of the Chibougamau Commission (page 214) to have assayed: gold and silver, a trace; copper, none. One horizon is reported by prospectors to contain gold, but it is not known to the writers.

Taché Lake

A sulphide replacement deposit comparable with that at Bear bay, occurs 800 to 1,000 feet south of the southwestern end of Taché lake. Like the Bear Bay deposit it consists largely of pyrrhotite and lies along the outer contact of the basic intrusive rocks that border the northern margin of the anorthosite. It is probable that similar mineralization is developed along the northern margin of these basic rocks east of Taché lake.

The Taché Lake mineralized zone strikes about south 60 degrees west, and is broken into two parts by a cross-fault striking north 30 degrees east. The eastern part of the zone has a length of about 700 feet and is exposed in seven trenches spaced at intervals of about 100 feet. It extends from the cross fault to the portage that leads south from Taché lake. The most easterly trench exposing this part of the zone is situated on the portage at a point 1,000 feet south of the lake. The few trenches east of the portage disclose little mineralization. The western part of the zone is offset 500 feet to the north along the cross-fault and is cut off westward by the Taché Lake fault. It lies along the top of the high hill 800 feet south of Taché lake and has been trenched at a few places on this hill.

The mineralization occurs in massive, chloritic rocks whose original nature is unknown. The rock along the south side of the mineralized zone and in places within the zone contains rather abundant, irregular pods of magnetite. The magnetite-bearing rocks are believed to be highly altered, pyroxene-rich gabbro forming a border phase 500 to 600 feet wide along the northern margin of the anorthosite. They are lithologically similar to rocks closely associated with the magnetite-bearing serpentine north of Magnetite and Bag bays, which also lie along the northern border of the anorthosite. The chloritic rocks immediately north of the magnetite-bearing rocks on the Taché Lake portage include altered, fine-grained diabase impregnated with considerable apatite. The chloritic rocks on the north side of the high hill west of the portage are inferred to have been medium-grained gabbro and greenstone, but they are now highly altered and sheared.

The mineralization consists largely of pyrrhotite occurring in veinlets and disseminated in the country rock. The chalcopyrite content is slightly higher than that in the Bear Bay deposit and in places forms 5 per cent of the rock. The chalcopyrite occurs as tiny, irregular seams with the pyrrhotite and in places with quartz and pyrrhotite in small veinlets. As in the Bear Bay deposit actinolite is present in places with the sulphides.

Many of the trenches do not expose rock throughout. In the trench 250 feet west of the portage the mineralized zone has a width of at least 25 feet and consists of 25 to 50 per cent pyrrhotite with some chalcopyrite. Similar but less heavy mineralization occurs in trenches in the eastern part of the high hill that lies south of the lake. The rocks there are highly sheared and the constituent sulphides and magnetite in places are drawn out into streaks.

Rapid River

A mineralized zone occurs in the volcanics on Rapid river, 3,000 feet west of the Roy-McCorkill township line. The zone can be followed for about 250 feet along the river to where it passes westward under water, and has been stripped at one point on the north bank. The volcanics consist partly of massive greenstone and partly of finely banded, siliceous rocks. Their cleavage planes strike north 70 to 75 degrees east, and dip 80 degrees south. They are flanked 100 to 200 feet to the north by a serpentine-pyroxenite intrusive. The mineralized zone follows the strike of the cleavage. At the stripping the volcanics across a width of 20 feet

are heavily stained due to the weathering of sparsely disseminated sulphides, but the mineralization is moderately intense only across a width of 6 feet. The sulphides are principally pyrrhotite, with a little pyrite, chalcopyrite, and probably sphalerite. One hundred feet west of the stripping a quartz porphyry dyke outcrops on the north side of the river, but whether it cuts across the mineralized zone is not certain. The dyke is accompanied by barren stringers of glassy quartz that strike at right angles to the mineralized zone.

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