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GERIDO LAKE - THEVENET LAKE AREA, NEW QUEBEC

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GEOLOGICAL REPORT 104

GERIDO LAKE - THÉVENET LAKE AREA

NEW QUEBEC

by

PIERRE SAUVÉ AND ROBERT BERGERON

QUÉBEC

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GERIDO LAKE - THÉVENET AREA

NEW QUEBEC

by

Pierre Sauvé and Robert Bergeron

INTRODUCTION

General Statement

This report deals with the geology of five 15-minute map-areas centred some 45 miles due west of Fort Chimo, New Quebec, and covering approximately 780 square miles. The western halves of the Gerido Lake, Thévenet Lake, and Harveng Lake areas were mapped by Bergeron during the summers of 1953, 1954, and 1955 respectively, whereas the eastern halves of the Gerido Lake and Léopard Lake areas were mapped by Sauvé in 1954 and 1955. In this report, "the area" refers to these five areas combined, unless otherwise stated. Figure 1 shows the relative positions of the five areas, and their individual boundaries are as follows:

	Longitudes	Latitudes
Thévenet Lake area, west half	69°15'-69°30'	58°00'-58°15'
Gerido Lake area, east half	69°30'-69°45'	58°00'-58°15'
Gerido Lake area, west half	69°45'-70°00'	58°00'-58°15'
Harveng Lake area, west half	69°45'-70°00'	58°15'-58°30'
Léopard Lake area, east half	69°30'-69°45'	57°45'-58°00'

The area lies in the middle and eastern parts of the Labrador Geosyncline or Trough and is comprised of metasedimentary and volcanic rocks injected by sills of meta-gabbro.

The discovery of copper and nickel minerals in that part of the Trough southwest of Ungava bay, and including the present area, has led to active prospecting in recent years.

Access

All parts of the area are easily reached by floatplanes. A floatplane base is located at Stewart lake and is joined to the Fort Chimo air-strip by 3 miles of gravel road. Regular flights from Montreal and Roberval serve Fort Chimo. During the navigation season from mid-July to mid-October Fort Chimo can also be reached by ship.

The area may also be reached by canoe from Aux Feuilles bay and from Koksoak river. The latter is only 3 miles southeast of the Léopard Lake area. However, despite the numerous lakes, travel by canoe is difficult within the area because of the lack of navigable rivers. There are no roads in the area.

Field Work

The field mapping was done on a scale of two inches to one mile. Extensive use was made of vertical aerial photographs supplied by the Department of Mines and Technical Surveys, Ottawa. All rock exposures visited were plotted on a transparent tracing paper placed over the aerial photographs, and then transposed to base maps supplied by the Quebec Department of Hydraulic Resources.

For the most part, traverses were run in zig-zag lines at half-mile intervals across the trend of the rock formations. In areas of complex structure, the lines were spaced more closely. Most of the outcrops were visited. The larger ones were examined only in a few places and their limits were plotted from the aerial photographs. Only a few "pace and compass" traverses, as through the wooded valley in the southwestern part of the Léopard Lake area, were run.

A small, structurally complex area east of Rachel lake in the Thévenet Lake area was mapped in detail by Sauvé in 1958. Here, every outcrop was visited.

Outcrops are generally plentiful over the area, but in certain localities, they are scarce. The sedimentary rocks are commonly poorly exposed, except in parts of the east half of the Gerido Lake area.

Acknowledgments

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Previous Work

In 1893, A.P. Low (1895) made a reconnaissance traverse along the Koksoak river. During 1930 and 1931, parts of the area were prospected and a few sulphide showings were staked by the Cyril Knight Prospecting Company. Many of its claim posts are still visible. For a brief period in 1945, Frobisher Limited prospected the country near Gerido lake. More recent work done by exploration companies is reviewed below in the section on Economic Geology.

The only systematic work in the region was done by W.F. Fahrig (1955), of the Geological Survey of Canada, who mapped an area south of the 58th parallel on the scale of four miles to the inch during the summer of 1953; this mapping included the Léopard Lake area.

DESCRIPTION OF THE AREA

Settlement and Resources

Inhabitants

Eskimos live near the shores of Ungava bay, but during the winter, some Eskimo families move inland to hunt white or polar foxes. Remnants of winter camps were found in a few places in the area.

Indians of the Montagnais-Naskopi tribe generally live south of the 57th parallel. However, after the closing of the Fort McKenzie trading post in 1948, about 175 of them moved to Fort Chimo. In 1956 they moved to Schefferville.

The only settlement near the area is Fort Chimo, a Hudson Bay Company trading post founded in 1842. Fort Chimo also contains a detachment of the Royal Canadian Mounted Police, a post office, hospital, Department of Transport meteorological station, hotel, an Anglican mission, and a Roman Catholic mission.

Flora

Phytogeographically, the area is classified as Forest Tundra, that is, the northernmost part of the subarctic forest of coniferous trees where they grow in clusters along river banks, the shores of lakes, and in protected valleys. The dominant trees are black spruce and larch (tamarack). The only deciduous trees are a few varieties of willows and alders. Some species of herbaceous arctic plants also grow in the area.

"The real tundra begins in the territory between latitudes 58° and 59°. Its southern boundary forms a sinuous line which starts south of Portland promontory, on the east shore of Hudson bay, and passes slightly north of the major part of Aux Feuilles river and crosses it near its mouth" (Gilbert and Bergeron, 1957, p. 8).

Agricultural Possibilities

The agricultural possibilities are limited by the severe climate and the rocky or swampy nature of the ground. Experiments in sheep raising were started in 1955 in the Fort Chimo area and in some places along the Koksoak river. These have shown that sheep can survive through summer. During the same year, experiments were started in growing some varieties of cereal and vegetables at Fort Chimo.

Fish and Game

Game is scarce. The only fur-bearing animals seen in the area are otters, foxes, and black bears. Flocks of ducks, willow ptarmigans, gulls, and Canada geese inhabit the territory. Rough-legged hawks dwell on the abundant cliffs of the area. Snowy owls were numerous in 1956. However, in the other years between 1953 and 1958, they were seldom seen.

Fish are plentiful almost everywhere. The main varieties are grey (lake) trout, speckled trout, and arctic char.

Weather

The region has only two seasons, winter and summer. The average daily temperature rises above 32°F. for a period of about four months. The snow melts in late May and early June and the lakes are free of ice near the end of June. Regular nightly frosts start in late August or early September. In July and August the daytime temperature is usually between 60° and 70°F., but occasionally goes above 90°F. in July.

Meteorologists estimate the rainfall in the tundra as 10 to 20 inches. The rainy days are numerous, but heavy rainfalls are scarce. Thunderstorms are unusual.

Physiography

Topography

The ground near the area slopes gently and fairly consistently northeast toward Ungava bay. Thus, the divide between the waters flowing to Koksoak river and those flowing to Aux Feuilles bay or directly into Ungava bay is much closer to the river than to Aux Feuilles bay. The highest point in the area, 1,125 feet above sea-level, is in the Léopard Lake area in the south.

The lowest elevation, at the northern boundary of the Harveng Lake area, is less than 150 feet above sea-level. Although the relief is not high, steep slopes and cliffs are common. Many ridges stand 200 to 400 feet above the nearest valleys.

The main topographic features are a faithful reflection of the geological pattern, largely as a result of the contrasting hardness of the sedimentary and igneous rocks. Much of the area is broken by alternating ridges and valleys, coinciding respectively with bands of gabbro and argillites. High ridges are commonly underlain by thick sills or lava flows, low ridges by thin sills or, in some cases, by iron-bearing rocks or dolomite. The topography is low and rolling in the northern parts of the Harveng Lake area and of the Gerido Lake area (east half), and in a few other smaller areas. Thick sills and lavas are missing in these places. Near the Koksoak river, in the southern part of the Léopard Lake area, some gabbro sills form short, aligned ridges with steep, rounded ends. The ridge and valley pattern forms broad arcs at the nose of some large folds.

A striking topographic feature west of the middle of Gerido lake is a plateau 4 miles long and 2 miles wide, bounded for the most part by almost vertical cliffs. It is composed of volcanic and intrusive rocks overlying argillites.

Drainage

There are innumerable lakes and ponds in the area. Small ponds are common on broad, rocky ridges. Many have no inlet or outlet, and partly or completely dry out during the summer.

The streams are small since the area straddles the water divide between the drainage basins of the Koksoak river and of Aux Feuilles lake - Aux Feuilles bay. The outlets of Gerido, Harveng, Rougemont, and Thévenet lakes, and Robelin creek in the southwestern part of the Léopard Lake area, are among the largest streams.

Most of the area drains northward to Aux Feuilles bay. However, parts of the Thévenet Lake, Léopard Lake, and Gerido Lake areas drain southward to the Koksoak.

GENERAL GEOLOGY

PRECAMBRIAN

Regional Setting, Age

The area lies in a folded belt of slightly to moderately metamorphosed sedimentary and volcanic rocks known as the "Labrador Trough" or "Labrador Geosyncline". This belt extends in a southeasterly direction from north of Payne bay on the western shore of Ungava bay, to the southwestern corner of Labrador, or more than 500 miles.

The rocks of the belt are commonly referred to as "Proterozoic" or "Late Precambrian". However, this is based mainly on the lithology, the grade of metamorphism, and the fact that the rocks of the Geosyncline unconformably overlie a granitic, so-called "Archean" basement. Only a few age determinations have been published (Cummings, et al., 1955; Roscoe, 1957). These suggest an age greater than 1,500 millions of years for the rocks of the Geosyncline. Recent work by Beall and Sauvé (1960) suggests that regional metamorphism in the northern part of the Trough took place some 1,600 to 1,800 million years ago. Deposition of the rocks possibly occurred between 2,450 and 2,000 million years ago.

Near latitude 58°, the Labrador Geosyncline may be divided into two parts. The western part consists of sedimentary rocks. It is 6 to 8 miles wide at this latitude, but becomes wider to the south. At the western boundary, gently dipping rocks overlie unconformably a basement of granitic gneisses (Bérard, 1957). The greywackes and associated rocks in the southwestern corners of the Gerido Lake and Léopard Lake areas and the Abner dolomite and Chioak formation in the northwestern corner of the Harveng Lake area are in this western part. The eastern part, in which most of the present area lies, is some 30 miles wide and is bordered to the east by granitic gneisses that appear at three places along the eastern edge of the Thévenet Lake area. It includes sedimentary, volcanic, and basic intrusive rocks. The relationship between the rocks of the eastern and western parts is not known; the problem is briefly discussed below in the chapter dealing with structural geology. The grade of metamorphism clearly increases eastward and some of the gneisses lying east of the area are metamorphosed rocks of the same age as those of the Geosyncline (Sauvé, 1958). Some or all of the microcline gneisses in the Thévenet Lake area (west half) may be part of the crystalline basement of the Geosyncline.

KANIAPISKAU GROUP

Fahrig (1955a 1955b) and Roscoe (1957) use the term Kaniapiskau group for the rocks of the Geosyncline between latitudes 56° and 58°. The rocks of the present area are the same.

Western Part

Chioak Formation

The name "Chioak" comes from the Eskimo word "Shiogha' luk", which means coarse sand, and was coined by geologists working for Fenimore Iron Mines Limited along the western border of the Labrador Geosyncline. Bérard (1958) has studied the Chioak formation in the area west of Harveng Lake area. He described it as a horizontally and vertically variable sequence of conglomerates, sandstones, black and red argillites, shales, and chlorite schists.

A small patch of this formation occurs in the northwest corner of the Harveng Lake area. The few outcrops visible there consist of slightly contorted biotite-chlorite schists.

TABLE OF FORMATIONS

		Pleistocene and Recent	Till, sand, gravel, silt	
PRECAMBRIAN	INTRUSIVE ROCKS	(Western part)	(Eastern part)	(East of Rachel lake)
			Meta-gabbro, partly fresh gabbro, ultramafic rocks, quartz diorite, blotchy gabbro	Amphibolite, ultramafic rocks
	TROUGH ROCKS	<u>Kaniapiskau Group</u> Larch greywacke and subgreywacke Shale Abner dolomite Chioak formation Iron-bearing rocks	Thévenet formation 2000' Hellancourt volcanics 4500'± Baby formation Upper phyllite with quartzite 1500'± Iron-bearing member 150'± Lower phyllite 2000'(?) upper part with quartzite lower part without quartzite Harveng dolomitic schist	Mica schist and conglomerate Volcanic conglomerate Volcanic rocks Garnet schist Iron-bearing rocks Mica schist, garnet schist, staurolite schist, kyanite schist, quartzite Calcareous schist, actinolite-calcite schist and mica schist, kyanite and garnet schists Garnet schist Tremolite marble
		Pre-Kaniapiskau ?	(Basement rocks ?)	Microcline Gneiss

Abner Dolomite

This rock was named after Abner lake in the Bones Lake area (Bérard, 1957) by geologists working for Fenimore Iron Mines Limited. From Abner lake, the dolomite formation may be traced almost continuously to the northwestern part of the Harveng Lake area (Bérard, 1958).

The Abner dolomite overlies conformably the Chioak. The contact is marked by a thin interlayering of dolomite and biotite-chlorite schists. The estimated thickness of the formation is 400 feet.

The dolomite is dark grey, buff, or brown on fresh surfaces and buff on weathered surfaces. Individual beds range in thickness from a few inches to 6 feet, the average being one foot. The dolomite is usually cut by an intricate network of quartz veinlets giving the weathered surface a characteristic boxwork appearance. The rock is usually fine to medium grained and in some places contains much detrital quartz (up to 20%). The diameter of the carbonate grains varies between 0.05 and 0.6 mm. Granules of cryptocrystalline dolomite, 0.25 to 1.0 mm.long, have been noted in a few places in the sandy dolomites. Microcline, apatite, and zircon also occur in minor amounts.

Other Dolomitic Rocks

Dolomite is probably present below the alluvium at the southern boundary of the Léopard Lake area, half a mile west of the iron formation. It is not exposed in the area, but it outcrops half a mile south. This dolomite is rather pure and fine grained, and has a light grey to buff weathered surface. Bedding is well developed and is a few to several inches thick. It is highly contorted locally. This dolomite is similar to the Abner dolomite, but their stratigraphic relationships are not known.

Iron-bearing Rocks

Iron-carbonate rocks outcrop in the broad valley in the southwestern part of the Léopard Lake area.

In the group of outcrops about 1 1/2 miles southwest of Robelin lake, the formation consists mainly of quartz and iron carbonate beds interbanded with slightly ferruginous schists. Some schists are chiefly composed of two carbonates, quartz, and minor amounts of muscovite and chlorite. Carbonate beds are few in the western outcrops but become more abundant and thicker to the east. The rock is aphanitic and dark, and weathers to a dark purplish grey colour. A conglomerate member, several feet thick, overlies the iron carbonate rocks in one place. The fragments consist largely of iron carbonate, chert, and carbonate-bearing quartzite. They have been appreciably stretched with their long axes nearly parallel to the bedding. They are generally a few inches long, but some are more than 2 feet. The dark matrix contains iron oxide, iron carbonate, and quartz. A few feet of iron carbonate-bearing quartzite is exposed above the stretched conglomerate.

Table 1

Partial Chemical Analyses of Iron Carbonate Beds near Robelin Creek, Léopard Lake Area

Sample No.	S-93		S-94	G-143
SiO_2	31.48%			
Fe	23.04	"Soluble" Fe	23.10%	27.20%
CaO	1.70	" CaO	0.89	11.49
MgO	7.40	" MgO	5.79	8.46
MnO	2.38	" MnO	1.95	2.09
CO_2	23.08	CO_2	21.66	39.15

A few small outcrops occur near the southern boundary of the area. There, massive to well-bedded iron carbonate is interbedded with a ferruginous, schistose rock and some chert. The schistose rock contains much quartz and carbonate. The carbonate beds are bluish grey to black and weather reddish brown to dark purplish grey. They are crisscrossed by numerous quartz veinlets. What may be an intraformational conglomerate occurs in one outcrop. It consists of aphanitic, dark grey fragments of carbonate rock weathering dark purplish grey, set in a matrix of light grey, fine-grained (1mm.) carbonate weathering brownish red. The fragments are slabby, up to a few inches long, and generally less than 1/4 inch thick.

Although the only exposures are non-magnetic carbonate rocks, the presence of many strong magnetic anomalies suggests that magnetic iron-bearing rocks may underlie part of the valley.

Larch River Formation

Greywackes and possible subgreywackes are interbedded with minor slates or argillites in the southwest corners of the Gerido Lake and Léopard Lake areas. They are part of a group of rocks termed Larch River formation by geologists of Fenimore Iron Mines Ltd. The formation is poorly exposed and highly sheared in the Gerido Lake area, but is well exposed and generally well preserved in the Léopard Lake area. In the latter, some of the greywacke beds are up to 20 feet thick, although most are from 3 inches to 3 feet thick. Some beds show faint graded bedding. Fine lamination, and possibly minute cross bedding, occur at the border of the greywacke beds, perhaps marking their tops. Concretions in the form of flat ellipsoids,whose long axes are generally shorter than 12 inches, are common in the cleaner types of sandstones. The long axes are commonly parallel to the bedding, but in some cases they show a preferred orientation at a small angle to it. The bedding is perfectly preserved within some concretions and is undisturbed at this boundary. The concretions contain a rather small proportion of carbonate cement, but the surrounding rock contains much less. The concretions form pits on the weathered surface. Cleavage is mainly absent or poorly developed in the greywackes, and alternating beds of uncleaved greywackes and good slates are common.

The argillites and slates are aphanitic and dark grey to greenish grey. The greywackes and possible subgreywackes are, in part, of lighter colour. Dark quartz grains, 1 to 2 mm. in diameter, are visible to the naked eye. The clastic grains, mainly 0.1 to 0.5 mm., are made of quartz, feldspar, and chert with some volcanic and sedimentary rock fragments present. Muscovite and sphene are also detrital. Most grains are angular and show extremely poor sphericity. Sorting is variable, but is generally very poor. Chlorite, sericite (illite), epidote, carbonate, and pyrite are present in the matrix. The matrix is generally submicroscopic and cannot be resolved under the microscope. The cleaner sandstones are more finely bedded and a lighter green than the true greywackes.

Phyllites

Phyllites occur east of the greywackes. They may be part of the Larch River formation but, in the area, they are easily separated from the greywackes, and may be faulted and of more than one age and formation. In the Léopard Lake area, the phyllites just east of the greywackes may lie stratigraphically below them. Across the valley, some phyllites dip with a moderate angle below the iron-bearing rocks.

The phyllites are mainly grey to dark grey. Black, probably carbonaceous, phyllites are common 7 miles north of the southwestern corner of the Léopard Lake area. Some phyllites nearer the same corner have small specks of pyrite and magnetite. Cleavage is everywhere well developed and bedding cannot be recognized in some places. The beds are generally tightly folded, the folds plunging gently either to the northwest or to the southeast.

Eastern Part

The stratigraphic sequence is fairly well known over much of the area and is outlined in the Table of Formations. The main exception, east of Rachel lake, is described separately. The sequence west of Gerido and Léopard lakes is also poorly known; these rocks are described after the Baby formation as they may be part of it.

Harveng Dolomitic Schists and Dolomites

The name Harveng is tentatively given to this formation after the area in which it was first observed. Although the formation is highly folded and its base not exposed, its thickness apparently exceeds 700 feet.

The formation consists of dolomitic schists grading downward into sandy and massive dolomite. It outcrops within a small anticlinorium striking north-northwest in the northeast corner of the Harveng Lake area.

The upper part of this formation consists of semi-schistose, fine-grained, light grey, dark grey-weathering rocks in beds 1 inch to 3 inches thick. The essential minerals are dolomite (50-60%), sericite (15-20%), quartz (15-25%), feldspar (3 to 5%), and biotite (1 to 5%). Rhombohedra of ferrodolomite are common and give a rusty colour to the weathered surface.

These rocks grade downward into thicker (2-6 inches) beds of fine-grained, light grey, reddish-grey-weathering dolomite. Some beds are entirely dolomite, but more generally the rock contains 10-20% of quartz.

The Harveng formation may or may not be a direct extension of the Abner dolomite. It differs from the Abner in being more sandy and free of crisscrossing quartz veinlets. Moreover, mapping by Bérard (1959) to the north of the Harveng Lake area has failed to establish any correlation between the two formations.

Baby Formation

This formation is named after Baby lake where, in part, it is well exposed.

The formation consists of three members. The lower member is made up of argillites, phyllites, and schists with numerous quartzite beds towards the top. At the base, phyllites grade downward into the Harveng dolomitic schists. The member occurs mainly in the Harveng Lake area and in the northern part of the eastern half of the Gerido Lake area. Although poorly exposed, except near Baby and Avoine lakes, and tightly folded, this member is thought to be 2,000 feet or more thick.

The middle member consists of iron-bearing rocks with minor phyllites, and is 100 to 150 feet thick. The upper member, roughly 1,500 feet thick, is made up of argillites, phyllites, and some quartzites. It is rather poorly exposed although it occurs at many places in the area, close to the volcanic formation.

The phyllites of the lower and upper members are similar and can only be differentiated by their position with respect to the middle, iron-bearing, member.

Pelitic Rocks The argillites and phyllites of these three members are generally grey or greenish-grey on the fresh surface and slightly paler on the weathered surface. Close to the iron-bearing member, some argillites are coloured in red or blue by minute amounts of disseminated hematite. A few black shales are present, especially in the uppermost part of the upper member.

Primary bedding is well preserved in many places. It commonly consists of fine laminations 1-3 mm. thick. Less commonly, the laminations are thicker, (1-3 cm.) without traces of finer lamination. Grain gradation has been observed in some of the thick laminae. Another type of lamination consists of rythmically alternating light and dark bands in which much finer laminations may be present. The thickness of these varve-like bands varies between 1/2 and 3 cm., but it is fairly constant within a single outcrop.

Cleavage, although well developed generally, is missing in some pelitic rocks. It is due to the alignment of small mica flakes distributed either throughout the rock or mainly along definite planes. The spacing of these planes varies from a fraction of one mm. to a few cm. but is generally small. Cleavage is normally much better developed in pelitic rocks distant from the contact of gabbro sills than in those found near the sills.

Under the microscope, the pelitic rocks are seen to be completely recrystallized into crystals which generally are a few tenths of one mm. in size. Quartz is present in all the rocks in small (0.01 to 0.1 mm.),anhedral, in part elongated, grains. It is commonly strained. Albite is present in all the phyllites and low-grade schists. Its grain-size is comparable to that of the quartz. Potash feldspar was not detected. Most of the quartz and feldspar grains are of metamorphic origin, but some may be detrital. Small garnet crystals occur near Thévenet lake.

Small muscovite flakes are everywhere present, except in the eastern part of the area where biotite locally takes its place. Biotite generally occurs in flakes that are easily visible to the naked eye. It shows random orientation in many cases. Much is pleochroic in yellowish (X) to deep brownish green (Z), but some is brown. Chlorite is a minor, but persistent, constituent. It occurs as flaky or irregular tiny crystals, a few hundredths of one mm. long. Its pleochroism is commonly marked from very pale yellowish (X) to olive green (Z). The optical direction X is perpendicular to the cleavage except in a few doubtful cases where the mineral is nearly isotropic. Where observed, its 2V is small and the mineral is optically negative. Birefringence is about 0.004 or less. Epidote is also a persistent mineral. Some grains have a brown core, apparently of metamict allanite. Equidimensional grains of carbonate appear in many rocks. Near the iron formation, the mineral is an iron carbonate and weathers to limonite. Some iron carbonate occurs in nodules, as much as 0.5 cm. in diameter. Apatite is present in small amount in many of the rocks. Tourmaline occurs in slender, microscopic prisms lying along the bedding or cleavage. It is found mainly in the pelitic rocks near the iron-bearing member, and is common, though not abundant, near Thévenet lake. Sphene is fairly common. Pyrite, magnetite, and hematite occur in many pelitic rocks adjacent to the iron-bearing member.

The argillites and phyllites consist mainly of quartz, albite, chlorite, and muscovite or biotite in variable proportions. Some rocks made essentially of quartz and feldspar may have been derived from fairly clean, fine-grained sandstones. On the other hand, laminae composed almost entirely of mica may represent former clay parting. Most argillites and phyllites are intermediate in composition between these extremes and were probably derived mainly from siltstones and fine, impure sandstones. The silica content of three samples chemically analyzed is between 52 and 64 per cent, which is about right for siltstones. Generally, argillites rich in chlorite are also rich in muscovite or biotite; these rocks must represent the finer-grained sediments. However, a few argillites and phyllites from the north end of Hellancourt lake contain much chlorite (roughly 25%) but less than 1% mica. Their potassium content is much less than that of the common argillites. They may be close in chemical composition to the lavas, although the lavas have a higher calcium content. They contain numerous granules made of chlorite and minor quartz. These rocks were possibly tuffs, but apparently are not abundant in the Baby formation.

Adinoles. The pelitic rocks at the contact of some sills have been changed into "adinoles" (Harker, 1950, p. 128). These rocks are composed in large part of albite, or quartz and albite, with minor amounts of the minerals commonly found in the argillites. Albite makes up more than 50% of some rocks. All gradations between quartz-albite-rich rocks and common argillites are found. The fine bedding is commonly well preserved in the adinoles. They are generally extremely fine-grained rocks with a good conchoidal fracture and a hornfels appearance. The types richest in quartz and albite are light grey and have a vitreous to greasy lustre.

Some adinoles are cut by thin veins of almost pure alkali feldspar; the feldspar has undulatory and irregular extinction and has refractive indices lower than those of the albite in the country rock. Some adinoles are "spotted", containing small, clearly-defined, white-weathering patches made of quartz, albite, and a minor amount of clinozoisite set in a matrix made up largely of these same minerals, plus some chlorite and leucoxene. The patches are about 1 mm. in diameter. Some are larger than the fine bedding and cut across it. Many undeformed patches have partly straight edges and are clearly pseudomorphous after some mineral, probably a contact-metamorphic one. The partial chemical analysis of an adinole is given in Table 2. Soda metasomatism has obviously been important in adinoles rich in quartz and albite. However, some of the coarsest-grained quartz and albite rocks look like, and may be, recrystallized, fine sandstones.

Table 2

Partial chemical analysis of an adinole,
1/2 mile south of Rougemont lake

SiO_2	65.82%		
Al_2O_3	16.64%		
Na_2O	7.57%	normative orthoclase	0.5%
K_2O	0.10%	normative albite	64.1%
CO_2	0.24%		
	90.37%		

Adinoles and hornfels are commonly found only a few inches from the contact of the sills. However, more than 20 feet of spotted adinole is exposed about one mile west-northwest of the south end of Rougemont lake, in a long sedimentary lens in a sill. Spotted adinole, a few feet thick at least, also outcrops 1/2 mile south of Rougemont lake and on the west shore of the long peninsula in the lake.

Quartzites. The quartzites of the Baby formation occur in units ranging in thickness from a fraction of an inch to 20 feet or more. Some of the thicker units are indicated separately on the maps. Outcrops of quartzite are fairly common at the following localities: near Rougemont and Archiac lakes in the Léopard Lake area; on the west shore of the southern part of Gerido lake, northeast of Bowen lake, on the small peninsula in Albert lake, and on the east shore of St-Pierre lake in the Gerido Lake area; and west of Baby and Avoine lakes in the Harveng Lake area.

The quartzites are white to dark grey or greenish grey and generally fine-grained, although they range up to coarse-grained types containing granule-sized (2 to 4 mm.) particles. The coarse quartzites commonly are in beds 2 feet or more thick, which may be separated by thin beds of argillite. The fine quartzite usually show parallel laminae a few millimeters thick. Quartzite lenses a few inches long and shaped like an eye are found in phyllites on some islands in the southern part of Rougemont lake. Apparently they represent boudinage structure.

Detrital grains smaller than 1/4 mm. merge with the recrystallized groundmass, but those larger than 1/2 mm. stand out well in it. Although the former outline of these grains has been largely destroyed during metamorphism, the shape of some quartz grains suggests that they had a fair sphericity. A few quartz grains have partial rings of inclusions which apparently represent the original boundaries of well rounded clastic grains.

Clastic grains consist of quartz, feldspar, and minor zircon. The feldspar is generally albite but microcline has been detected very rarely. Many of the feldspar grains in somewhat feldspathic quartzite have been almost completely replaced by quartz. It is possible that much potash feldspar was originally present and has been replaced by quartz and albite, the potassium entering the sericite matrix. The rare rock fragments present are mostly aggregates of quartz crystals. Many quartz aggregates are microcrystalline and are possibly derived from chert. Others are made of relatively large quartz grains. The crystallographic orientation of some of the large crystals is only slightly different from that of their neighbours in the same fragment; such aggregates could have formed by slight fracturing and recrystallization of single quartz grains. Chloritic or shaly rock fragments, seldom as much as 2 cm. long, are also found. A small pebble, 5 mm. long, is composed of carbonate (50%), apatite (about 30%), and small amounts of chlorite, quartz, and feldspar. This composition is close to that of slightly impure collophane.

The same minerals are found in the groundmass as in the argillites and phyllites, although in different proportions. Quartz and albite (about An_8) are much more abundant in the groundmass; much of this material may be detrital and some of the quartz probably came from granulation and recrystallization of the borders of large detrital grains. Epidote, which occurs in all the pelitic rocks, is absent in some of the coarse quartzites, but is generally present in the medium- and fine-grained types. Other minerals are carbonate, muscovite, chlorite, biotite, tourmaline, apatite, sphene-leucoxene, and metamict allanite.

A monoclinic pyroxene, possibly diopside, is abundant in one quartz-feldspar-rich rock which is free of chlorite and mica. The rock is at the contact of a gabbro sill and is either an adinole or a contact-metamorphosed, fine-grained quartzite. The pyroxene is in radiating aggregates of colourless, elongated, curved crystals. It has the following properties: moderate birefringence (roughly 0.030), extinction angle Z against elongation of 40°; 2V about 60°; optically positive.

The modes of a few quartzites are listed in Table 3. The fact that the recrystallized groundmass in some of the coarser quartzites forms only a small part of the rock suggests that the sediments must have been well sorted. The coarse quartzites are commonly rich in quartz and were mainly ortho-quartzites and subarkoses (Pettijohn's terminology, 1954). Some arkoses were probably present. The medium- and fine-grained quartzites are intermediate in composition between the coarse quartzites and the argillites. Some have a rather high chlorite to mica ratio. Accurate estimates of the original matrix fraction are impossible in these rocks. Their composition is suggestive of some sorting and most of them were probably subarkoses.

Table 3

Modal Composition of Some Quartzites, Baby Formation

(In volume percentage)

	Coarse Quartzites					Medium and fine quartzites	
Sample No.	S-204	S-205	R-179	S-262	S-136	S-64	S-140
Quartz	82	80	93	57	64	79	65
Quartz or feldspar				9			
Feldspar	3	5	p	10	22	7	17
Muscovite	11	9	6[1]	} 24[2]	} 14		
Chlorite	4	5				13[3]	17[3]
Carbonate	p	1	1	p	p		1
Clinozoisite	-	-	-	-	-	1	p
Larger grains	½-2 mm.	½-1 mm.	1-3 mm.	½-3 mm.	1-3 mm.	¼-½ mm.	0.2 mm.

1. Includes minor chlorite
2. Also includes some quartz and albite
3. With minor muscovite
p. Present

Iron-bearing Member

All the iron-bearing rocks in the east half of the Gerido Lake area belong to the middle member of the Baby formation. They also occur at roughly the same stratigraphic level in the Harveng Lake area, about one mile west of Baby and Avoine lakes. The member includes some lenses of less ferruginous phyllites. Also, minor amounts of iron-bearing rocks may occur in lenses close to the main unit.

The member comprises an assemblage of ferruginous rocks that vary considerably in appearance and composition, but are gradational into one another. An important part of the member consists of a highly fissile, carbonate-bearing rock that weathers to rusty brown. It may grade into a less common and less fissile siderite-rich rock with a green or greenish-grey fresh surface and a red or purplish-red weathered surface; parts of this iron carbonate rock carry much pyrite. Another common type has siderite nodules disseminated in an aphanitic, grey to black matrix made of chert (microcrystalline quartz), chert and iron oxides, or silicates. The nodules range in size from very small up to 1 cm. and are much coarser than the laminae. They lie across the laminae and, in some places, the laminae are preserved within the nodules. Also present is a black, partly fissile rock with much visible magnetite; by increase in magnetite content, this may pass into a heavy, black to bluish-black facies with a metallic lustre. However, this "metallic" iron-bearing rock is not abundant and commonly occurs in bands 1/2 to 2 cm. thick, separated by rock much leaner in iron. Jasper forms a very small part of the member. It has a purple tinge, perhaps as a result of metamorphism. It occurs in thin bands, seldom more than 2 cm. thick, and is generally interbedded with magnetite-rich rocks.

Much of the iron-bearing rock is finely bedded, with laminae 1 mm. thick or less being common.

Quartz and carbonate commonly make up 60-90% by volume of these rocks. The remainder consists of silicates, iron oxides, and pyrite. In "chert" and jasper, quartz occurs in mosaics of fine (0.03 to 0.05 mm.), equigranular grains. However, its grain size is different in rocks not composed of nearly pure quartz. Siderite is commonly subordinate in amount to quartz. It is missing in jasper bands and scarce in "metallic", magnetite-rich bands. It occurs as rhomb-shaped crystals but is more common as small, equidimensional grains disseminated throughout the rock or concentrated in nodules.

Muscovite, biotite, and chlorite are minor constituents of the iron-bearing rocks. The rocks commonly contain one or two of these minerals, but seldom contain the three together. The minerals are generally microscopic in size. Muscovite is a major constituent of some thin, shaly laminae. Biotite makes up more than 5% of the rock. It is pleochroic from pale yellowish (X) to moderate or dark olive green (Z). Perhaps all the chlorites are optically negative. Some are strongly pleochroic in light yellow (X) to bright green (Z) and have a birefringence of about 0.004 and a very small optic angle. Others are green with a slight brownish tinge and are very similar to those commonly found in the argillites. Stilpnomelane is fairly common, but not abundant, and occurs for the most part in very small crystals, although some are 1/2 mm. long. The most common variety is strongly pleochroic in golden yellow (X) to very dark brown (Z). A green variety is probably present although it was not positively identified. In one thin section, the pleochroism of stilpnomelane is from golden yellow to very dark brownish red; thin basal plates are bright red. Stilpnomelane may occur with chlorite or biotite or both; it was not seen with muscovite.

Magnetite occurs in euhedral crystals ranging in size from very small to 0.5 mm. It usually forms only a small percentage of the rocks, but makes up about 30% by volume of some "metallic" bands. Hematite is finely disseminated throughout some rocks, but forms an insignificant part of the iron-bearing member. It is generally accompanied by magnetite. Pyrite is abundant in some of the iron-bearing rocks, especially the carbonate-rich ones, and forms euhedral crystals ranging in size from microscopic up to about 2 cm. It is not found with hematite and only rarely, in small amounts, with magnetite.

Apatite occurs in small amounts in many of these rocks and a concentration of it was seen at the contact of a jasper band and a magnetite-rich band. It is in equidimensional grains, 0.05 mm. in diameter.

Feldspar, which is present in all the argillites, is absent in many of the iron-bearing rocks and is not abundant in the others. It occurs in small veinlets in some cases, and was formed late. Epidote was not observed in the iron-bearing rocks. A soda-amphibole, with optical properties near those of arfvedsonite, was found close to a gabbro sill. Its pleochroic colours are aquamarine (X), pale yellow (Y or possibly Z), and violet. Some prismatic crystals are as much as 1 cm. long. It occurs in a magnetite-rich cherty rock with a fair amount of feldspar. As feldspar is commonly very scarce in the iron-bearing rocks, sodium was probably added to this rock and Harker's statement (1950, p. 295) that "quartz-glaucophane-schists are to be interpreted as metamorphosed adinoles" may apply here.

Rocks West of Léopard and Gerido Lakes - Baby Formation?

Exposures of metasedimentary rocks are scarce and mainly restricted to a thickness of a few feet or a few tens of feet at the base of meta-gabbro sills to the southwest of the Rasle Lake - Léopard Lake valley and to the west of the northern part of Gerido lake. These rocks are poorly known. The rocks west of Gerido lake lie below volcanic rocks and are probably part of the Baby formation, although iron-bearing rocks do not outcrop there. The rocks southwest of Léopard lake may also be part of the Baby formation.

The bulk of these rocks is apparently made up of argillites and phyllites similar in appearance and mineralogy to the pelitic rocks of the Baby formation. Quartzite is abundant west and northwest of Alain lake in the Gerido Lake area. Nearby, east of a small lake one mile north of Alain lake, is a conglomerate consisting of rounded boulders of dolomite about 4 inches long embedded in a sandy matrix. Cross-bedded quartzite overlies the conglomerate. Minor quartzite also occurs about one mile west of the south end of Léopard lake. Minor amounts of dolomite, tremolite-carbonate rocks, and iron-bearing rocks are present and are described below.

Dolomite occurs in a valley 1/2 mile southwest of the south end of Rasle lake. A thickness of only a few tens of feet is exposed. The rock is very fine-grained to aphanitic, bluish grey to dark grey on the fresh surface, and light grey, buff, or light orange on the weathered surface. It is well bedded; fine laminae 1 mm. thick are preserved in some places. Much of the rock is fairly pure carbonate. One analysed sample contains 51 per cent $CaCO_3$ by weight , 44 per cent $MgCO_3$, and a little $FeCO_3$. Thus the carbonate mineral is dolomite. A few impure beds, rich in actinolite and minor chlorite, are found. They weather in relief and the light green actinolite needles are easily seen. Some green, aphanitic, schistose beds made up largely of chlorite, or chlorite and actinolite, are also present. Narrow quartz veinlets criss-cross the dolomite in a few places.

Small amounts of tremolite-carbonate rocks are found at or near the contact of gabbro sills in the southeastern corner of the Léopard Lake area. They presumably formed from siliceous dolomite and appear to be at a stratigraphic level fairly close to that of the dolomite in the valley near Rasle lake. The rock is mainly very fine-grained with barely visible needles of amphibole, although some coarse (1/2-inch), grey amphibole crystals have been found. It is pale greenish-grey and commonly well bedded. Carbonate and tremolite-actinolite are the chief minerals. In some samples, tremolite is less abundant than carbonate, while, in others, it forms most of the rock. It occurs in prisms 0.05 to 0.4 mm. long. Small (0.05 to 0.2 mm.), equidimensional grains of clinopyroxene (probably diopside) are found in minor amounts in some rocks and may be due to contact metamorphism. Albite, clinozoisite, and apatite also occur in some rocks. Zoisite (2 V about 30^0, optically positive) has been found with clinopyroxene and magnetite.

Thin beds of dolomite are numerous among phyllites on the point on the west shore of Gerido lake near latitude $58^009'$. Minor dolomite also occurs near the western limit of the Gerido Lake area, near latitude $58^012'$.

Iron-bearing rocks are poorly exposed. They form beds and thin members or lenses, possibly at different stratigraphic levels, in the pelitic rocks southwest of the Léopard Lake valley.

On the west shore of Rasle lake, magnetite-bearing schist is exposed in a small outcrop. This rock is finely (1/2 to 1 mm.) laminated in green and white and consists mainly of quartz, biotite, chlorite, and carbonate with a little magnetite. Biotite and chlorite are green and strongly pleochroic.

At the north end of Léopard lake is found another small outcrop of well bedded, ferruginous sedimentary rock, with a few beds of chert and of iron-magnesium-calcium carbonate. The carbonate beds are dark grey with a reddish-brown weathered surface. Rounded, detrital quartz grains are visible under the microscope. Muscovite is a minor constituent. One analyzed sample contains 10.79% "soluble" Fe, 23.49% "soluble" CaO, 8.44% "soluble" MgO, 3.51% "soluble" MnO, and 33.84% CO_2. Ferruginous argillites are found 1/4 mile west of Bow lake, at many places on the east shore of Ducreux lake, and in one place 1 mile west of the north end of Léopard lake. Beds containing iron silicates and iron carbonate are interbanded with, and grade into, magnetite-bearing schists and common muscovite-chlorite argillites. The ferruginous rocks are mainly very fine grained or aphanitic, green, dark grey, or black on the fresh surface and black or blue-black on the weathered surface. The carbonate-bearing beds weather to brown or reddish-brown. The iron silicate minerals are stilpnomelane (common), and grunerite (scarce). In hand specimens, stilpnomelane appears as tiny (less than 1 mm.), black, very shiny specks. The mineral is strongly pleochroic in yellow and dark brown. Grunerite is easily recognized in hand specimens as it occurs in needles or stubby prisms, 1 to 5 mm. long, with good longitudinal cleavage. It is commonly light yellowish-brown to white, with a silky to adamantine lustre. The proportion of the minerals varies widely. Some thin beds are made up essentially of one iron silicate mineral.

Ferruginous schists occur on the west shore of Gerido lake, near latitude 58°12', and on the broad peninsula in Gerido lake, at longitude 69°50' and latitude 58°05'. Phyllites with ferruginous carbonate beds also outcrop near the southern tip of the peninsula in Gerido lake near latitude 58°11'.

Hellancourt (Volcanic) Formation

Name and Distribution - These volcanics are named after Hellancourt lake (east half, Gerido Lake area), where the formation has been studied in greatest detail. Also, this is the only place where both the base and the top of the formation may be seen. The formation is commonly well exposed and occurs in each of the five map-areas.

Correlation - Most, if not all, of the volcanic rocks of the area probably belong to the Hellancourt formation. As much of the correlation in the area is based on this assumption, the evidence to support it follows. (1) In most places, the lavas are similar in texture, in composition, and even in such peculiarities as the predominance of massive lavas in the lower part of the formation and abundance of pillow lavas near the top, the presence of blotchy lavas in the lower part at many places, the rarity of amygdules, and the tabular cavities in pillow lavas. (2) Blotchy gabbro occurs closely below the lavas almost everywhere, except in part of the Thévenet Lake area. The only place where this gabbro is not overlain by lava is southwest of Léopard lake, and here overlying lavas may have been eroded away. The consistent distribution of this unusual rock suggests that most of its occurrences belong to a single sill underlying a single volcanic formation. (3) Top determinations from pillows indicate that the lavas in most of the Léopard Lake area and in the western half of the Gerido Lake area belong to a single formation, if no fault of large displacement is present. (4) The iron-bearing member of the Baby formation can be traced almost continuously from the southeastern part of the Harveng Lake area to the northwestern corner of the Thévenet Lake area. The lavas near Thévenet lake, south of Dupuy lake (Léopard Lake area),and near Bourgault lake (Harveng Lake area) overlie this member and must lie at about the same stratigraphic level. The main occurrences of lavas which may not belong to the Hellancourt formation lie east of Rachel lake.

Thickness. The formation is between 4,000 and 5,000 feet thick on the western limb of the syncline near Hellancourt lake, where shearing is rather mild or missing, but is much thinner, owing to intense shearing, on the eastern limb of the fold. Near Gerido lake, the top of the formation is not exposed. Its thickness is therefore unknown, but is in excess of 3,000 feet.

Field Characters - The bulk of the formation is made up of pillow and massive flows of meta-basalt. Minor agglomerates occur and some of the coarser-grained rocks may be meta-diabase sills. These sills, if they exist, make up only a small part of the formation. Although, in general, pillow lavas predominate towards the top of the formation and massive flows predominate towards the base, there are many exceptions. For instance, near Hellancourt lake, thick massive flows present near the base of the formation give way laterally (southward) to abundant pillow lavas interlayered with thinner massive flows.

Ellipsoidal Lavas - Wilson (1941) classified pillows into three types on the basis of shape, namely, mattress, bun, and balloon. All three types are found in the area, although the first two are rare. The tops of the balloon-shaped pillows are convex upward and their lower surfaces fit the shapes of the underlying pillows; thus, many show a downward-projecting tip above the junction of two other pillows. Most of the pillows must have been fairly plastic when they formed, because they commonly fit snugly together without much interstitial space. Scoriaceous material is present in the interstices, but is rarely abundant. A few ball-like pieces of solidified lava, 3 to 6 inches in diameter, are also found in the interstices. The remaining space is filled with quartz and carbonate. The pillows are commonly 2 to 5 feet long, but may be longer, and in any one outcrop they tend to be of one size.

The pillows are made up of an aphanitic, green rock. Their rims, about 1/2 inch thick, are green, glassy-looking, aphanitic, and rich in secondary epidote. The original structure of the glass is still partly visible under the microscope.

In a few places, there are re-entrants of the glassy-looking rim into the pillow. Judging from the shape of these pillows, the structure may be due to the merging of two individual pillows with partial refusion of the common boundary. A dark layer a few millimeters thick is present just inside the rim of the pillows. In thin section, the layer is seen to consist of small varioles 0.05 to 0.25 mm. in diameter, which, despite metamorphism, still show the characteristic black cross under the nicols. Some varioles have a crystallite nucleus. Concentric lamination was found at only two places in the Léopard Lake area. It is faint and consists of alternating slightly paler and darker layers. In one long and flat pillow, the inner rings are disposed around at least three different centres, the larger rings merging together, and the outermost ones paralleling the edge of the pillow.

Tabular Cavities in Pillow Lavas - This seldom-described structure is common in the pillow lavas of the area. Originally, it consisted of one or more tabular cavities separated by thin bands of solidified lava. The former cavities are now filled with quartz and carbonate. The upper surface of the uppermost cavity of a pillow is generally curved and parallel to the upper surface of the pillow. The lower part of the same cavity is flat and all the other cavities below have nearly flat upper and lower surfaces; all these flat surfaces are parallel. Here and there, a cavity may be directly connected with the one above or below. More rarely, two cavities at the same level are separated by a thin wall of solidified lava. The tabular cavities are commonly from 1/2 inch to 2 inches wide, and the thickness of lava that separates them ranges from one inch to a few inches. The ratio of the volume of the cavities in a pillow to the volume of the pillow varies from pillow to pillow, but is generally small. Only rarely does the space occupied by the voids exceed one or two per cent of the volume of the pillow. Some outcrops show numerous pillows with cavities; others show none.

The cavities are more abundant in what was originally the upper half of the pillows. Those of one pillow are always parallel to cavities in the surrounding pillows, to flow contacts, and to the local attitude of the volcanic formation. They occur in perfectly preserved pillows as well as in sheared ones, and they never intrude, or even touch, the glassy-looking rim of the pillows. These relationships indicate that they were not produced by any such secondary process as fracturing during folding. Instead, they must have formed horizontally in the pillows when the lava was solidifying. They represent voids which were left between the solidified upper crust of the pillows and the horizontal upper surface of the liquid lava in the pillows. Superposed cavities indicate successively lower levels at which the liquid lava stood.

The concentration of the voids in the upper part of the pillows makes them a useful "top and bottom" criterion, especially since the shape of the pillow lavas alone is not everywhere characteristic enough. However, they must be used with caution where the pillows are badly deformed. They are also useful in that they mark the original horizontal plane more accurately than does the shape of the pillows, because the latter may have had an initial dip, or may not be elongated enough to define accurately the strike and dip of the flow.

Massive Flows - The massive flows commonly are green and very fine grained. However, the grain size varies from aphanitic at the contact to 1 or 2 mm. in the centre of the flow or to 3 or 4 mm. in some thick flows. The flow contacts are commonly sheared and poorly exposed. The massive flows are generally capped by a few feet of scoriaceous lava and fragmental material. In this material are found abundant, small lava fragments with minute amygdules and varioles. Angular and conspicuously streaked fragments may originally have been stretched glass. Rarely, some bulbous, ellipsoidal, or irregular masses of lavas are present among the fragmental material. Lower contacts of massive flows are commonly structureless, the chilled margin resting on the vesiculated top of the underlying flow. In some places, however, upward passage from pillow to massive lavas without intervening scoriaceous material suggests that both types of lavas formed from the same outpouring. In one place, an upward gradation was seen from small to larger pillows and even "mattress-like" pillows, followed by a 5-foot flow, and then, by a 30-foot flow. Scoriaceous material was found below the small-pillowed lavas and at the top of the 30-foot flow.

Columnar jointing was seen in a few places. The columns are commonly 8 inches to 2 feet wide, but larger ones are found in thick flows. Columns 3 to 5 feet wide, some with good hexagonal outline, are well exposed near the nose of the syncline near Hellancourt lake.

The flows are generally 15 to 150 feet thick but 300-foot flows occur in a few places, as near Hellancourt lake, and thinner flows are also present here and there. Shallow valleys formed by the soft, sheared flow tops appear as parallel lines on aerial photographs. Therefore, the flows apparently maintained a fairly even thickness over at least moderate distances. As the flow tops are roughly parallel to the bedding in the sedimentary rocks below the volcanic formation the initial dip of the flows may have been, as a rule, relatively small.

Pyroclastic Rocks - Pyroclastic material is scarce in the Hellancourt formation. Near Hellancourt lake, a breccia, about 15 feet thick, was traced for one mile; its extent may be greater, since another outcrop of breccia was seen 2 miles away along the strike. The breccia consists of abundant lava fragments up to 5 inches in diameter lying in a sheared, chloritic matrix. Some fragments are subrounded, but most are angular. Although its exact nature is in doubt because of the shearing in the matrix and the scarcity of outcrops, the breccia looks like an agglomerate. A few bands of chloritic schists (sheared tuffs?) several feet thick occur among the volcanic rocks, as, for example, west of Archiac lake in the Léopard Lake area. It is possible that some of the rock classed as sheared and brecciated flow tops are actually pyroclastics. However such rocks form only a minor part of the formation.

Petrography - The primary texture is poorly preserved in the unsheared meta-basalt west of Thévenet lake. In these rocks much of the original plagioclase was tabular and commonly showed little parallel orientation. Apparently it crystallized chiefly after the flows came to rest. The texture is best preserved in the coarser-grained part of the massive flows. In many of these, the feldspar occurs in laths ranging in length from 0.1 to 1.0 mm. and averaging about 0.3 to 0.5 mm. The actinolite crystals, which probably formed chiefly from pyroxene, are equidimentional and average 0.2 to 0.4 mm. in size. The texture may have been mainly intergranular or intersertal, and, less commonly, ophitic, although this is not certain. In a few places, actinolite crystals, 4 mm. or more in size, include slender laths of plagioclase; here the texture may have been poikilitic. Radiating intergrowths of curved actinolite and albite crystals seen in some thin section probably formed from similar intergrowths of pyroxene and plagioclase. Phenocrysts are rare, except in a few flows of "blotchy lavas" near the base of the volcanic formation. They are altered plagioclase crystals that occur individually and, more commonly, in clusters. The clusters generally are 1-2 cm. in diameter and are identical to those in the blotchy gabbro. The phenocrysts are probably intratelluric, because some full-sized aggregates are found within the chilled rim of ellipsoidal lavas and in the chill zones of the massive flows.

Mineralogy - In meta-basalts west of Thévenet lake, the original plagioclase is replaced by a semi-opaque mixture which, where it can be resolved, is seen to consist of pseudomorphous albite riddled with very fine-grained, poorly crystallized clinozoisite (or possibly zoisite). A small amount of sericite was recognized in some rocks. Iron-epidote may be present instead of clinozoisite; it is commonly coarser grained than the clinozoisite. Iron-epidote is also common in fractures and shear zones in the lavas. Augite remnants, rimmed with amphibole, were seen in a flow east of the south end of Hellancourt lake. Actinolite is the main ferromagnesian in many lavas. It occurs in equidimensional to prismatic crystals whose cores, in many cases, are chlorite. Most of the actinolite is colourless under the microscope,but some blue-green amphibole is also present. Chlorite is commonly pale, with anomalous blue birefringence colours and very low birefringence. Its optical direction X is perpendicular to the cleavage and, therefore, it is probably optically negative. Chlorite with anomalous brown birefringence colour and Z perpendicular to the cleavage is also present, but is much less common. Chlorite has probably replaced pyroxene in the core of some actinolite crystals, plagioclase to a minor extent, some magnetite, and possibly some glass or chlorophaeite (interstitial between sharp, euhedral plagioclase crystals). It also fills some amygdules and is present in thin veins. Quartz and carbonate are also present in small amounts throughout the volcanics. They are abundant in small fractures, in tabular cavities in the ellipsoidal lavas, and in the vesiculated flow tops. Minor amounts of pale brown biotite occur in some lavas east of Hellancourt lake. Magnetite, sphene-leucoxene, pyrite, and pyrrhotite are minor constituents. Apatite was found in a massive flow or a meta-diabase sill within the formation. Tourmaline is fairly abundant in a fragment from a brecciated flow top, one mile west of the northern part of Rougemont lake.

The volcanic rocks east of Thévenet lake are mainly fine-grained, dark, schistose amphibolites. Their mineralogy is similar to that of the amphibolites derived from the intrusive rocks described below.

Chemical Composition - The chemical composition of four metavolcanic rocks from the Hellancourt formation is listed in Table 4. Analysis No. 1 differs from the three others in containing more sodium and less calcium. Its composition is intermediate between tholeiitic basalt and tholeiitic andesite. It differs from the common meta-basalts of the area in containing fairly clear albite. Whether the higher sodium content is primary or due to a secondary alteration, such as a slight spilitization is not known. The three other analyses are very similar. The norms of these rocks are given in Table 5. The presence of normative quartz and hypersthene indicates that the rocks are tholeiite basalts. The average of the four analyses (No. 5 in Table 4) is almost identical to Nockolds' average (1954) of 137 analyses of "normal tholeiitic basalt". The titanium content is slightly lower and the ferrous iron content slightly higher in the rocks of the area. Of interest is the very low potassium content in the Hellancourt meta-basalts. The Skaergaard magma (in Walker and Poldervaart, 1949, p. 649) is among the few basalts from other petrographic provinces with such a low potassium content.

Table 4

Geochemical Analyses of Tholeiite Meta-basalts

	1	2	3	4	5	6
SiO_2	49.86	48.60	49.44	50.38	51.2	51.3
TiO_2	1.58	1.28	1.55	1.17	1.4	2.0
Al_2O_3	13.62	13.74	13.89	14.22	14.3	14.2
Fe_2O_3	2.25	2.66	3.47	2.56	2.8	2.9
FeO	11.25	10.13	9.88	9.02	10.4	9.2
MnO	0.17	0.22	0.20	0.23	0.2	0.2
MgO	6.20	6.75	5.83	6.75	6.6	6.4
CaO	8.42	10.97	10.38	10.70	10.5	10.5
Na_2O	2.99	2.02	1.70	2.18	2.3	2.3
K_2O	0.18	0.12	0.20	0.09	0.2	0.8
Li_2O	0.00	0.00	0.00	0.00		
P_2O_5	0.14	0.12	0.14	0.10	0.1	0.2
H_2O+	3.00	2.99	2.98	2.07		
H_2O-	0.08	0.08	0.07	0.11		
CO_2	0.00	0.20	0.00	0.21		
S	0.08	0.02	0.09	0.04		
	99.82	99.90	99.82	99.83	100.0	100.0
SrO	0.01	0.03	0.03	0.03		
BaO	0.00	0.00	0.00	0.00		
V_2O_3	0.07	0.05	0.06	0.06		
Cr_2O_3	0.02	0.03	0.02	0.04		
CuO	0.02	0.03	0.02	0.03		
NiO	0.00	0.01	0.00	0.01		
ZrO_2	0.01	0.01	0.01	0.00		
Co_2O_3	0.00	0.03	0.00	0.00		
SnO_2	0.00	0.00	0.00	0.01		

0.00% of each of the following elements in 1,2,3, and 4: Ag, As, Be, Cb, Bi, Cd, Ga, Ge, La, Li, Mo, Pb, Sb, Y, Zn.

0.0% of Ce, Ta, W.

1,2,3. Samples 6L, R-5, 8L respectively; tholeiite meta-basalt, 1 and 3: southeast of Hellancourt lake, Gerido Lake area (East Half). 2: west of Rougemont lake, Gerido Lake area.

4. Sample S-129, tholeiite meta-basalt with pyroxene remnants, southeast of the Hellancourt lake, Gerido Lake area (East Half).

1,2,3,4. Analyses by Laboratories Branch, Quebec Department of Mines. Analysts: F. East, J. Gagnon, D. Lamontagne, V. Plamondon

5. Average of 1,2,3, and 4 calculated to 100%, free of water and carbon dioxide.

6. Normal tholeiitic basalt, average of 137 analyses (Nockolds, 1954), recalculated free of water.

TABLE 5

Norms of Meta-basalts Given in Table 4

(Calculated to 100%, free of water, carbon dioxide, and sulphur)

	1		2		3		4		5		6	
qz	1.3		2.1		6.8		3.9		3.5		3.5	
or	1.1		0.6		1.2		0.5		0.8		5.0	
		51.1		47.1		46.6		48.8		48.4		50.3
ab	26.1		17.7		14.9		18.9		19.4		19.1	
		An_{45}		An_{60}		An_{64}		An_{59}				
an	23.9		28.8		30.5		29.4		28.2		26.2	
$CaSiO_3$	7.7		11.2		9.3		10.3		9.6		10.4	
		di 15.3		di 22.1		di 18.4		di 20.2		di 19.0		di 20.4
$MgSiO_3$	16.1		17.5		15.1		17.4		16.5		16.0	
		hy 25.5		hy 21.9		hy 19.6		hy 20.8		hy 21.9		hy 17.3
$FeSiO_3$	17.0		15.3		13.6		13.3		14.8		11.3	
mt	3.4		4.0		5.2		3.8		4.1		4.2	
il	3.1		2.5		3.1		2.3		2.8		3.8	
ap	0.3		0.3		0.3		0.2		0.3		0.5	
$\frac{FeO+Fe_2O_3}{FeO+Fe_2O_3+MgO} \times 100$	68		65		70		63		67		65	

Fifteen samples from the Hellancourt formation in the east half of the Gerido Lake area were melted to glass beads, and the refractive indices of the glasses were measured (method in Mathews, 1951). The small variation in indices (Table 6) suggests that the chemical composition of the volcanic rocks does not vary much and is fairly close to that of the four analyses of Table 4. This correlates with seven silica determinations done by chemical analyses. Samples 1L to 13L (Table 6) are from a suite of specimens taken from the lower 2,000 feet of the formation. Apparently, vertical variation in chemical composition in the lower half of the formation is slight, at least at this place. The Hellancourt volcanics in the Harveng Lake and Léopard Lake areas are similar to those of the Gerido Lake area as indicated by microscopic examination.

Table 6

Refractive Indices of Artificial Glasses

Refractive indices of artificial glasses made by fusion of meta-basalts and meta-diabases from the Gerido Lake area (Method by Mathews, 1951). Three glass beads were made of each sample. The maximum error on the determination of the refractive indices is less than 0.002 in all cases and commonly less than 0.001. Fusions and determinations of indices made by R. Paquet of the Laboratories Branch of the Quebec Department of Mines.

	Sample	Index	% SiO_2	(anhydrous weight percentage)
Meta-basalts: (near Hellancourt lake)	13L	1.6111		(about 2,000 feet above base of formation)
	11P	1.607		
	8L	1.609	51.0	
	6L	1.602	51.5	
	3L	1.594		
	2P	1.594	52.5	
	1L	1.604	52.0	(base of formation)
	S-129	1.593	51.4	
	S-138	1.608	50.6	
	R-133	1.608		(possibly meta-diabase)
(west of Rougemont lake)	R-4	1.601		
	R-2	1.606		
	R-5	1.606	50.2	
	R-8	1.612		
	R-4	1.612		(blotchy lava)

Conclusions - The only intrusive rocks recognized underneath the lavas are sills. The absence of any visible volcanic necks or swarms of dykes which may have served as lava feeders is puzzling. There are many possible explanations:- (1) Feeders may lie under lava synclines; (2) dykes parallel to fold trends may have been confused with the innumerable sills in poorly exposed areas; (3) the lava may have risen by means of slightly transgressive sills (unlikely); (4) most vents are located outside the area. The difficulty in the last hypothesis lies in the large size of the areas mapped, but dykes and plugs are also scarce over most of the Columbia plateau, despite excellent exposures (Waters, 1955, p. 708). This hypothesis seems the most likely, but cannot be verified owing to the rather intense folding and thrusting that the rocks in the area have experienced.

The lava was mainly liquid when it poured out of the volcanic vents and may have come to rest when crystallization was not advanced. This is indicated by the general absence of phenocrysts in the volcanic rocks and their chilled borders, and because the feldspar laths show little preferential alignment. High mobility of the lava is further indicated by the close fitting of the pillows and by the fact that the upper surface of the lava was horizontal in partly filled pillows as indicated by the superposed tabular cavities. Mobility is also suggested by the even thickness of some individual flows and by the fairly gentle initial dips. The small amount of vesiculated lava is indicative of a dry magma within the area, although it need not have been dry at the supposedly far-removed vents. The magma probably flowed rather quietly, at least within the area, because few pyroclastics are present. However, this may be expected of a dry and mobile basaltic magma.

Thévenet Formation

The Thévenet formation overlies the Hellancourt volcanics. It is definitely recognized only in the core of the syncline southwest of Thévenet lake, but may be present east of Rachel lake (Thévenet Lake area). The top of the formation is not exposed but its thickness exceeds 2,000 feet.

The formation consists of zones of massive argillites and quartzites or of both interbedded.

The argillites are usually dark grey, well indurated, thickly bedded and, in many places, well laminated. The essential minerals are quartz and feldspar in angular silt-sized grains with interstitial chlorite, sericite, and biotite.

The quartzites are thickly bedded, medium to dark grey on weathered surfaces, and light grey on fresh surfaces. The essential minerals are quartz (about 80%), feldspar (8% to 10%), muscovite (5% to 10%), and biotite and chlorite (about 5%). Accessory minerals include zircon, apatite, and pyrite.

An interesting feature of many of the quartzites is the presence of concretions 1 inch to 2 inches in diameter. They are elongated parallel to the bedding and, therefore, are useful for strike and dip determinations.

Where quartzite and argillite are interbedded, the former is in beds 6 inches to 1 foot thick and the latter in beds 2 to 6 inches thick.

Rocks East of Rachel Lake

The varied assemblage of rocks east of Rachel lake is more highly metamorphosed than the rocks farther west and belong to the amphibolite facies of metamorphism. Tectonically, it is highly complex and the stratigraphic succession is poorly known. A tentative stratigraphic order appears in the Table of Formations. From work done on the Freneuse Lake area (Sauvé, 1956b), the structure is known in the northeast corner of the Thévenet Lake area. Here, the succession is broadly that shown in the Table of Formations, except that staurolite and kyanite were not detected and no schists were observed above the volcanic rocks. The volcanic rocks are probably Hellancourt and some of the rocks following below the volcanics are probably Baby. The succession east of Rachel and Francine lakes is unknown, except for the fact that a volcanic conglomerate and some mica schist overlie pillow lavas which could be part of the Hellancourt formation. However, going west and northwest from the gneisses to the volcanic rocks, the order of the rocks encountered is roughly that shown in the Table of Formations and compares broadly with the sequence in the northeast corner of the area. The folding is so complex, however, that more than one iron-bearing formation or volcanic formation may be present.

Microcline Gneisses

Granitoid microcline gneisses occur in three small areas along the eastern limit of the west half of the Thévenet Lake area.

The gneisses are grey or pink, medium-grained, poorly to well foliated. Layering is generally poor or missing. Carlsbad twins in coarse microcline crystals are easily seen in a few outcrops. The essential constituents are quartz, microcline, and plagioclase. In some rocks, quartz and microcline grains are elongated parallel to the foliation. Quartz shows strong undulatory extinction, and the grid twinning of microcline is well formed. Some plagioclase grains are fractured and healed. Biotite and muscovite occur commonly in small amounts but, in some cases, may make up about 20% of the rock. Some of the gneisses contain a small percentage of hornblende and no muscovite. Apatite and zircon are common accessory minerals. Epidote and tourmaline are less common. Hematite was seen in quartz-rich gneiss close to the contact with schists.

The change from schists to gneisses is striking. The schists show a very good layering resulting from sedimentary bedding, whereas the gneisses show no or only poor layering. Microcline is extremely scarce in the schists, but is ubiquitous in the gneisses. Garnet, on the other hand, is common in schists, but was not seen in the gneisses. In the rare places where observed, the contact between schists and gneisses is fairly sharp. In general garnet schists are separated from somewhat schistose, relatively mica-rich gneisses by a few feet of microcline-bearing schist or schist-gneiss. The stratigraphic relationship between the gneisses and the other rocks of the area is not clear. From evidence seen in the Freneuse Lake area (Sauvé, 1956b, 1957), the gneisses in the northeastern corner of the Thévenet Lake area clearly lie stratigraphically below the schists and marble found to the west. These gneisses may belong to the crystalline basement of the Trough, in which case they are Pre-Kaniapiskau. Near the middle of the eastern edge of the Thévenet Lake area, the plunges of the folds are very steep and even vertical. Thus, it is not certain if the gneisses are above or below the schists here. The common presence of tremolite marble at or near the contact of schists and gneisses coupled with its general absence elsewhere suggests a possible correlation of the gneisses east of Rachel lake with those in the northeastern corner of the area.

Tremolite Marble

A band of tremolite marble, 50 or more feet thick in places, is present west of the gneisses in the northeastern corner of the Thévenet Lake area. Another band outcrops south of the southern exposure of gneisses. Half a mile north, a 10-foot band of marble is not more than 10 feet away from the gneisses. More tremolite marble occurs a short distance south and west of these last occurrences, but it would seem to be at a different stratigraphic level.

The marble is white and commonly has a white, light grey or light buff weathered surface. Its layering is very good and is mainly derived from sedimentary bedding. In places, 1- to 3-inch bands of tremolite alternate with carbonate beds. In other places, the layers may be marked by tremolite, magnesian mica, carbonate, or quartz. In some of the southern occurrences, the layering is extremely contorted, even the axial-planes of small folds being folded. Tremolite commonly occurs in aggregates of radiating needles. The aggregates are spherical where isolated, but they commonly coalesce. Needles of dark brown and black tourmaline are visible in the marble south of the southern occurrence of gneisses.

Calc-silicate Rocks, Calcareous Schists

The calc-silicate rocks are characterized by the presence of much carbonate and some light green actinolite. They grade into calcareous schists which are free of amphibole, and these, in turn, may grade into ordinary schist with minor carbonate. The calc-silicate rocks and calcareous schists occur to the west of the marble and may overlie it. They are mixed with mica schist, garnet schist, and kyanite-garnet schist. They are scarce or missing in what is possibly the higher part of the sequence, near the iron-bearing and volcanic formations.

These rocks commonly have a good foliation and, locally, a good layering. Much of the calc-silicate rock is light green, and light green actinolite crystals are easily seen in hand specimen. Some of the rock contains iron carbonate and a black amphibole. The weathered surface is commonly deeply pitted owing to differential erosion of carbonate and silicate.

Besides actinolite and carbonate, the calc-silicate rocks commonly contain quartz, plagioclase, and pale brown biotite, and some contain much colourless chlorite. Clinozoisite may or may not be present. In one place, diopside was seen close to a meta-gabbro sill. Muscovite is scarce or missing where actinolite is present, but is abundant in calcareous rocks free of actinolite. Some rocks contain two carbonate minerals, one being iron-bearing. Accessories include tourmaline, sphene, and possibly rutile.

Schists and Quartzite

Much of the metamorphosed pelitic rocks near the eastern border of the Thévenet area are highly crumpled. They are commonly well layered and foliated. The foliation is, in large part, parallel to the sedimentary bedding. The grain size of the schists increases eastward from fine-grained on the east shore of Rachel lake to medium-grained near the microcline gneisses. In general, they are coarser grained than the metasedimentary schists to the west. Many schists contain quartz and feldspar lenses and veinlets disposed largely parallel to the schistosity. The mica schists vary in colour from silvery white to dark grey and some are brownish. They consist mainly of biotite, muscovite, quartz and plagioclase, with chlorite, epidote, carbonate, apatite, tourmaline, magnetite, and pyrite as accessory minerals. Muscovite is finely or coarsely crystalline. Quartz occurs as irregular small grains disseminated through the rock, or in aggregates of grains arranged in small lenses or thin stringers parallel to the micaceous layers. Some of the biotite is green, but most is brown to red-brown.

Garnet is present in many mica schists that are very low in carbonate. It is scarce or missing in the mica schist overlying the volcanic conglomerate east of the north half of Rachel lake. Garnet crystals are only 1 or 2 mm. in diameter near the east shore of Rachel lake but farther east, near the gneisses, they are commonly 1/4 to 1/2 inch. Some crystals are more than 2 inches in diameter. Small garnet grains are commonly euhedral, whereas the larger ones are subhedral or anhedral. Inclusions are common and are usually irregularly distributed but, in some crystals, they are arranged in a spiral forming a "snowball" structure.

Staurolite occurs as brown, slender prismatic crystals as much as 1/2 inch long in mica-garnet schists. It is especially common in the vicinity of the iron-bearing rocks west of the southern part of Rachel lake but also occurs among the calcareous schists in a few rocks farther east and in a few places near the eastern edge of the area, near latitude $58^{o}11'$. Kyanite occurs in many places in a band about one mile wide along the eastern edge of the area between latitudes $58^{o}05'$ and $58^{o}07'$. Some kyanite blades are as much as 4 inches long. The blades are blue or white and are most easily seen in quartzo-feldspathic lenses in the schists. Kyanite also occurs as small, colourless, prismatic crystals which can easily be overlooked in hand specimens. Kyanite is everywhere associated with garnet and, in places, with staurolite.

Grey or white quartzite occurs locally among the mica schists. It is most common in a zone about 1 1/2 miles east of the southern part of Rachel lake. Beds of quartz-pebble conglomerate are interbedded with grey mica schist above the volcanic conglomerate. They are mentioned in the description of this last rock.

Iron-bearing Rocks

Although iron-bearing rocks are abundant a mile east of the southern half of Rachel lake they are complexly folded and thus probably form a thin unit. A thin member also occurs 1 to 2 miles northeast of Rachel lake. These occurrences lie near the volcanic rocks and are possibly equivalent to the iron-bearing member of the Baby formation. Two small lenses of magnetite-bearing rocks occur near the eastern edge of the area; one at latitude 58°05', the other at 58°13'. They are close to the microcline gneisses and possibly lie below the other iron-bearing rocks.

The main constituents of the iron-bearing rocks are quartz, magnetite, garnet, iron amphiboles, and carbonate. Iron carbonate is abundant in the iron-bearing rocks northeast of Rachel lake and scarce elsewhere. These rocks are generally very well layered. Some thin bands are white and consist essentially of quartz, others are dark and are made up of quartz and magnetite, and still others contain garnet and amphibole, with or without magnetite. In many rocks, red garnet is more than 1/4 inch in diameter. The iron amphiboles weather easily and amphibole-rich rocks have a rusty-brown weathered surface. The amphibole is commonly coarse and may occur in aggregates of radiating needles. Two types of amphibole are present and occur together in a few places. One, possibly a soda-amphibole, is strongly pleochroic in blue-green or green and is black in hand specimens. The other is colourless under the microscope but pale brown to reddish brown in hand specimens; it is probably close to the cummingtonite-grunerite series. The two amphiboles appear stable in the presence of each other and are finely intergrown in rare cases. Accessories include biotite, chlorite, apatite, and tourmaline. Zircon was seen in a quartzose band.

Some poorly-layered, garnet-hornblende, magnetite-free rocks are closely associated with ordinary amphibolite and some may be derived from ferrogabbro. However, the combined occurrence of large and abundant garnets with coarse, radiating iron-amphibole (rusty-weathering) seems fairly typical of the metasedimentary iron-bearing rocks. The presence of continuous quartz bands is also diagnostic of these rocks.

Volcanic Rocks

The structure is so complex that it is not clear if all the volcanic rocks east of Rachel lake belong to a single formation. Inasmuch as they have the chemical composition of basalts, and as at best some of them lie a short distance above iron-bearing rocks, they may be part of the Hellancourt formation.

Most of the volcanic rocks are highly sheared. The best preserved are 2 1/2 miles slightly north of east of the northern tip of Rachel lake. There, the bulk of the formation is made up of volcanic pillows similar in size and shape to those of the Hellancourt formation. Many pillows have tabular cavities. Massive rocks below the pillow lavas may be sills or flows. The shearing increases greatly southward and it is not clear if the fine-grained, laminated amphibole east of the southern half of Rachel lake is derived from lava or diabase.

The rocks are in the amphibolite facies of metamorphism. They consist mainly of hornblende and subordinate plagioclase, with minor quartz, epidote, sphene, apatite and opaque minerals.

Volcanic Conglomerate

A generally sheared volcanic conglomerate overlies the pillow lavas 2 to 3 miles east of the northern tip of Rachel lake. Probably the same conglomerate, but extremely sheared, outcrops 1 1/2 miles to the south. The shearing makes it difficult to estimate the thickness of the conglomerate, but it is probably 500 feet or more.

This rock is poorly known. At one place, it consists mainly of pebbles of aphanitic lava (now amphibolite) with a few fragments of medium-grained meta-basalt or meta-diabase and some quartz pebbles. The last are scarce in the lower part of the conglomerate but apparently become progressively more abundant higher in the formation. The volcanic pebbles are fairly well rounded and many are elongated, although this may be due to tectonic deformation. Most pebbles are 1/2 to 1 inch in diameter although some are as large as 4 inches. Generally, the matrix forms only about 25% of the rock.

At another place, the rock is more sheared. Many of the fragments are angular and some are 4 inches long. The matrix is of sand-size and not abundant. The highly sheared rock is similar to an ordinary, foliated ortho-amphibolite, but differs in containing many more carbonate-formed pits on the weathered surface and a few to many quartz or quartzo-feldspathic ovoids or lenses. Some rocks contain two carbonate minerals. Other major constituents are hornblende, epidote, quartz and zoned plagioclase. Minor constituents are biotite, chlorite, apatite, and opaque minerals.

The basal part of the formation is the volcanic conglomerate with carbonate-rich, very fine-grained material and, in some places, beds of grey mica schist. The formation grades upward from conglomerate to hornblende-bearing, biotite schist with occasional sheared, dark, carbonate-bearing bands, and then mica schist with beds of quartz-pebble conglomerate. The pebbles are about 1 inch in diameter. Also, in the mica schists, are a few bands of sheared, carbonate-plagioclase-quartz rock with numerous rods rich in epidote and actinolite. The rods may be highly deformed pebbles.

Intrusive Rocks

Sills are the only important intrusive bodies in the area. West of Thévenet lake, they are made up largely of meta-gabbro and meta-diabase, with minor amounts of ultramafic gabbro, quartz diorite, and partly unaltered gabbro. East of the lake, the sills are made up of amphibolite and ultramafic rocks. No clear distinction is made between the terms "meta-diabase" and "meta-gabbro" in this report. The term meta-gabbro is more generally used, with the term meta-diabase being applied mainly to fine-grained rocks from relatively thin sills and from the borders of thick sills.

Distribution and Thickness

Sills are abundant in the sedimentary rocks of the area. However, none were found among the greywackes of the Larch River formation in the southwestern part of the area nor in the Thévenet formation. Some sills may occur among the volcanic rocks but none have been definitely recognized.

The sills range in thickness from a few feet to about 3,500 feet, although few are thicker than 1,500 feet. Their thickness and abundance may be partly related to their position in the stratigraphic column. Most of the very numerous sills in the lowest member and part of the iron-bearing member of the Baby formation are less than 200 feet thick, but some are about 300 feet thick. The very thick sills occur shortly above or in the iron-bearing member, the thickest being north of Thévenet lake, and west of Hellancourt, Rougemont and Baby lakes. Generally, only one very thick sill is present at any one place. In the west half of the Gerido Lake area and in the southwestern part of the Léopard Lake area, the many sills present are between 300 and 1,000 feet thick. A sill of blotchy gabbro is found below the volcanic formation almost everywhere except in the Thévenet Lake area. It is 300 to 1,000 feet thick for the most part but is much thicker a few miles north of Léopard lake. The sills in the eastern part of the Thévenet Lake area are schistose and their present thickness may be much less than their original thickness.

Most sills maintain a fairly uniform thickness over moderate distances although, locally, some of the very thick sills show abrupt changes in thickness. Two such occurrences are found east of the north end of Rougemont lake and southeast of Lafortune lake in the Léopard Lake area.

The aggregate thickness of the sills around and to the north of Hellancourt lake is in excess of 5,000 feet. This includes one 3,500 feet thick.

Internal Structures

Small Inclusions. Three types of inclusions are recognized in the sills. One type consists of well-bedded, hard, undeformed argillite identical to that commonly found at the contact of the sills. The bedding is not parallel to that of the sedimentary rocks bordering the sill. The meta-diabase is chilled around a few inclusions that occur a few feet from the borders of sills.

Another type of inclusion occurs at many places in what is probably a single sill exposed discontinuously for more than 15 miles in the Léopard Lake area. The sill lies east of the small occurrence of volcanic rocks at the western boundary of this area and extends to the southeast corner of the area. This type of inclusion has not been seen in other sills. The fragments, 4 inches to several feet long, are well banded, many of them on a rather fine scale. Fragments and banding are contorted in many cases. The meta-gabbro around the inclusions is not chilled; instead, a few inches of a much coarser-grained, "pegmatitic meta-gabbro" may surround the inclusions. The passage from meta-gabbro to pegmatitic gabbro is gradational, but from pegmatitic gabbro to inclusions it is fairly sharp. The inclusions consist of the same minerals as are in the meta-gabbro, but in different proportions. Their textures are also similar. Albite riddled with clinozoisite is pseudomorphous after partly euhedral plagioclase crystals. Actinolite and minor chlorite may have replaced pyroxene, although this is not certain. Leucoxene has a texture similar to the exsolution texture of titaniferous magnetite which it has replaced. Apatite and quartz are primary. In general, the inclusions contained more quartz and, perhaps, a more sodic plagioclase than the surrounding gabbro. The good banding suggests that the inclusions were bedded sedimentary rocks because such good banding was not seen in any meta-gabbro of the area. If sedimentary, the fragments must have been intensely transfused (metasomatized) and completely recrystallized. The coarser crystallization of the marginal, pegmatitic meta-gabbro may have been promoted by the volatile content of the inclusions.

Small, whitish inclusions, a few inches long, occur in many places, especially in the upper and lower parts of very thick sills. Many are elongated, some are slab-like, a few have pointed ends and appear slightly stretched. The elongation of the fragments is commonly parallel to the attitude of the sill. They consist mainly of albite, clinozoisite, and a small amount of quartz; the plagioclase is euhedral against the quartz. Some may have had the same origin as the inclusions described above. A few gabbroic and diabasic inclusions, some with feldspathic rims, have also been observed.

Layering. Layering in some sills consists of alternating bands of different minerals, or of the same minerals in different proportions. Some bands are made up solely or chiefly of feldspar, others are of pyroxene or amphibole, and still others are rich in titaniferous magnetite. The contact between bands may be gradational or sharp. In some bands, feldspar shows a gradation in grain size; locally, the size of the feldspar laths increases with the percentage of feldspar in the band. A faint foliation produced by the sub-parallel arrangement of tabular feldspar crystals is common in the layered rocks and is parallel to the layers.

The layers are a few millimeters to a few centimeters thick and keep the same thickness through a single outcrop. Layered zones in sills can be traced for at least a few thousand feet along the strike. All the observed layering is parallel to the attitude of the sill in which it occurs and it was presumably sub-horizontal originally. It is a rare feature and has been observed only in the very thick sills, usually towards their centres, and is well shown west of the central part of Hellancourt lake and west of the northern part of Rougemont lake.

Feldspathic Streaks. Thin feldspathic streaks are found in many places, especially in the lower part of very thick sills. They are usually a few millimeters thick and one to 3 or 4 meters long. They lie parallel to the attitude of the sills. Some are planar but, more commonly, they are slightly curved and the convexity generally faces toward the top of the sill. Even where abundant, the streaks do not intersect. Their origin is uncertain; they may represent an extreme stretching of the feldspathic inclusions previously mentioned, or they may be related to the layering, or both.

Schlierens, Veins, and Irregular Masses. Thin veins and irregularly-shaped schlierens of medium- to coarse-grained "pegmatitic meta-gabbro" (originally similar to Walker's "dolerite-pegmatite", 1953) and of acidic material occur among finer-grained meta-gabbro in the middle and upper parts of many sills. The contacts are fairly sharp or gradational within short distances. The veins are a few inches thick and the schlierens are a few feet long. In thick sills, pegmatitic meta-gabbro may occur in fairly extensive masses and in gradational contact with the meta-gabbro. The quartz content is commonly lower in the large than in the small bodies.

An irregular mass, slightly more mafic than the gabbro in which it occurs, was found in a thick sill north of Rougemont lake. The mass is about 8 feet long and 2 feet thick and is elongated parallel to the contacts of the sill.

Acidic Dykes. A few quartzo-feldspathic dykes are present in the upper part of some sills, especially the thick ones. The dykes are a few inches to about 2 feet thick. Some are straight and maintain a fairly even thickness for more than 100 feet. Their contacts against the country rock are welded and fairly sharp, but not chilled. Their attitude is generally sub-parallel to that of the sill. Smaller veinlets that cut the rocks in random directions may be associated with the larger dykes.

Diabase "dykes". Small "dykes" of meta-diabase cut meta-gabbro in three or four places in the Léopard Lake area. The meta-diabase is chilled at the contact; the meta-gabbro is not. The "dykes" have sinuous, unmatching walls. Their widths vary from a few inches to a few feet within short distances. They could be traced for only a few feet or a few tens of feet. They were found in blotchy sills in two instances; both dyke-rock and country-rock contain blotches but in different proportions. Such "dykes" may represent injections from the liquid, central part of a sill into its solidified border.

Sill Contacts

The sill contacts, especially the upper ones, are poorly exposed but, where seen, they are commonly sharp, except in a few places at the top of thick sills. The meta-diabase is chilled at the contact.

Poor exposure of the sedimentary rocks makes it difficult to estimate how concordant the sills are. In small outcrops, the contact commonly follows the bedding very well but, here and there, it cuts across a few feet of strata. Small apophyses of meta-diabase occur at the base of sills in a few places. In the southeast part of the Léopard Lake area especially, the contacts seem irregular and tongues of sedimentary rocks apparently extend into the sills, and vice-versa. The sedimentary rocks may be slightly contorted near such contacts or arranged in isoclinal folds. The orientation of these fold axes differs from the regional orientation of fold axes; hence the contorted strata and the isoclines may have resulted from local stresses set up during the injection of the sills.

Breccia and Granophyre Balls. Some odd structures were found at three different places at the top of gabbro sills in the Léopard Lake area. Although they are apparently in sedimentary rocks they may be a result of the intrusions. They are described below.

(1) Breccia. At a small waterfall about 1,000 feet west of the south end of Rougemont lake, a dark rock with abundant quartzose fragments lies above, and in sharp contact with, a quartz-rich meta-gabbro with some quartzo-feldspathic schlierens. The fragments are 6 inches to a few feet across. The most abundant are largely composed of quartz and albite, with quartz greatly predominating. Chlorite, muscovite, epidote, and sphene are accessories. The quartz is largely in equi-granular grains, 0.3 to 0.6 mm. in diameter, with sutured boundaries; some of the larger grains have good sphericity. The other minerals, as well as some quartz, are in much smaller grains. The texture and composition are similar to those of a meta-quartzite.

Some of the fragments are spirally banded and look like "rolled-up" parts of recrystallized quartzite or chert beds. The fragments do not touch one another. They are made up of quartz, albite, chlorite, muscovite, and minor amounts of epidote, sphene, and sulphides. The composition is possibly fairly close to that of the argillites. The groundmass is largely structureless, but, in places, contains a fine, contorted lamination suggestive of bedding.

The breccia is about 10 feet thick. Its upper contact is poorly exposed, but it may be gradational into the overlying, undisturbed, finely-bedded argillites; this is supported by the presence in the upper part of the breccia of a few undeformed, angular fragments of well-bedded argillite and chert. The origin of the breccia is not clear, but it probably was caused by intense deformation. The influence of a fault is not too likely as schistosity is lacking in the groundmass. Deformation caused by the injection of the sill may be a better explanation since it would account for the apparently greater deformation nearer the sill. Also, the high temperature at the time of intrusion may explain why the brittle quartzose fragments were deformed plastically.

(2)A "pseudo-conglomerate" outcrops on the west shore of the peninsula in Rougemont lake. It lies above granophyre found at the top of a gabbro sill, but the contact between the granophyre and "pseudo-conglomerate" is not exposed. The fragments of the "pseudo-conglomerate" consist essentially of granophyric intergrowth of quartz and alkali-feldspar. Feldspar is perhaps slightly more abundant than quartz. Accessories include chlorite, clinozoisite, muscovite, leucoxene, and sulphides. The granophyre below differs only in containing many more phenocrysts of quartz and feldspar, 1 mm. in size. The granophyre balls are mainly well rounded, sub-spherical, and 1 foot to 3 feet in diameter. A few scattered, larger, angular pieces are also present. The groundmass is dark grey, massive and very fine grained. It consists mainly of quartz, albite, muscovite and chlorite, with feldspar as the most abundant mineral. Equidimensional grains of quartz and feldspar are set in a finer-grained matrix of the other minerals. Minor amounts of clinozoisite, sphene, apatite, and opaque minerals are present. The groundmass may have been derived from shale. A few thin veins of granophyre cut across one granophyre ball and, in some places, two. The origin of the "pseudo-conglomerate" is uncertain. That it probably was not formed by sedimentary processes is indicated by the similarity between the balls and the underlying granophyre and by the thin granophyre veins of similar composition. More likely, the formation of the balls is related to the intrusion of the gabbro magma. They could have been formed by injections of acidic magma in the sedimentary rocks or by fusion of sediments at the contact. They could also have formed by selective replacement of previous structures such as concretions, although this seems much less likely.

(3) Granophyre balls are poorly exposed near the western limit of the Léopard Lake area, 1/2 mile southwest of Rasle lake. The occurrence lies below sedimentary rocks and above a quartz gabbro or diorite with numerous, 1/2-inch, quartzo-feldspathic spots. The balls, set in a dark matrix, are similar to the granophyre balls described above, except that they are concentrically laminated.

Habit of Intrusion

Sedimentary Lenses, Split Sills. A large sedimentary lens, 1/4 mile west of the southern part of Rougemont lake in the Léopard Lake area, splits a thick sill into two parts. The lens is 8 miles long and slightly less than 1,000 feet thick. Two other lenses occur in a thick sill, 3 to 4 miles north of Rougemont lake in the central part of the Gerido Lake area. One lens consists of argillite; the other, of iron-bearing rock. Each is about 1/4 mile long and up to a few tens of feet thick. The bedding of the lenses parallels the contacts of the sill and the bedding of the sedimentary rocks above and below the sill. The meta-gabbro is chilled against the sedimentary lens in at least one place.

Northeast of Rougemont lake, a thick sill splits southward into two sills separated by a band of sedimentary rocks more than 500 feet thick. The sedimentary band lies mainly under the east arm of Rougemont lake.

Magma Feeders, Multiple Intrusions. As mentioned previously, no dykes or volcanic necks that may have served as feeders for the flows or sills have been found in the area, and, therefore, it is possible that the feeders were located outside the area. This would imply important lateral flow of magma in some sills. Sills found at different places, but at about the same stratigraphic horizon, may be directly joined (all the very thick sills of the area lie at about the same stratigraphic level, for example). In this connection, it is interesting to note that most of the blotchy gabbro may occur in a single sill below the volcanic formation. Similarly, another uncommon, very mafic sill occurs between the iron-bearing member of the Baby formation and the Hellancourt volcanics at different places in the Freneuse Lake area (Sauvé, 1956b).

Some features suggest that some sills were not emplaced in a single injection. For instance, the large, unbroken sedimentary lenses enclosed in thick sills can hardly be pieces from the sill roof that sank to the middle of the intrusives. Instead, it seems more likely that these sills were made by multiple intrusions (or variations of this as explained below) and that a slightly transgressive intrusion left behind part of the sedimentary rocks that occurred at the base or the top of a previous intrusion. Similarly, it is unlikely that the split sill could have been emplaced by a single injection without disrupting the very long sedimentary band found in the middle of the sill. Fine-grained zones found in the middle of some sills also suggest multiple intrusions. A fine-grained zone in the thick sill west of Hellancourt lake is underlain by much diabase pegmatite, which is commonly found in the upper part of the sills, and overlain by ultramafic gabbro, which is found at the base of sills in many places.

As used here, "multiple intrusion" does not necessarily imply that the magma from the first injection crystallized completely before the second injection. It is just as possible that the first part was still partly liquid when the second part was injected. This process would leave little evidence of multiple intrusions such as chilled zones and enclosed sedimentary lenses. The process could grade into a very long, possibly slightly intermittent injection which would be terminated only when a good part of the sill was already crystallized.

Features suggestive of multiple intrusions have been seen in nearly all of the very thick sills, in a few sills about 1,000 feet thick, but not in sills less than 300 feet thick.

Types of Gabbro

Common Meta-gabbro and Meta-diabase. These rocks make up the bulk of the sills of the area. Their fresh surfaces are generally medium to dark greenish grey, although some are pale grey, and their weathered surfaces are dark brown to black.

The original texture is partly preserved in many sills. Calcic plagioclase has been replaced by pseudomorphous patches of clinozoisite and albite, and the ferromagnesian minerals, mainly pyroxene, have been replaced by pseudomorphous actinolite and chlorite. The most common textures are ophitic and subophitic, but a hypidiomorphic-granular texture is seen in places in the thick sills. A common texture consists of more or less equidimensional actinolite grains that partly enclose a few small plagioclase grains near their borders, whereas the bulk of the plagioclase is clustered between the actinolite grains. The ophitic texture may pass into a poikilitic one in which large actinolite crystals produce a mottled lustre in hand-specimens. Poikilitic meta-gabbros are especially abundant in the lower part of some of the thick sills, but are also found in a few thin ones. Plagioclase grains commonly range in diameter from 0.2 to 1.0 mm. and actinolite,from 0.5 to 3.0 mm., except in poikilitic meta-gabbro where it is more than 5 mm. and sometimes as large as 2 centimeters.

Albite (An_{3-8}) and clinozoisite commonly make up 40 to 60% of the volume of the rock. Clinozoisite is generally extremely fine grained and is disseminated through the albite crystals. It is so abundant that it is difficult to recognize albite in many slides.

Amphibole and chlorite form 35 to 55% of the volume of the ordinary meta-gabbro. The amphibole is generally tremolite-actinolite. Its properties are: 2V from 76° to 82° but mainly 78° to 80°, Z against c 15° to 17°, optically negative colourless or weakly pleochroic from colourless to pale green. Actinolite may enclose patches of, or may be rimmed by, moderately to deeply pleochroic "hornblende" in crystallographic continuity with actinolite. This is common in chlorite-poor or chlorite-free rocks. Hornblende has a smaller 2V (some measurements: 63°, 68°, 70°) and a lower birefringence than actinolite. A deep blue-green hornblende occurs in many rocks in the western part of the Thévenet Lake area. Its pleochroic formula is: X: yellow; Y: deep green; Z: deep blue-green. Chlorite has a very low birefringence. The interference colours are commonly anomalous in brown, brownish-grey, grey and greyish-blue. Anomalous brown chlorite is generally optically positive; anomalous blue chlorite is commonly negative. The former variety is more abundant than the latter. Their pleochroisms vary from nil to moderate in yellow to green. Absorption may be either $X > Z$ or $Z > X$, but is always least in the direction perpendicular to the cleavage. Much of the chlorite forms small patches within actinolite crystals. Actinolite is generally more abundant than chlorite, especially in the middle part of thick sills. Chlorite may be nearly as abundant as actinolite in sills of moderate thickness,at the borders of thick sills,and in some sheared meta-gabbros. Meta-gabbros with calcite have generally less actinolite and clinozoisite and more chlorite than calcite-free meta-gabbros. Actinolite is missing in a few carbonate-rich rocks.

Primary quartz occurs in interstitial grains in many mata-gabbros. It is always present in the upper part of the thick sills, but also occurs in the middle and lower part of some sills. It generally forms about 1 to 3 % of the quartz-bearing meta-gabbros. An increase in quartz content toward the top of the sills is fairly common, and some meta-gabbros in the upper part of sills contain 7 to 9% quartz. Small granules of metamorphic quartz are common in relatively chlorite-rich meta-gabbros.

Apatite is a primary accessory mineral commonly found in quartz. Primary titaniferous magnetite occurs in small amounts. The crystals may be subhedral, but are commonly moulded around the shape of the former pyroxene or plagioclase crystals. Leucoxene (mainly sphene) has partly or completely replaced titaniferous magnetite. The intergrown structure of magnetite and ilmenite is preserved in leucoxene in many places. Muscovite may occur in minor amounts in plagioclase. Green and brown biotites are common in some thin sills near the eastern limit of the Gerido Lake area and in the Thévenet Lake area. Stilpnomelane occurs in some quartz-bearing meta-gabbros in the upper part of very thick sills. It is also present in a few thin sills of quartz-free and quartz-poor meta-gabbro in the southwestern part of the Léopard

Lake area. It is commonly pleochroic from red-brown to golden yellow with bright red, thin, basal plates. Green and brown stilpnomelane are also present. Chalcopyrite, pyrrhotite, and pyrite occur in places, and are commonly associated with quartz and chlorite.

Carbonatized and Potassium-enriched Gabbro. A few meta-gabbros contain much carbonate and some contain much muscovite. Most of these gabbros are found in the eastern half of the Gerido Lake area, and they occur mainly near the axial planes of tight anticlines. Some of the most extreme cases of carbonatization and sericitization occur in thin sills in or near the iron-bearing formation near Hianveu lake and, also, about 5 miles southeast of this lake. In these places, the rock has a light grey weathered surface and is quite different in appearance and composition from the common meta-gabbros.

There is complete gradation from ordinary meta-gabbro with minor carbonate to carbonate-rich rocks. Where carbonate forms 5 to 10% of the rock, actinolite is present in small amounts. As the percentage of carbonate increases, actinolite and epidote become less abundant until they disappear, whereas chlorite becomes increasingly abundant. In one example, a rock contains 17% quartz, 15% albite, 14% carbonate, 51% chlorite, 3% leucoxene, and traces of epidote and muscovite. If the H_2O and CO_2 were subtracted, the chemical composition of this rock would fall within the range of the common meta-gabbro. In other rocks, potassium was added as well to form muscovite, with a corresponding decrease in the amount of chlorite. Rarely, nearly all the chlorite was transformed. For example, one rock contains 17% quartz, 26% albite, 28% muscovite, 28% dolomite and magnesite-siderite, 1% rutile, and only traces of chlorite. Nearly 50% of some rocks is of carbonate.

The original texture is almost entirely destroyed in the carbonatized gabbro. Albite occurs in elongated crystals with albite twins parallel to their elongations. This is the only remnant of the diabasic texture. It helps to distinguish the meta-gabbros from the metasedimentary rocks, since the albite of the latter is generally equigranular.

Amphibolite. Amphibolites are abundant among the schists east of Rachel lake and are obviously more highly metamorphosed equivalents of the meta-gabbro and lavas found to the west. These rocks are green to black. They generally show a very good foliation parallel to that of the surrounding schists. Some amphibolite bodies pinch and swell, probably as a result of tectonic deformation.

The rocks are made up essentially of hornblende and subordinate plagioclase. A common texture consists of a sub-parallel arrangement of slender prismatic hornblende crystals, about 1 to 2 mm. long, with trains of much smaller (0.1 to 0.3 mm.), equigranular plagioclase grains between the prisms. Some rocks have abundant "lumps" of hornblende, 3 to 7 mm. in size, set in a schistose matrix of much finer hornblende and plagioclase. The schistosity wraps around the lumps. Some lumps contain lath-shaped inclusions chiefly composed of feldspar and epidote. These features obviously derive from an original ophitic or poikilitic texture in a coarse-grained gabbro.

The hornblende is commonly green; some is blue-green. In some rocks, which are probably rich in iron, blue-green amphibole may occur with a minor amount of colourless amphibole, possibly of the cummingtonite series. Plagioclase is generally in very fine grains, equigranular, and strongly zoned, the rim being more calcic than the core. It has refractive indices higher than that of Canada balsam. Epidote occurs in small, zoned crystals, 0.1 to 0.3 mm. in size. It is better crystallized and much less abundant than in the greenschist facies. It is missing in many amphibolites. Garnet is commonly in fine grains but may occur in crystals up to 6 or 7 mm. in diamater. However, it is missing in more than half of the amphibolites. Accessory minerals include quartz, chlorite, biotite, sphene, pyrite or pyrrhotite, and magnetite. Talc occurs in one sample of carbonatized or ultramafic gabbro along with carbonate, chlorite, minor amounts of magnetite, and colourless amphibole.

Fresh Gabbro. Partly fresh gabbro with remnants of the original plagioclase or pyroxene occurs in the centres of some of the very thick sills of the area. It is fairly common in the eastern half of the Gerido Lake area. It also occurs in the middle part of a sill, which is less than 1,000 feet thick, south of Dupuy lake in the Léopard Lake area.

Sufficiently fresh gabbro can easily be distinguished in the field from the more altered gabbros. It has a dark grey to black fresh surface, and the cleavage of its laths is commonly visible. On the other hand, common meta-gabbros do not generally show the plagioclase cleavage and their fresh surfaces are usually greenish or a very light colour; furthermore, the brown tinge of the hypersthene is easily seen with the naked eye in some samples.

Olivine was probably present in less than half of the gabbros, but it is highly susceptible to alteration and is preserved only in a few cases. It occurs in rounded granules 0.5 to 0.7 mm. in diameter or, more rarely, in euhedral crystals. Some grains are as large as 2 mm. Some granules are enclosed in pyroxene and, less commonly, in bytownite. Occasionally the olivine encloses small pyroxene or plagioclase granules. The border of olivine is commonly replaced by tremolite and serpentine. Rounded granules of tremolite or chlorite-serpentine within pyroxene indicate the former presence of olivine in some of the gabbro.

Pyroxene is much more abundant than olivine. Both clinopyroxene and orthopyroxene are present, although the latter was found in only a few thin sections and, even in these, clinopyroxene is more abundant than orthopyroxene. Orthopyroxene commonly shows a very faint pleochroism from pink to green. In one case, it has a 2V of 104^0 suggestive of a bronzite composition (nomenclature of Walker and Poldervaart, 1949). Orthopyroxene may have extremely fine lamellae parallel to (100) and resembling fine polysynthetic twinning. It occurs in euhedral to subhedral, equidimensional to slightly elongated crystals, 1/2 mm. to 2 mm. in size. Some crystals are partly replaced by talc along grain boundaries and along fractures. It is also partly altered to tremolite-actinolite. Augite crystals have a 2V of 54^0 to 48^0, Z against c of about 40^0 to 46^0, and are optically positive. Some are zoned, their 2V decreasing from the core outward. Fine lamellae of even width are parallel to (001), larger lamellae of uneven width are present in (100). In some rocks, the lamellae have a patchy distribution even in single augite crystals. Augite may be subhedral, sub-ophitic, and even poikilitic. Its length rarely exceeds 3 mm. except in poikilitic gabbro where it may be greater than 2 centimeters. Augite may be partly altered to actinolite.

Fresh plagioclase ranges in composition from sodic labradorite to calcic bytownite (about An_{88} in some cases). More sodic primary plagioclase is also present, but it is not abundant and occurs mainly in narrow rims around labradorite crystals in some quartz-bearing gabbros. Zoning is common and may be "normal", rhythmic, or even reversed. Polysynthetic twins are also common; the twinning being predominantly after the albite law. The plagioclase crystals are commonly euhedral to subhedral. Usually, the sodic rim of plagioclase is irregular against quartz and may be intergrown with it. In places, nearly opaque patches of clinozoisite occur at random in the plagioclase crystals.

Partly fresh gabbros grade laterally into altered ones. All stages were seen from calcic plagioclase with a few patches of clinozoisite to completely altered albite riddled with clinozoisite, and from fresh augite to augite almost entirely replaced by actinolite. Many gabbros contain small remnants of augite with none of the former plagioclase. Only a few feldspathic gabbros contain labradorite remnants with no trace of pyroxene. The partly fresh gabbros are more altered near narrow veinlets and small shear zones.

None of the gabbro is entirely fresh and the partly fresh gabbro was obviously emplaced before metamorphism. Both partly fresh and highly metamorphosed gabbros occur in many places in the east half of the Gerido Lake area. Their distribution indicates that differences in temperature, rock pressure, or shearing stress cannot account for the preservation of only part of the gabbros. Originally, the chemical and mineralogical compositions, grain-size, and texture were the same in the fresh and the altered gabbro; thus, these features cannot account for possibly slower reaction rates and chemical disequilibrium in the fresh gabbros. The altered gabbros contain more "combined" water than the fresh gabbros (both contain negligible amounts of "adsorbed" water). Thus, water must have been added to the sills for complete alteration. As the gabbro is quite impervious, a "deficiency" of water accounts very well for the presence of the partly fresh gabbro. This also explains why fresh gabbro occurs mainly in the centres of the very thick sills. Furthermore, this explanation is consistent with the present water distribution in the thick sills: very little water in the fresh central parts, more water in some chlorite-rich contacts. In addition, near small fractures and shear-zones, which may have served as channels for water, the fresh gabbro is more altered. Finally, the gabbros that need more water for complete alteration, namely the ultramafic types, are better preserved in some cases. For example, olivine is poorly preserved in the fresh gabbro in the central parts of some sills but is abundant in a few ultramafic rocks near the borders of sills.

Ultramafic Gabbro. In the lower and middle parts of some of the very thick gabbro sills occur long lenses of more or less highly metamorphosed meta-gabbros or ultramafic gabbros composed of more than 70% of ferromagnesian minerals. Some of these lenses are more than a mile long. They occur in the sills near Hellancourt lake, in those east of Lafortune lake in the eastern part of the Gerido Lake area, and in those in the northwestern corner of the Thévenet Lake area. Ultramafic rocks also occur east and northeast of Rachel lake where they apparently make up the bulk of sills that are a few hundred feet thick.

In the field, many ultramafic rocks are easily recognized by a characteristic brown or reddish brown weathered surface, but some have a light green surface. Fractures are abundant and fairly characteristic of these rocks, and many are distinctly magnetic.

Where preserved, the original texture is commonly hypidiomorphic-granular or allotriomorphic. Much olivine and serpentine occur as rounded granules poikilitically enclosed in pyroxene or in actinolite-tremolite pseudomorphous after pyroxene.

The dominant minerals are actinolite, serpentine, and chlorite, with some pyroxene and rarer olivine. Two different chlorite-like minerals occur side by side in some thin sections. One is optically positive and its birefringence is very low to nil with anomalous dark brown tints. It is similar to the chlorite in the meta-gabbros. A small part has apparently replaced plagioclase and the mineral may be a normal, aluminous chlorite. The other mineral has anomalous bluish interference tints, is pleochroic from nil to weak in flesh (X) to green (Z), apparently has a small 2V, and is optically negative. In many cases, it obviously has replaced olivine. It may be an aluminum-free or aluminum-poor chlorite and is called serpentine in this report. Calcic plagioclase (about An_{85}) is partly preserved in a few cases. In altered rocks rich in serpentine, plagioclase and clinozoisite are missing. Brown and reddish brown hornblende is present in minor amounts in some rocks. It clearly predates tremolite-actinolite and may be pre-metamorphic because: (1) it is not the typical metamorphic amphibole found in these rocks, and (2) it is rare in very altered rocks but occurs in relatively fresh ones in which even olivine is largely preserved. It has partly replaced pyroxene in some cases and is possibly a late magmatic or deuteric mineral. Secondary magnetite, formed during the alteration of olivine,is relatively abundant in serpentine-rich rocks.

All gradations from common gabbro to ultramafic gabbro were seen. The less mafic meta-gabbros are similar to the gabbros but contain, or originally contained, 20-30% feldspar. The composition of the ultramafics is variable; Table 7 gives the modal composition of 4 types. The fresh types are less common than the altered ones. Some are close in composition to pyroxenite and peridotite, but most of them probably contained slightly more than 10% calcic plagioclase.

Table 7

Modal Composition, in Volume Percentage, of Ultramafic Gabbro

Sample No.	S-81	R-196	R-160	R-189-174
Plagioclase	16.8	8.1		
Clinozoisite	5.6	4.0		
Olivine	18.0	15.3		
Hypersthene	2.6	3.2		
Augite	37.9	48.5		17.8
Brown hornblende	0.4			0.2
Actinolite	12.5	3.6	65.4	12.6
Serpentine	4.7 (Serpentine and Chlorite)	13.5		61.9
Chlorite		1.4	33.9	
Opaque	1.5	2.4	0.7	7.5

In thick sills, ultramafic gabbro grades into common gabbro. No chill or fine-grained zones could be observed between the two. The ultramafic rock, in this case, probably formed by differentiation from the basaltic magma within the sill, possibly by crystal settling. It may also have formed by a separate injection of ultrabasic magma within the sill, but the hypothesis of differentiation is favoured because of the lens-like character of the ultramafic bodies and their restriction to the lower and middle parts of sills. The ultramafics that formed the bulk of relatively thin sills are highly deformed and poorly known. They possibly crystallized from an ultrabasic (i.e., less than 45% silica content) or nearly ultrabasic magma.

Diabase-Pegmatite. The manner of occurrence of diabase-pegmatite or pegmatitic gabbro (dolerite-pegmatite of some authors) has been described previously. In the field, the rock is easily distinguished from the common gabbro by a grain size that is at least double that of the gabbro and by the fair amount of 1/4- to 1/2- inch quartz grains. These distinctions hold good although the grain size of the diabase-pegmatite varies widely, even in hand specimen. Coarse magnetite crystals are common; feldspar crystals are larger than 3 mm.; actinolite and hornblende crystals may be more than 1/2 inch long and some are 4 inches long.

The mineral components of the diabase-pegmatite and the diabase are the same, but their proportions differ. Albite (An_5), with inclusions of clinozoisite-epidote, is pseudomorphous after a more calcic plagioclase. Commonly, the ratio of clinozoisite to albite is small and albite is fairly clear. Thus, the original plagioclase was probably more sodic in the diabase-pegmatite than in the diabase. In a few cases, however, albite is clouded with much clinozoisite and the original plagioclase was apparently relatively calcic. In such cases, plagioclase-clinozoisite grains are rimmed with clear albite at the contact with quartz, but not at the contact with amphibole. Some of these cloudy crystals show signs of resorbtion, with embayments filled by quartz. Plagioclase crystals are generally anhedral but some, especially those in contact with, or within, amphibole are subhedral to euhedral. Actinolite and blue-green hornblende are abundant as elongated, partly curved, crystals. In some places they are arranged in radiating bunches. Although the texture may be primary, actinolite, at least, is metamorphic. In a few rare cases, clear evidence of replacement by actinolite is seen around small clinopyroxene remnants. Quartz is always in anhedral grains, in part intergrown with albite. It is more abundant in the diabase-pegmatite than in the meta-gabbro and commonly more abundant in the small patches or schlierens than in the large masses of diabase-pegmatite. Titaniferous magnetite and apatite are also more abundant here than in the common meta-gabbro. Sphene, chlorite, muscovite, and carbonate are minor constituents of some rocks.

The large, irregular masses of diabase-pegmatite are apparently a normal product of the crystallization of the gabbro, as suggested by their ubiquitous occurrence in all the very thick sills. A gradation in grain size between gabbro and diabase-pegmatite may be observed locally. The diabase-pegmatite is richer in quartz and sodic plagioclase than the gabbro. These minerals are typically late-forming in the crystallization of the gabbro and the diabase-pegmatite also probably formed rather late. Tomkeieff (1929, in Walker and Poldervaart, 1949, p. 662) and Walker and Poldervaart themselves (1949) attribute the formation of some diabase-pegmatite to a concentration of volatiles in the magma, thereby reducing viscosity and promoting the growth of large crystals. This may well apply to the rocks of the area. The sharply defined schlieren and lenses of diabase-pegmatite possibly formed differently, perhaps from inclusions of acidic rocks.

Transition Rock, Quartz Diorite, Granophyre

The upper part of the very thick sills is commonly markedly acidic and may contain large lenses of metamorphosed quartz diorite. The rock is abundant near Rougemont, Dupuy, and Hellancourt lakes, and east of Montplaisir and Des Moineaux lakes in the Gerido Lake and

Léopard Lake areas. Small lenses of quartz diorite also occur north of the middle part of Léopard lake, and 3/4 mile southwest of Rasle lake, near the western boundary of the Léopard Lake area. Commonly, the lenses are larger in the thicker sills. West of Hellancourt lake, about 700 feet of quartz diorite occurs in a sill roughly 3,500 feet thick. Acidic quartz diorite and granophyre also occur in small dykes or veins, up to a foot thick, in quartz-bearing meta-gabbro in the upper part of some sills. The contacts are welded but not chilled.

The contacts between gabbro and the large lenses of quartz diorite are commonly poorly exposed. West of the south end of Hellancourt lake, the observed relationships seem typical of many other places in the area. The gabbro passes upward (eastward) into a quartz-bearing gabbro with minor stilpnomelane. Then comes a thin (roughly 10 to 30 feet) zone made up of "transition rock" rich in stilpnomelane. This rock grades within a short distance into quartz-feldspar-rich diorite with variable grain size and composition. This rock, in turn, changes slowly upward into a rock containing more feldspar and less quartz, then into a more mafic quartz diorite. Near the upper contact of the sill, the rock becomes finer grained and passes into a meta-diabase with small quartzo-feldspathic spots here and there. The contact with the overlying argillites is sharp.

Description and Composition. These rocks vary much in appearance and composition. The relatively mafic types are less abundant than the acidic ones and form, in many places, a transition zone between quartz-bearing gabbro and acidic quartz diorite. There is complete gradation between these rock types.

The "transition rock" consists of metamorphosed ferrogabbro and mafic quartz ferrodiorite. It is commonly black or dark grey and fine grained, deeply weathered, and contains abundant, easily visible specks of black or blue quartz as well as characteristic shiny black, tiny crystals of stilpnomelane. The ferromagnesian minerals make up about 50% of the rock; the feldspar and clinozoisite contents vary widely. The feldspar, albite, contains much clinozoisite, but is generally clearer than the albite of the common meta-gabbro, suggesting a more sodic original plagioclase. It is commonly euhedral where it is found against or partly enclosed by a ferromagnesian, and subhedral to anhedral against quartz. Anhedral grains of metamorphic actinolite and hornblende are abundant. Primary, pale green clinopyroxene is partly replaced by actinolite in one thin section. Chlorite and biotite are abundant in some rocks. Stilpnomelane, although one of the most characteristic minerals, is not abundant. Apatite is present in most thin sections but forms only a small part of the rock; however,it is much more abundant here than in the meta-gabbro. Other minerals generally present are titaniferous magnetite, sphene, and epidote.

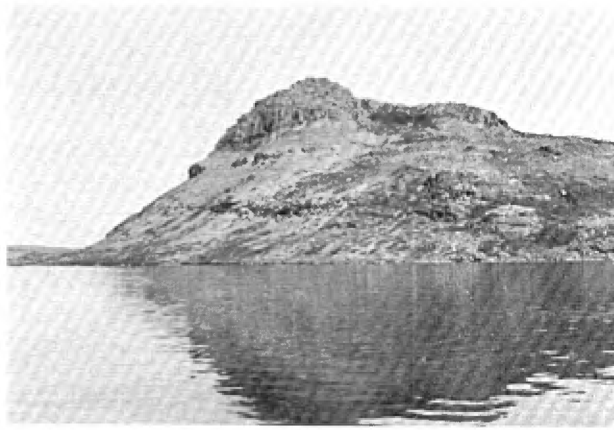
The mafic rocks may grade into a medium grey, feldspar-rich rock. The latter has a dark grey weathered surface that is generally faintly spotted in lighter grey owing to clustering of feldspar grains. The feldspar-rich rock may grade, in turn, into a more acidic, quartz-feldspar-rich, light grey to white rock. A some places, the texture is granular and the rock looks much like a quartzite in hand specimens. The more acidic types may consist of more than 80% quartz and feldspar. Quartz alone makes up more than 40% of a few specimens, but most commonly makes up between 10% and 35%. Feldspar is generally the dominant mineral and a large part of the acidic rock contains about 50% feldspar. It consists of fairly clear albite and contains only a small amount of clinozoisite or epidote. Feldspar and quartz commonly occur in anhedral grains. Many rocks rich in quartz and feldspar have a mosaic texture or show an intergrowth of the two minerals varying from "graphic" to irregular. Chlorite, actinolite, and biotite are present in much of the rock. Stilpnomelane, typically present in the relatively mafic part, may be scarce or even missing in some specimens of the acidic quartz-diorite. Apatite is also much less abundant here. Muscovite is present in some acidic rocks, but scarce in the relatively more mafic types.

Abrupt lateral changes in texture and composition occur in some places, especially in the most acidic rocks. Thus, small pods or masses, composed mainly of quartz or quartz and epidote, are found.

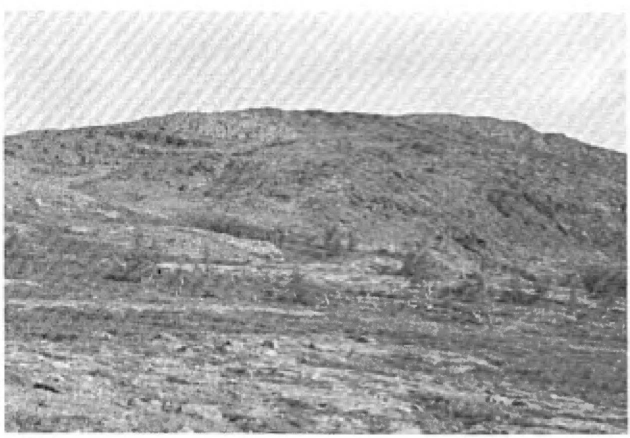
Although granophyre is not abundant it may form the bulk of the most acidic types of rock. It is well developed on the western shore of Rougemont lake, near its northern end, and near the southern tip of the long peninsula in Rougemont lake. The granophyre is mainly composed of intergrown quartz and feldspar but typically has a few phenocrysts 1 mm. in size. The phenocrysts are made up of euhedral grains of quartz and feldspar, surrounded by a rim of intergrown quartz and feldspar with the mineral in the phenocryst in crystallographic continuity with the same mineral in the rim. Some quartz phenocrysts show signs of resorbtion.

The chemical composition of two of these rocks is listed in Table 9. One, (No. 4) a "transition rock", is a metamorphosed quartz-bearing ferrogabbro. Another, (No. 5) more acidic, was a quartz (ferro) diorite. Both rocks are characterized by extremely high FeO to MgO ratio.

PLATE I



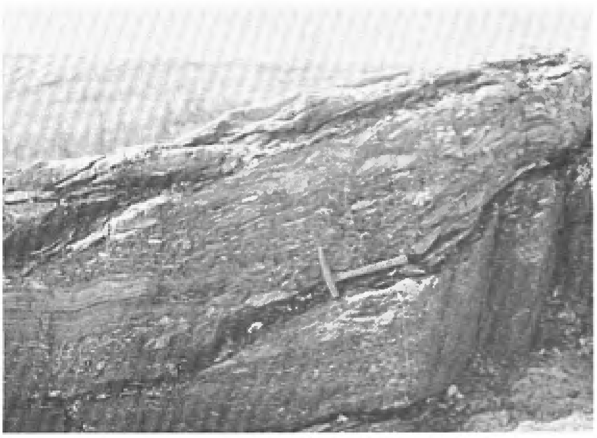
A.— Gabbro sill overlying phyllites, northern part of Rougemont lake.



B.— Scarce vegetation, east of Rougemont lake, Gerido Lake area. Gabbro sill (light area, left of centre near sky-line is cut by a fault).

C.— "Barren Lands". Looking southwest across southern part of Gerido lake.

PLATE II

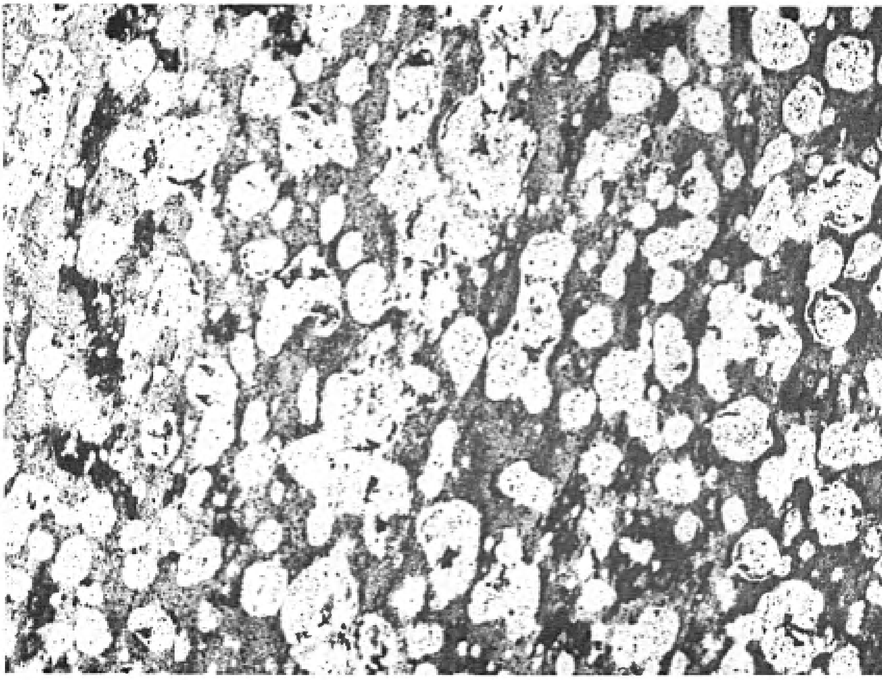


A.– Ferruginous conglomerate above iron-bearing rocks, east of Bow creek, Léopard Lake area.

B.– Straight bedding and fracture cleavage in phyllites close to a thick gabbro sill.

C.– Folds in the iron-bearing member of Baby formation, southwest of Hianveu lake, Gerido Lake area.

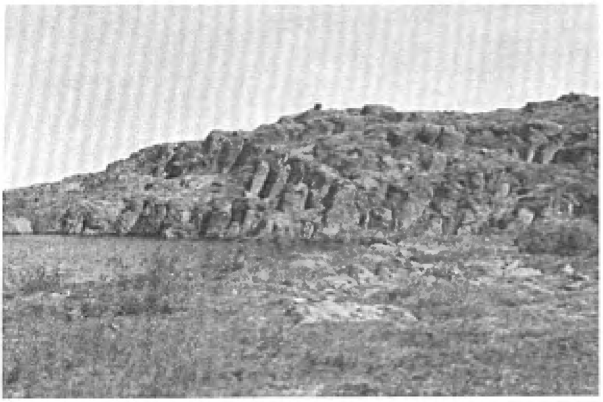
PLATE III



A.– Photomicrograph of a "spotted adinole". Mainly quartz and albite with minor chlorite, clinozoisite, and sphene concentrated in the dark areas. Clear areas probably pseudomorphous after a contact metamorphic mineral (11.3X).

B.– Irregularly folded quartzose bands in marble, east of Rachel lake.

PLATE IV

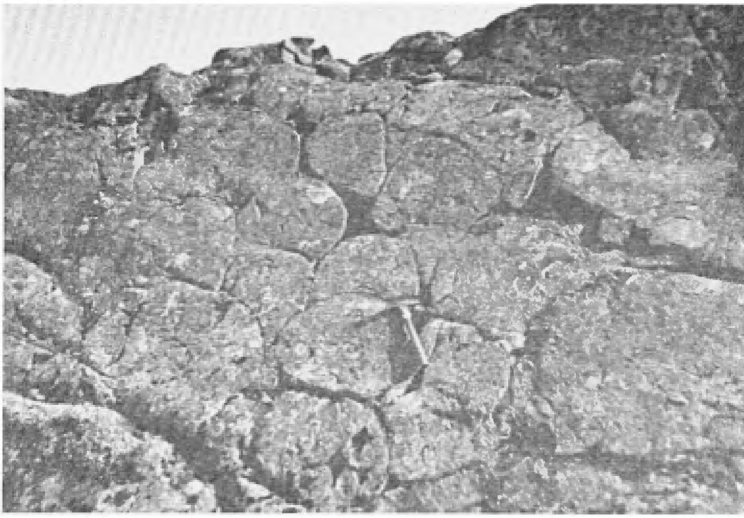


A.– Columnar jointing in lava flow, east of Hellancourt lake, Gerido Lake area.

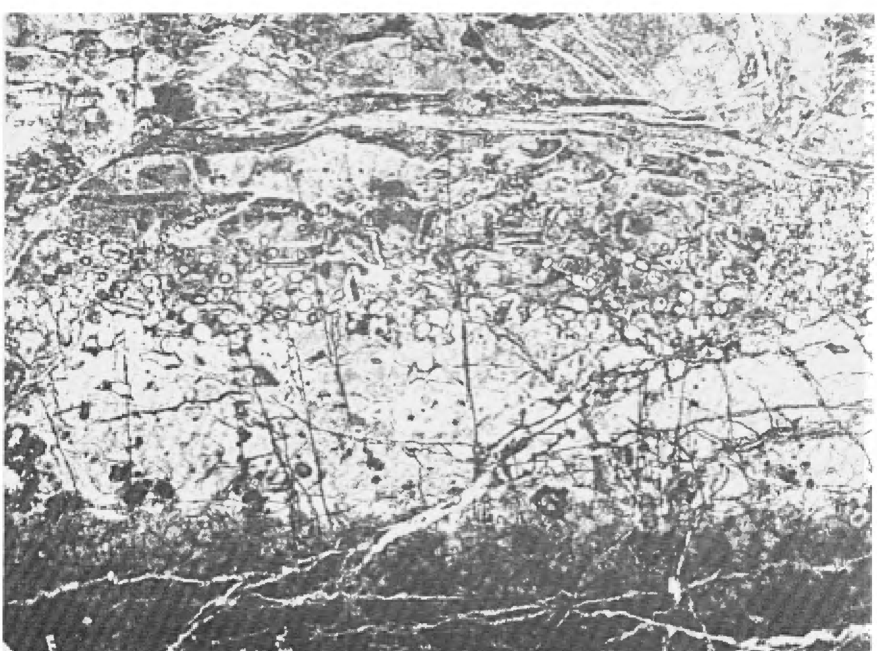
B.– Abundant tabular cavities in a pillow. Strike of the flow parallels the hammer handle and the cavities. Dips vertical; tops to the right.

C.– Unusually abundant tabular cavities in the upper part of a pillow. Flow is vertical; tops are to the right.

PLATE V

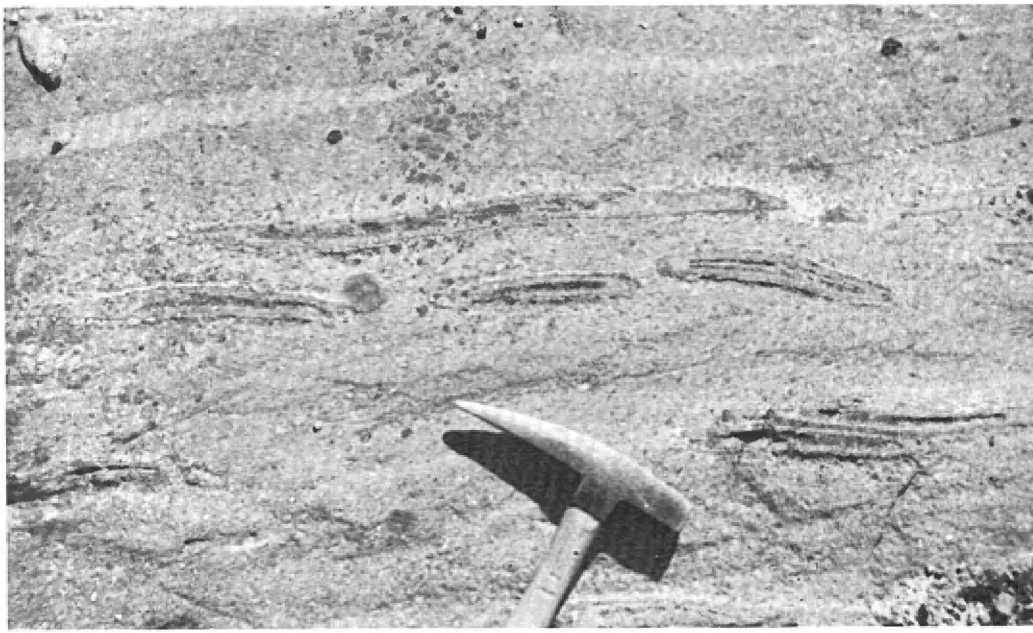


A.— Pillow lavas with very little scoriaceous material. Snug "fit" of pillows and long downward-projecting tips (above hammer and two feet left of hammer) indicate mobility of lava.



B.— Photomicrograph of the edge of a volcanic pillow. Structure of fracture glass preserved in upper part. Individual varioles near middle of photograph pass downward into larger, coalescing varioles. (11.3X).

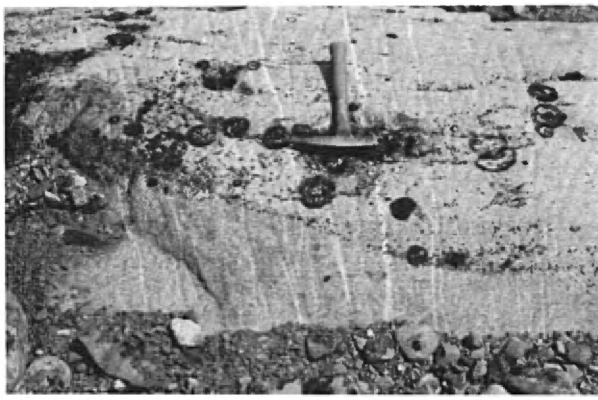
PLATE VI



A.– Concretions in Thévenet formation, southwest of Thévenet lake.

B.– Quartz-pebble conglomerate interbedded with mica schist. Above volcanic conglomerate, east of Barrie lake, Thévenet Lake area.

PLATE VII



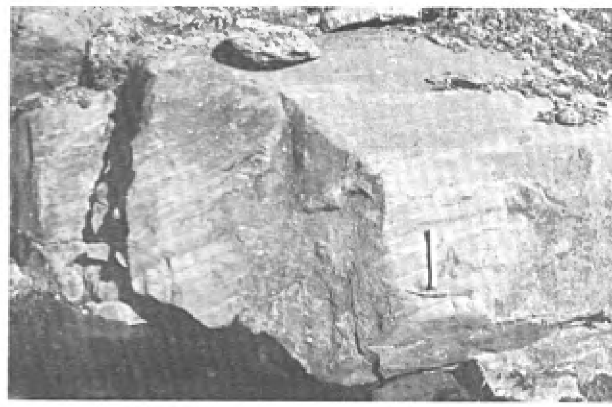
A.— Feldspathic streaks in gabbro.

B.— Aligned, slightly stretched inclusions in gabbro.

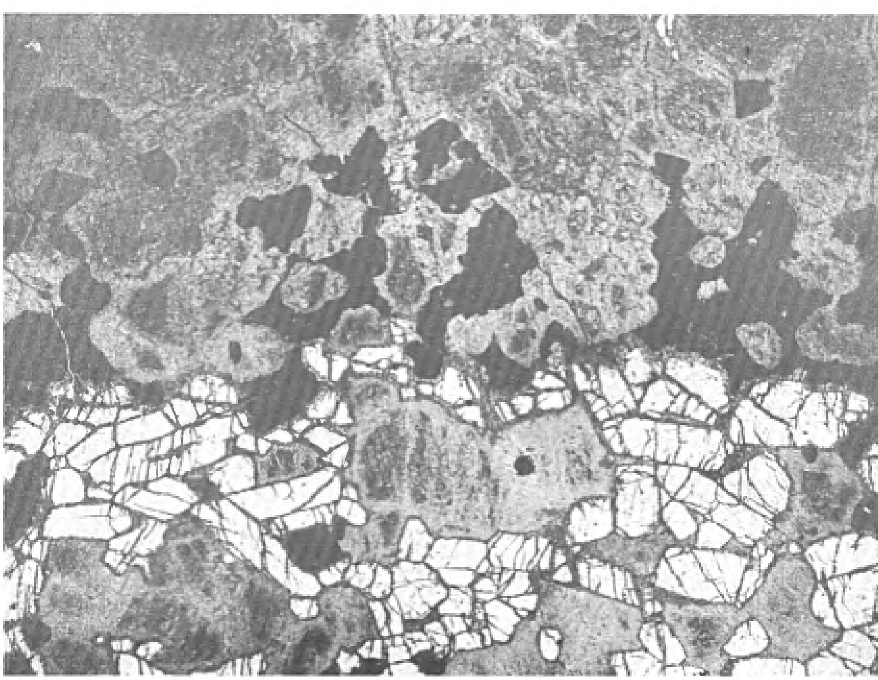
C.— Aligned, slabby inclusions in gabbro.

PLATE VIII

A.– Layering in a vertical gabbro sill.

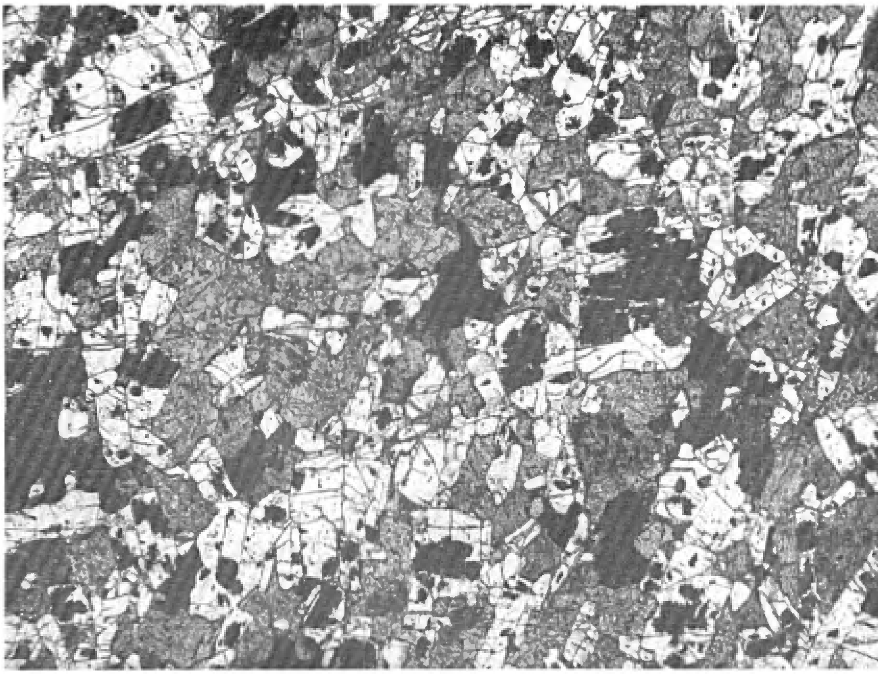


B.– Layering in gabbro.

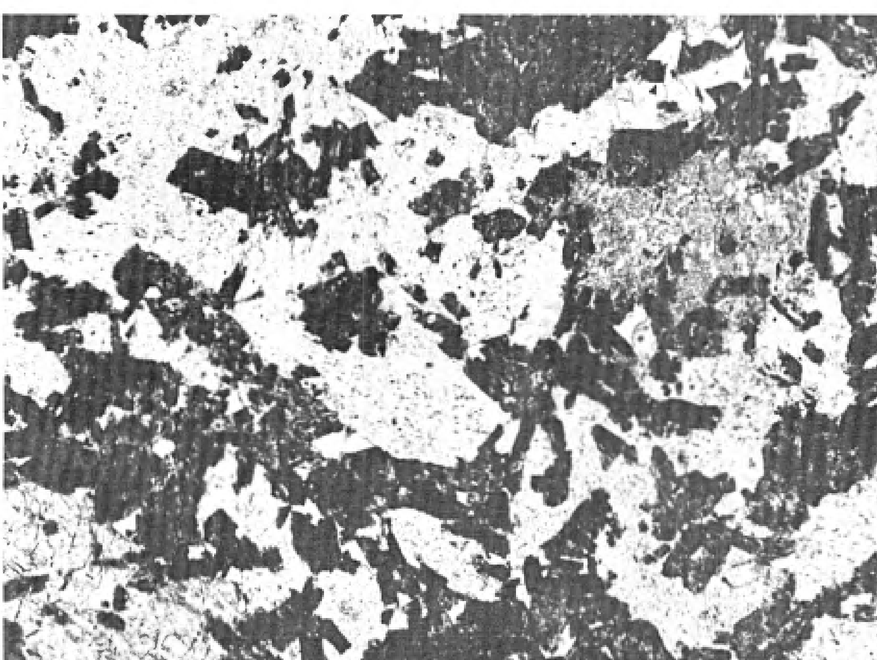


C.– Layered meta-gabbro. Labradorite is white, titaniferous magnetite is black, dark grey pyroxene is surrounded by lighter grey actinolite. (10X).

PLATE IX



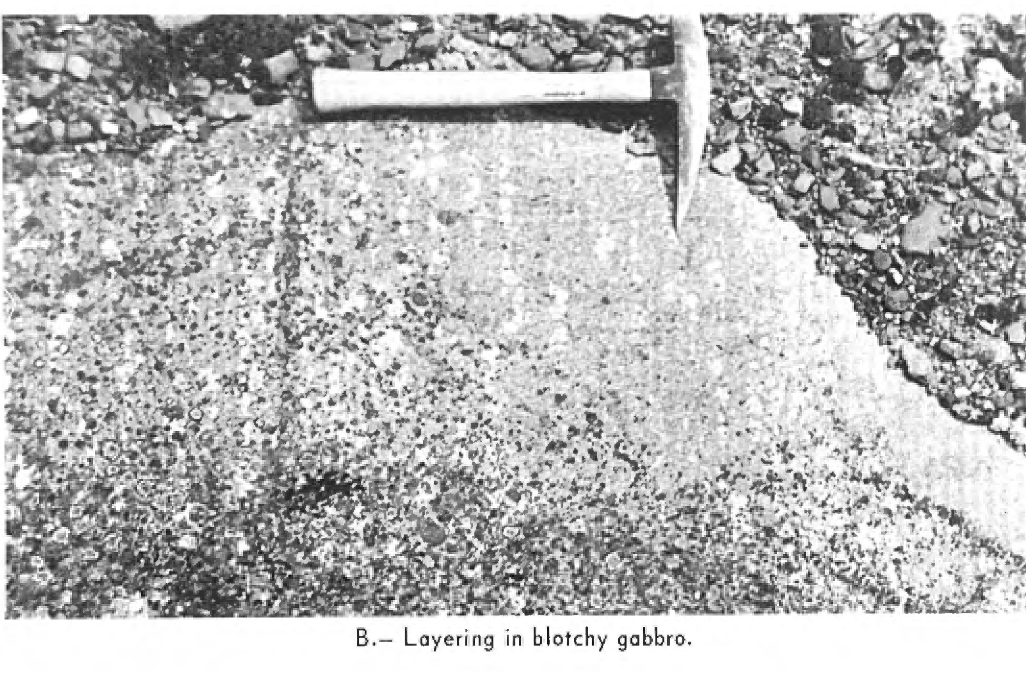
A.– Partly fresh gabbro. Labradorite contains dark clinozoisite patches. The few black patches outside the feldspar are magnetite. Pyroxene and minor amphibole are grey. (15X)



B.– Quartz-bearing meta-gabbro with well preserved original texture. The rock contains primary quartz (clear white), light-grey actinolite with minor chlorite, and a dark mixture of albite and clinozoisite. (15X)

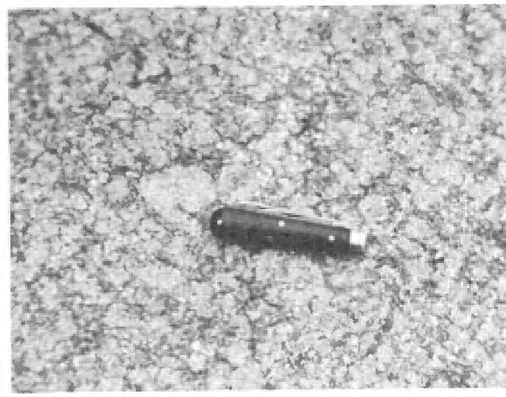
PLATE X

A.— Blotchy gabbro with large feldspathic patches.

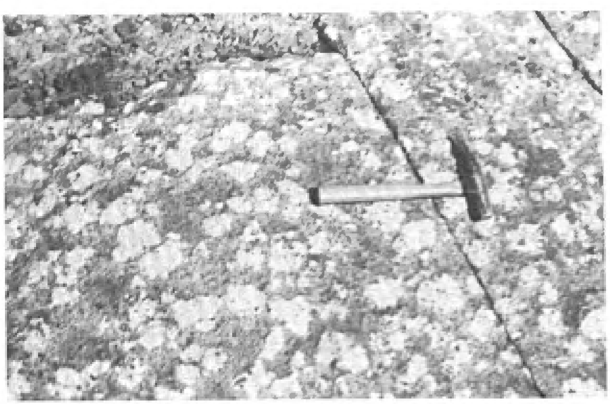


B.— Layering in blotchy gabbro.

PLATE XI



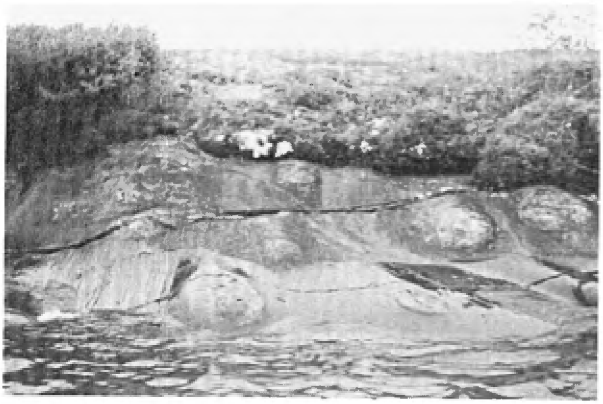
A.– Typical blotchy gabbro.



B.– Blotchy gabbro with large patches.

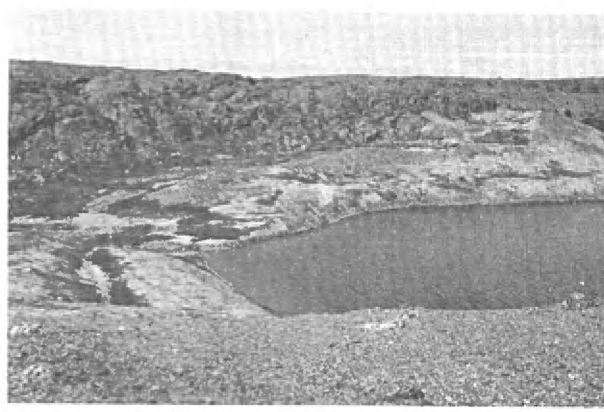
C.– Blotchy gabbro in amphibolite facies of metamorphism, east of Rachel lake.

PLATE XII



A.— Granophyre "balls" above gabbro sill, near southern end of long peninsula in Rougemont lake.

B.— Small esker in valley, east of Rougemont lake, Gerido Lake area.



C.— Esker, 1 mile north of Thévenet lake. Gabbro sill across the lake, overlying schist with clearly defined contact.

The writers believe that stilpnomelane is commonly characteristic of rocks with a high FeO to MgO ratio. The mineral occurs in all the "transition rock" and relatively mafic quartz diorite of the area and is missing in nearly all other meta-igneous rocks.

<u>Origin of Quartz Diorite</u>. The following relationships between quartz diorite and gabbro are summarized here as they are significant in explaining the origin of the quartz diorite.

1- Quartz diorite occurs only in association with gabbro sills.
2- It is present only at the top of the gabbro sills.
3- It forms only a small part of the sills in which it occurs.
4- It is related to the thickness of the sills, being abundant only in the very thick ones.
5- In thick sills in which it is missing and in sills of medium thickness, a tendency to enrichment in quartz and sodic feldspar at the top of the sills is commonly visible. This consists of quartz-bearing gabbro, diabase-pegmatite, and diabase with relatively coarse-grained, quartzo-feldspathic spots.
6- There is gradation from gabbro to ferrogabbro, to relatively mafic quartz (ferro) diorite, to acidic quartz diorite.

The quartz diorite may have formed by the following processes:

1- Contact effect of gabbro on sedimentary rocks.
2- Separate injection of magma with the chemical composition of quartz diorite.
3- Differentiation from basaltic magma within the sills.

(1) In some regions, a small amount of granophyre has formed by the melting of sedimentary rocks during intrusions of diabase (for instance, see Walker and Poldervaart, 1949). However, this hypothesis does not account for the large size of the masses of quartz diorite of the present area, especially since much smaller sedimentary lenses present in the middle parts of some thick sills have their bedding perfectly preserved and show no suggestion of alteration into quartz diorite. It does not easily account for the transition zone between gabbro and quartz diorite because, in some respects, the transition zone is not intermediate in composition between the two other rocks. For instance, the transition rock is commonly richer in iron and phosphorus than the gabbro below or the quartz diorite above. In view of these considerations, it is not likely that an important part of the granophyre and quartz diorite consists simply of fused or metasomatized sedimentary rocks.

(2) It is improbable that the quartz diorite is due to the separate injection of an acidic magma because this hypothesis does not explain most of the aforementioned constant relationships between gabbro and quartz diorite. In particular, it does not explain the composition of the transition zone, the presence of quartz diorite only in the upper part of the sills, and its absence in thin sills.

(3) The hypothesis that the quartz diorite formed by differentiation from the basaltic magma within the sills readily explains all the aforementioned relationships between the gabbro and the quartz diorite. As mentioned previously, there is a tendency for an upward accumulation of quartzo-feldspathic material in many sills of medium and great thickness and the quartz diorite is presumably only a more advanced stage of this phenomenon. The restriction of significant amounts of quartz diorite to the very thick sills may be due, in part, to the greater abundance of "source material" there and, in part, to the longer time of crystallization which should be favourable to some processes of differentiation such as crystal settling.

As mentioned below, the composition of the transition zone may be explained as a product of the normal differentiation of a basaltic magma. That a small percentage of acidic magma can form by differentiation from a basaltic magma has been shown by Wager and Deer (1939) in the case of the Skaergaard intrusion; on the basis of laboratory experiments, Bowen (1937) also argues that the last liquid to crystallize from common magma should be enriched in alkali-alumina silicates.

As the minerals of the quartz diorite are essentially those which formed late in the gabbro, the chemical composition of the quartz diorite corresponds roughly to the composition of the late crystallizing liquid in the gabbro (broadly speaking, as the composition of the quartz diorite varies from place to place and the composition of the residual liquid was changing with the progress of crystallization). If it was roughly in equilibrium with the gabbro, the quartz diorite must have formed when the sills in which it occurs were largely crystallized. Its low content of early-crystallizing minerals indicates that it was still mainly liquid when most of the sill had already crystallized. Sinking of crystals in the basaltic magma could produce an acidic residual liquid in the upper part of the sill when crystallization of the sill was advanced. This seems in accordance with all the known facts and, therefore, differentiation within the sills is considered to be the most probable mode of origin of the quartz diorite.

Similarly, the acidic quartz diorite present in narrow dykes or veins in some of the gabbro may have formed from an acidic residual liquid left after the crystallization of a large part of the basaltic magma. This liquid may have been present in the pores of the crystal mesh or may have been concentrated near the top of the sill before it was forced into fractures in the largely solidified crystal mesh.

Blotchy Gabbro

The blotchy gabbro or "leopard rock" is characterized by rounded, sharply defined, light-coloured spots or patches of albite and clinozoisite representing metamorphosed aggregates of calcic plagioclase crystals. All gradations occur from gabbro containing a few spots to a rock consisting mainly of spots, but "typical" blotchy gabbro is commonly made up of 25 to 50% spots. The spots generally vary in diameter from 1/2 inch to 2 inches, but many are 3 to 4 inches in diameter in the Leopard Lake area, and a few are more than 8 inches across.

As mentioned above (see Correlation, Hellancourt Volcanics), nearly all blotchy gabbro occurs just below the base of the Hellancourt volcanics and may belong to a single sill. The rock is common in all the map-areas except the Thévenet lake, where it occurs at only a few places near the volcanic rocks east of Rachel lake.

The blotchy sill is not entirely made of blotchy gabbro. In the southeastern part of the Gerido Lake area, blotchy gabbro occurs apparently as disconnected lenses in a continuous gabbro sill. More commonly, blotchy gabbro occurs only in the middle of the sill in a continuous band. For example, east of Gerido lake and near the southern limit of the Gerido Lake area, the blotchy sill contains the following facies: - The base is chilled and contains very few spots; it is thus similar to the blotchy or glomeroporphyritic lava. It grades upward into a diabase with about the same amount of spots, then into a poikilitic gabbro. About 40 feet above the base is a transition zone in which the spots increase greatly in number and which grades upward into a typical blotchy gabbro composed of roughly 30 to 50% spots. The percentage of white spots in the blotching rock at first may increase slightly upward, but decreases gradually in amount near the top of the sill. In some places, the patches in the upper part are larger (2 to 4 inches). The upper 30 feet of the sill is made of a diabase with only a few patches. The upper contact of the sill, about 360 feet above the lower contact, is also chilled. Except for the thickness of the sill, this exposure appears typical of the blotchy sill. In rare places, the gabbro below the blotchy part is not poikilitic. Also, gabbro with few spots may be in sharp contact with blotchy gabbro. Patches are not abundant at the contact with the sedimentary rocks, except in a few places where thin lenses or tongues of sedimentary rocks are present in the sill, as, for instance, near the eastern shore of Gerido lake.

Layering, which is not common in the sill, consists of a planar concentration of patches or of bands alternatingly rich and poor in patches. It is parallel to the base and top of the sill. In some places, the patches are slightly elongated and their long axes lie parallel to the base of the sill.

Texture and Composition. The patches consist mainly of albite and clinozoisite pseudomorphic after aggregates of calcic plagioclase or "anorthositic lumps". The feldspar grains in the patches are much larger on the average than these in the common meta-diabase and meta-gabbro. They vary mainly between 1 mm. and 5 mm. and rarely attain 15 mm. in size. Some large feldspar grains are not in patches, but the tendency to clustering is marked. Feldspar varies from euhedral to anhedral. The euhedral grains are rather stubby and occur mainly at the rims of the patches and in lone crystals. The crystals in the patches are subhedral to anhedral and their boundaries are fairly straight. The space between the patches is mainly filled by large grains of actinolite and chlorite, probably pseudomorphic after pyroxene, and by some albite and clinozoisite. The actinolite is moulded against the feldspar grains. Lath-shaped feldspar grains (albite and clinozoisite), which are considerably smaller than those found in the patches, occur either between the actinolite grains or ophitically enclosed in them. The small feldspar grains seem more abundant where the patches are less abundant. Some feldspar grains have a rim of clear albite. Clearly defined, rounded patches composed mainly of chlorite are present within the actinolite grains of some rocks and indicate the former presence within pyroxene of another ferromagnesian mineral, possibly olivine. Titaniferous magnetite and leucoxene are present and apatite is common. At least a small amount of quartz is primary.

Minor chalcopyrite and pyrrhotite commonly appear in blotchy gabbro and are associated in many instances with quartz and chlorite. Replacement by quartz and sulphides is mainly restricted to the ferromagnesian minerals between the large albite-clinozoisite spots. Quartz may form sharply-defined patches within actinolite grains. This texture may be due to selective replacement of a mineral which was formerly enclosed in clinopyroxene.

Table 8

Composition of Blotchy Sill, East of Gerido Lake
near Southern Limit of Gerido Lake Area

Modal Composition (in volume %)

	7'*	30'	Blotchy gabbro average of 52' 78', 102', 125'	330'
quartz	8.4	6.3	5.0	9.3
albite and clinozoisite	37.6	46.2	59.1	39.5
actinolite	25.5	29.8	21.0	27.9
chlorite	20.6	13.8	11.9	16.1
sphene	4.8	2.4	1.8	4.1
magnetite-ilm.	0.2	0.2	0.1	0.7
sulphides	2.3	1.3	1.0	1.5
carbonate	0.6			0.9
apatite	---	p	0.1	p

* Number refers to height, in feet, of sample above base of sill; sill is 360 feet thick; typical blotchy from 45 feet to 300 feet; diabase at 7 feet and 33 feet, gabbro at 30 feet.

The composition of the blotchy gabbro is variable, but the rock is generally a relatively feldspathic gabbro. A minor part is anorthositic gabbro. Table 8 lists the modes of a suite of samples taken across the blotchy sill in the southern part of the Gerido Lake area, east of Gerido lake. The compositions of the border diabase in the lower and upper parts of the sill and of the gabbro below the blotchy part apparently fall within the range of composition of common metagabbro. The blotchy gabbro, which forms 2/3 to 3/4 of the sill at this place, is more feldspathic than common gabbro. The mode of the blotchy gabbro is not accurate because of the large size of the patches and because its composition varies from place to place.

Chemical Composition. Two chemical analyses from the blotchy sill appear in Table 9. One is from a diabase, 7 feet above the lower contact of the sill, which is 360 feet thick at this place. This rock was probably a quartz-bearing bytownite norite. The other is from the blotchy part of the sill in another locality and probably represents a former bytownite olivine norite. In both analyses, normative hypersthene (Table 10) greatly predominates over diopside. This is in marked contrast to the other analyses of gabbro and lavas of the area where normative diopside and hypersthene generally occur in comparable amounts. However, the samples for the two analyses in Table 9 come from localities only a few miles apart. There, the blotchy sill was probably a feldspathic norite, but this does not necessarily apply to the blotchy sill everywhere. Bytownite is the normative feldspar in both analyses. Again, this may or may not apply to the whole sill.

Origin. The bulk composition of the sill given in Table 8 appears to be different from that of the border diabase and may well have been different from that of the chilled edge of the sill. If so, the variations in the sill cannot be due strictly to differentiation "in situ". This suggests that the sill was emplaced by multiple injections or by a long-lasting injection. Further evidence of this is seen in the sedimentary lenses or tongues found in the blotchy sill at two places. The later injections of magma probably took place when the sill was still largely liquid, as suggested by the absence of fine-grained zones and the common gradation between ordinary and blotchy gabbro.

However, there is some evidence to support the hypothesis that the blotchy gabbro originated by differentiation rather than from a late injection unrelated to the early injection, as follows. (1) A genetic connection between the chilled edge of the blotchy sill and the blotchy gabbro is suggested by the presence of "blotches" in the chilled edge. The blotches are not abundant but are identical to those found in the typical blotchy gabbro; no other glomeroporphyritic patch has been found in the chilled edges of other sills. (2) Local layering is difficult to explain by the mixing of two magmas, but is easily accounted for by differentiation. (3) The major variations in composition across the thickness of the sill are similar at widely separated places. Thus, the hypothesis best in accord with the known facts appears to be that of a long-lasting injection with crystallization and differentiation proceeding during the injection. Locally, differentiation could have proceeded in place.

As in the case of the blotchy lavas, some patches in the chilled zones and border diabase of the blotchy sill may be intratelluric. However, it is possible that the bulk of the patches have formed within the sill. The only evidence in that respect is of a negative type, namely, that border diabase with abundant patches was seen only against the sedimentary lenses found within the sill. Some plagioclase must have crystallized early in this rock because it is found in the chilled edge of the sills and because the large crystals could only have collected together when the magma was still mainly liquid; this may be expected in a magma rich in the chemical constituents of plagioclase.

The blotchy gabbro is not sufficiently well known for a constructive discussion of the possible mechanism of differentiation by which the rock was formed. Another problem is the reason for the common association of the copper mineralization with the blotchy gabbro.

Composition of Magma. Most of the meta-diabases and meta-gabbro are commonly saturated in silica as indicated by the presence of primary quartz and by a few chemical analyses (Table 9). Under the microscope, the meta-diabases generally are similar to the medium-grained lavas which were mainly tholeiitic basalts. A few samples from the borders of sills have been melted, then chilled to glass beads. Their refractive indices compare well with those of glass beads made from the meta-basalts (Table 6). It is probable, therefore, that the bulk of the sills was derived from "normal" tholeiitic basaltic magma. Olivine diabases were present, but many occurred in the lower part only of sills of considerable thickness. This feature is not rare in tholeiitic diabases (Williams, Turner, and Gilbert, 1955, page 45). A few olivine diabases (No. 2, Table 9) occurred in sills a few hundred feet thick and may be derived from undersaturated magma. However, in the two analyses which contain normative olivine in Table 10, normative hypersthene is as abundant as diopside; in this respect, these analyses are closer to tholeiitic olivine basalts than to alkali basalts (Nockolds, 1954, Table 7).

Most meta-gabbros and diabases are poor in potassium as indicated by the absence of potash feldspar and by a very low mica content. Even the late-forming, quartz-rich differentiates of the gabbros do not contain much potassium and have a low potassium to sodium ratio (see analysis No. 5, Table 9). The chemical analyses in Table 9 show this same feature and the magma must have been very poor in potassium. As mentioned above, the Hellancourt meta-basalts also have a very low potassium content.

Many samples listed in Tables 9 and 10 have a high calcium to sodium ratio and contain normative bytownite. But only the first two analyses are from common meta-gabbro sills which do not show much differentiation. Analysis No. 1 contains normative bytownite. It is from the border of a sill and may represent the composition of the magma if chemical diffusion was unimportant between gabbro and argillite during injection and during regional metamorphism. Analysis No. 2 is from the middle part of a sill. Here, diffusion was not important, but the normative plagioclase is labradorite. The samples used in analyses 6 and 7 contain normative bytownite, but are from the blotchy sill. Modal bytownite occurs in many rocks but the original plagioclase is preserved only in thick differentiated sills. Thus, the data are scanty, but some of the magma may have been highly calcic and possibly formed some eucrite (bytownite gabbro) sills.

Order of Crystallization. The order of crystallization of the minerals is not known in detail because of the metamorphic alterations. In general, olivine appears to have crystallized early, as much of it is enclosed in pyroxene. However, a few pyroxene and plagioclase granules are enclosed in olivine and the latter mineral may have had a rather long period of crystallization. Calcic plagioclase and pyroxene started to crystallize early, probably in part contemporaneously with olivine. It is not clear which one appeared first. They crystallized until most of the magma, more than 90% in most cases, had solidified. Quartz and sodic plagioclase are partly intergrown and crystallized together. They formed only when most of the magma has solidified, as indicated by the following relationships. Pyroxene and calcic plagioclase are euhedral against quartz, with the calcic plagioclase rimmed by sodic plagioclase where in contact with quartz. Quartz is generally in the interstices between calcic plagioclase and pyroxene and, in some cases, it fills embayments in the plagioclase. Primary titaniferous magnetite is not abundant in the mafic and ultramafic gabbro. It is more abundant in the gabbro richest in quartz and in the "transition rock". It is rare in the acidic granophyre and quartz diorite. It had an extended period of crystallization but it probably formed in greater amount during the later part of the period of crystallization of calcic plagioclase and the early part of that of sodic plagioclase and quartz. Apatite is rare in the quartz-free and quartz-poor gabbro but is relatively abundant in relatively quartz-rich gabbro,in the "transition rock",and in the mafic quartz diorite. It is rare in granophyre and acidic quartz diorite. In the quartz-bearing gabbro, apatite is in or near quartz grains in almost every case. Therefore the bulk of apatite probably crystallized near the beginning of crystallization of quartz.

In general, the crystallization of the thick sills was probably from the base upward (with some modifications caused by multiple intrusions). This is suggested by the presence of olivine-rich ultramafics in the lower parts of some sills and by the concentration of late-forming minerals in their upper parts. Settling of crystals played an important role.

Table 9.- Geochemical Analyses of Meta-gabbro and Related Rocks

	1	2	3	4	5	6	7
SiO_2	51.05%	46.18	49.07	47.93	73.07	48.84	43.68
TiO_2	1.39	0.89	0.33	2.03	0.35	1.50	0.59
Al_2O_3	15.10	17.68	16.10	12.88	13.33	14.12	16.85
Fe_2O_3	4.37	2.20	1.60	6.50	0.79	2.08	1.75
FeO	6.79	7.38	4.77	12.48	2.42	12.45	8.74
MnO	0.27	0.14	0.16	0.41	0.05	0.15	0.18
MgO	5.90	8.76	9.99	2.00	0.41	6.39	11.76
CaO	10.30	10.21	13.90	9.88	1.89	8.15	10.56
Na_2O	0.80	2.41	1.02	2.24	5.11	1.24	0.72
K_2O	0.09	0.04	0.19	0.38	1.25	0.04	0.24
Li_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00
P_2O_5	0.12	0.07	0.01	0.52	0.12	0.11	0.03
H_2O+	3.80	3.72	2.74	2.39	0.78	4.00	4.86
H_2O-	0.09	0.13	0.09	0.25	0.11	0.13	0.16
CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	0.00	0.005	0.00	0.02	0.01	0.85	0.02
Rare earth oxide	--	--	--	--	0.02		
	100.07	99.82	99.97	99.91	99.71	100.16	100.14
SrO	0.08%	0.08	0.01	0.02	0.02	0.02	0.02
BaO	0.00	0.02	0.00	0.00	0.09	0.00	0.00
V_2O_3	0.04	0.04	0.04	0.02	0.01	0.06	0.04
Cr_2O_3	0.03	0.02	0.04	0.00	0.00	0.02	0.01
CuO	0.00	0.01	0.00	0.00	0.00	0.06	0.02
NiO	0.01	0.02	0.01	0.00	0.00	0.01	0.05
PbO	0.01	0.00	0.00	0.00	0.00	0.00	0.01
ZnO	0.01	0.00	0.00	0.00	0.00	0.01	0.00
ZrO_2	0.01	0.00	0.00	0.00	0.03	0.01	0.01
Co_2O_3	0.00	0.00	0.00	0.00	0.00	0.00	0.02
SnO_2	0.00	0.00	0.00	0.00	0.01	0.00	0.00
MnO	0.26	0.13	0.14	0.43	0.05	0.15	0.17

8				9			
SiO_2	44.81	CaO	8.53	SiO_2	75.03	CaO	0.69
TiO_2	2.55	Na_2O	3.35	TiO_2	0.31	Na_2O	4.24
Al_2O_3	13.96	K_2O	0.33	Al_2O_3	13.17	K_2O	3.85
Fe_2O_3	3.75	Li_2O	--	Fe_2O_3	1.56	Li_2O	--
FeO	16.66	P_2O_5	0.08	FeO	0.58	P_2O_5	0.02
MnO	0.17	H_2O+	0.34	MnO	0.01	H_2O+	0.28
MgO	5.54	H_2O-	0.19	MgO	0.15	H_2O-	0.13
			100.26				100.02

(Table 9, cont'd.)

0.00% in samples 1,2,3,4,5,6,7 of each of the following elements:
Ag, As, Be, Bi, Cb, Cd, Ga, Ge, Li, Mo, Sb,
0.0% in same samples of Ta, W.
0.0% Y in 1,2,3,4,6,7.
0.0% Ce and 0.0% La in 1, 2, 3, 6, 7.

No. 1: Sample S-165-b-54, from upper chilled zone of a meta-gabbro sill a few hundred feet thick, west of Lafortune lake, long. 69°35' W., lat. 58°14'N., east half of Gerido Lake area. Analysts: F. East, J. Gagnon, J. Plamondon, Laboratories Service, Quebec Dept. of Natural Resources.

No. 2: sample S-215-54; poikilitic meta-gabbro from middle part of a sill about 200 feet thick, long. 69°37'W., lat 58°14'N., east half of Gerido Lake area. Analysts: F. East, J. Plamondon, D. Lamontagne, Laboratories Service, Quebec Dept. of Natural Resources.

No. 3: sample S-36-54, quartz-bearing meta-gabbro from middle part of a sill roughly 2,000 feet thick, east of Rougemont lake, long. 69°38'W., lat. 58°01'N., east half of Gerido Lake area. Analysts: same as No. 2

No. 4: sample S-78-C-54, metamorphosed ferro-gabbro from transition zone between gabbro and quartz diorite, west of Hellancourt lake, long. 69°35'W., lat. 58°06'N., east half of Gerido Lake area. Analysts: F. East, D. Lamontagne, J. Gagnon, Laboratories Service, Quebec Dept. of Natural Resources.

No. 5: sample S-143-54, metamorphosed quartz-diorite, in upper part of very thick gabbro sill, north of Hellancourt lake, long. 69°36'W., lat. 58°09'N., east half of Gerido Lake area. Analysts: same as No. 4.

No. 6: sample S-280-54-7, diabase, 7 feet above the base of a 360-foot blotchy sill, long. 69°45'W., lat. 58°05'N., east half of the Gerido Lake area. Analysts: same as No. 2.

No. 7: sample S-25-54, poikilitic blotchy gabbro, long. 69°44'W., lat. 58°02'N., east half of Gerido Lake area. Analysts: same as No.2.

No. 8: hortonolite ferro-gabbro from the Skaergaard intrusion (Wager and Deer, 1939, p. 102). Compare with No. 4.

No. 9: acid granophyre from the Skaergaard (Wager and Deer, 1939, p. 208). Compare with No. 5.

Table 10.- Norms of Rocks Given in Table 9

(Calculated to 100%, free of water, sulphur, and carbon dioxide)

	1	2	3	4	5	6	7	8	9
qz	15.6		0.8	8.8	33.1	7.9			
or	0.6	0.2	1.2	2.3	7.5	0.2	1.5		
ab	7.0 } 46.3 An_{83}	21.2 } 60.2 An_{63}	8.9 } 50.0 An_{79}	19.5 } 46.4 An_{52}	43.7 } 60.0 An_{14}	11.0 } 45.6 An_{74}	6.4 } 52.0 An_{84}		
an	38.7	38.8	39.9	24.6	8.8	34.4	44.1		
c					0.4				
$CaSiO_3$	5.8 } di 11.2	5.8 } di 11.2	13.1 } di 25.1	9.5 } di 19.5		3.2 } di 6.4	4.6 } di 8.9		
$MgSiO_3$	15.3	10.6	25.7	5.1	1.0	16.8	16.0		
$FeSiO_3$	7.4 } hy 17.3	5.1 } hy 10.3	7.4 } hy 21.1	15.4 } hy 10.5	3.3 } hy 4.3	20.0 } hy 33.6	7.6 } hy 19.3		
$MgSiO_4$		8.6					10.4		
$FeSiO_4$		4.5 } ol 13.1					5.4 } ol 15.8		
mt	6.6	3.3	2.4	9.7	1.2	3.2	2.7		
il	2.7	1.7	0.6	3.9	0.7	3.0	1.2		
ap	0.3	0.2	tr	1.2	0.3	0.3	0.1		
$\frac{FeO+Fe_2O_3 \times 100}{FeO+Fe_2O_3+MgO}$ =	65	52	39	90	89	69	47	79	93

Successive Residual Magmas and Crystalline Phases Produced. Wager and Deer (1939) were able to calculate the composition at different stages of the changing residual magma of the Skaergaard intrusion and the composition of the solid phases separating from the magma at the same time. In summary, they found that the crystallization of the basaltic magma may be separated into two stages. The first stage is characterized by iron enrichment of the magma and lasted until more than 95% of the magma had crystallized. At first, magnesium-rich ferromagnesian minerals crystallized to cause an impoverishment in magnesium and an increase in iron in the magma. A magnesian gabbro is thus produced. The iron content of the ferromagnesian minerals increases gradually with crystallization. During this stage, the silica content does not vary appreciably; the content of potassium and sodium increases slowly but stays low. At the end of the first stage, iron-rich pyroxene and "iron ores" crystallized in large amounts to produce a ferrogabbro. This rapidly lowers the iron content of magma and increases its silica content; thus starting the second stage which is characterized by a gradual enrichment of the magma in silica, soda, and potash. According to Walker and Poldervaart (1949), a somewhat similar, though not so extreme, trend is present in the Karoo dolerites, the Insizwa intrusion of South Africa, the Tasmanian dolerites, the Palisade sill, and the Siberian traps. They conclude (p. 659)" .. that the iron enrichment is the normal trend of differentiation during the greater part of the crystallization of basaltic magma".

The basaltic magma of the Gerido Lake area apparently behaved in the same way. In the very late stages the magma was much enriched in silica and sodium as shown by the presence of the quartz diorite and granophyre in late dykes and in large masses. Obviously, the volume of the residual acidic magma was only a small part of the volume of the original magma. As gabbroic rocks apparently formed until late in the crystallization history, it seems probably that important silica increase took place mainly in the late stages. Only one analysis (No. 5) of quartz diorite is listed in Table 9 but it is typical of many rocks of the area. It has a high iron to magnesium ratio and it is similar to some analyses of Skaergaard granophyre (No. 9, Table 9).

The "transition rock" must have formed near the beginning of the stage of important silica enrichment of the magma. It nearly always contains stilpnomelane and, according to Turner and Verhoogan (1951, p.47), this mineral occurs in rocks having a high ratio of iron oxides to magnesia. Only one analysis (No. 4, Table 9) of the rock is available, but it is similar to that of some Skaergaard ferrogabbro

(No. 8, Tables 9 and 10) in having a very high iron to magnesium ratio. The actinolite in the lower part of many thick sills is nearly colourless and is probably rich in the tremolite "molecule", whereas quartz-bearing gabbro and transition rock in the upper part of thick sills commonly contain pleochroic amphibole which is possibly rich in the ferrotremolite molecule. Obviously, the ratio of iron to magnesium in the magma increases in the early and intermediate stages of crystallization. The "transition rock" is richer in apatite than most gabbros or than the acidic quartz diorite and suggests enrichment of the magma in phosphorous shortly before or during the early stages of important silica enrichment.

There are some differences, however, between the differentiation in the Skaergaard magma and the differentiation in the magma of the area. The acidic residual magma of the Skaergaard was less than 5% of the original basaltic magma (Wager and Deer, 1939). West of Hellancourt lake, a 3,500-foot sill contains about 700 feet of quartz diorite at one place. Unfortunately, the thickness of the quartz diorite varies from place to place and it is possible that some quartz diorite has not differentiated exactly in place. Instead, some late acidic magma may have migrated into the higher "rolls" of the sills or it may have been pushed or dragged along by late injections. It is, therefore, impossible to estimate accurately the percentage of residual acidic magma formed in the thick sills, but it may be much more important than in the case of the Skaergaard. A figure of 10% of acidic magma seems a reasonable guess. This difference may be due in part to the different silica content of the two basaltic magmas; the Skaergaard magma contained only slightly more than 48% (dry weight basis) of silica, whereas the basaltic magma of the area, if similar in composition to the basalts, contained about 51% of silica. Perhaps a slight difference in the original basaltic magma may become very important in the late stages of the crystallization. Apparently, enrichment in potassium during the late stages of crystallization was not important in the area, as most quartz diorites contain little of it. This is possibly due to a very low initial potassium content of the magma. Another difference is in the ferrogabbro produced. Those of the area are more feldspathic than the Skaergaard ferrogabbro. Although their iron to magnesium ratio is comparable, the ferrogabbro of the area contains less iron than many rocks of the Skaergaard, which contain as much as 25% iron oxides. This and the fact that the proportion of acidic residual magma formed may have been greater in the area make it improbable that the magma of the area was as enriched in iron as the Skaergaard magma.

Age of the Sills. The sills were obviously emplaced before the regional metamorphism. They were also intruded before the folding as indicated by the following evidence. (1) The sills roughly parallel the sedimentary strata, no matter how intricate the folding. They do not cut across the beds at the noses of the folds or at other places of structural weakness. (2) They generally maintain a fairly even thickness along the limbs and around the noses of the folds. This implies nearly equal ease of intrusion everywhere and is not likely to happen in rocks that already were tightly folded. (3) The gabbro sills are sheared and fractured near the axial plane of some sharp folds, but commonly show little deformation of the limbs. This deformation, so closely related to the axial plane of the folds or places of maximum curvature, must have been caused by the folding. (4) The sill of blotchy gabbro is repeated by a fault in the western part of the area, and this fault is probably related to the same general period of deformation that produced the folds. (5) The best evidence is that the sills, by their greater competency, have controlled the intensity of the folding in the argillites and schists. Where the sills are missing, the argillites are intricately or closely folded, the wave-lengths of the folds being only a few feet or a few tens of feet. Where sills of small and intermediate thickness are present the folds are much larger, with wave-lengths of a few hundred feet. At the nose of the large syncline in the east half of the Gerido Lake area, the argillites immediately underneath the very thick, competent sill are only broadly flexed in conformity with the sill. Therefore, the sills were already present and solidified at the time of the folding.

That a genetic connection existed between the magma of the sills and the Hellancourt lava is indicated by the similarity in chemical composition of these two formations. It is true that tholeiitic magma is of world-wide occurrence but, here, both liquids were apparently characterized by unusually low potassium content. Furthermore, the unusual blotchy rock occurs in both flows and sills. Although the flows and sills formed at roughly the same time, all sills are not necessarily exactly contemporaneous with the lavas.

PLEISTOCENE AND RECENT

Much of the area is covered by till left by the Pleistocene glaciers. The till mantle is thin or missing on the ridges but may be fairly thick in some valleys. Knob-and-kettle topography is well developed in the southwest corner of the Gerido Lake area and one mile west of Lafortune lake in the northeast part of the same area. Glacial striae are common, especially on lava outcrops whose surfaces are also highly polished. Over much of the area, their trend is mainly north-northeast, but in the Thévenet Lake area it is nearly north. Two or more sets of glacial striae occur together on many outcrops, diverging more than 60° in some cases.

The glaciers moved from southwest to northeast as attested by the following features: (1) roches moutonnées with gentle slopes and polished surfaces on the southwest and steep slopes with plucked out blocks on the northeast; (2) distribution of characteristic rocks to the northeast of their outcrops; (3) little or no till deposit on the west slopes of the ridges and thick deposits on the east slopes; and (4) drumlin-like deposits. The drumlin-like deposits are made of till, and are elongated in the direction of ice-movement; they differ from typical drumlins in having a steep rocky ridge at their stoss southwest end. From the crest of the rocky ridge, the till deposit slopes gently northeastward. The width of the drumlins is the same as the length of the rocky ridges, and depressions in the latter form long grooves down the slope of the glacial deposit. The drumlin-like deposits are best developed in the southern part of the Léopard Lake area and near the mid-length of the eastern border of the Gerido Lake area.

Most of the relatively few eskers consist of sorted gravel with pebbles generally smaller than 1 inch in diameter. The longest eskers, up to 3 miles, occur near Thévenet lake and in the northern part of the Harveng Lake area. The eskers southwest and east of Thévenet lake may have been formed by the same glacial stream. Eskers are seldom longer than 1,000 feet in the Léopard Lake area, but most of them occur close to a line which starts at the north end of Gory lake and extends northeastward through the middle part of Dupuy lake to the eastern edge of the area. They were probably formed by a single stream or stream system, perhaps the same one mentioned above. The eskers occur in valleys and on the slopes of ridges, but not on their tops. In some places, notably in the lavas northeast of Léopard lake, the ridges are bared to bedrock along a strip between small eskers or in line with some eskers. The same ridges are mantled with till a short distance away and elevations are about the same on top of the bare and mantled parts. The till mantle here was swept away by the glacial stream which deposited the eskers in the valley. Similarly, the eskers are short in the eastern half of the Gerido Lake area and most occur in a line extending from the west shore of Rougemont lake, 5 miles from its north end, to 2 miles west of the south end of Lafortune lake. One esker west of De Romer lake is about 3/4 mile long and consists over part of its length of two parallel ridges of unequal height. North of the same lake and in line with the esker, no till is found in an area about 1/4 mile wide and 1 mile long and was probably eroded by the glacial stream. Similar denudation has occurred west of De Romer lake and between Rougemont and Hianveu lakes. The esker system northeast of Harveng lake consists of many eskers joined together like a stream network.

Thick mud deposits are abundant in the wide valley in the southwestern part of the Léopard Lake area. They are well exposed in 20- or 30-foot banks of small streams that are actively cutting through them. The muds consist mainly of material finer than sand-size, although the occasional pebble is found. Stratification is rare and faint. The pebbles were probably dropped from floating ice. The material obviously accumulated in a quiet body of water, probably when the area was still partly submerged by the sea shortly after the period of glaciation. Submergence was proved by Bérard (1959) who found extensive terraces at about an elevation of 500 feet near Aux Feuilles, indicating that sea-level stood at that elevation for a long time. All the silt in Robelin Creek valley lies below an elevation of 475 feet.

Limonite Cement (Gossans). Sediments cemented with iron oxide or hydroxide are found at many places in the Labrador Trough and have often been called "gossans" or "transported gossans". Those of the area are not true gossans as they do not form a superficial cover on masses of pyrite, but they were always found fairly close to sulphide-bearing gabbro. Small deposits occur near the Gerido Lake - Livaudière Lake valley, especially west of the north end of Prinzèles lake and east of the southern part of Gerido lake. Other deposits were observed east of the Crochet Lake lava basin and east of Hellancourt lake, in the Gerido Lake area. Generally, the deposits consist of till by limonite. In places, till cemented by limonite is overlain by uncemented till; it is not clear if the limonite is interglacial or if it has cemented only the lower part of a till deposit in post-glacial time. One of the most interesting deposits is near the eastern limit of the Léopard Lake area, 1/2 mile south of Dupuy lake. There, flat-lying, very fine-grained shaly material cemented by limonite is overlain by till. The material must be water-laid, and either pre-glacial or interglacial. It contains twigs and leaves. A well preserved leaf is of a type that occurs on small bushes in the area today. Boulders and cobbles, some of them very well rounded, are also present.

METAMORPHISM

Contact Metamorphism

Contact effects due to the injection of diabase sills have been largely obscured by later regional metamorphism. Adinoles are the most striking results and have been described with other rocks of the Baby formation. Another result of contact metamorphism is the presence of a few high-grade metamorphic minerals found near sills among lower grade metamorphic rocks and of minerals not seen elsewhere in the area. For instance, garnet occurs a short distance below a sill about one mile southwest of Léopard lake within the muscovite-chlorite sub-facies. Well crystallized zoisite, coarse actinolite, and minor clinopyroxene occur near the southeastern corner of the Léopard Lake area. Clinopyroxene was also observed 2 miles east of the middle part of Rougemont lake. Soda-amphibole in iron-bearing rocks has been mentioned above. Tremolite occurs in some meta-sedimentary rocks near sills in the Gerido Lake area, but was not observed in similar rocks away from the sills.

Although most of the above features are probably a result of contact metamorphism, it is not clear what is due strictly to contact metamorphism and what is due to the combination of contact and regional metamorphism. For instance, diopside may have been fairly abundant in contact metamorphosed rocks but may largely have changed to tremolite during regional metamorphism. Had these rocks not been contact metamorphosed, they might have contained more water and carbon dioxide and might have formed epidote or calcite instead of tremolite.

Regional Metamorphism

All the Precambrian rocks of the area have been regionally metamorphosed. The grade of metamorphism increases eastward in the eastern half of Gerido Lake area and in the Thévenet Lake area, and northeastward in the Harveng Lake area. As mentioned below (see"Robelin Creek thrust fault"), the grade of metamorphism of the Larch River formation in the southwest corner of the Gerido Lake and Léopard Lake areas may be lower than in the rocks to the east.

Greenschist and Amphibolite Facies

The boundary between the greenschist and amphibolite facies is in the Thévenet Lake area, 1 or 2 miles west of the southeastern tip of Thévenet lake. From there, the boundary runs slightly east of north.

Its exact location is not known throughout the northern part of the Thévenet Lake area, but it crosses the northern boundary between longitudes 69°17' and 69°21'. Some meta-igneous rocks in the northern part of the Harveng Lake area are made up largely of albite, epidote, and a blue-green amphibole, with little or no chlorite. This assemblage is typical of Turner's albite-epidote-amphibolite facies, but it is mixed with rock assemblages typical of the greenschist facies (albite-epidote-chlorite-pale actinolite). Nevertheless, the former assemblage suggests an increase in metamorphic grade to the northeast in the Harveng Lake area.

Biotite Line

The approximate western and southwestern limits of occurrence of visible biotite are marked by a line in the east half of the Gerido Lake area and in the Harveng Lake area. The mineral is most easily seen in thin diabase sills and in some pelitic rocks. The location of the line is approximate because the biotite is very fine-grained and is not present in all the pelitic schists. The line was not traced to the southeastern part of the Gerido Lake area as the composition of the lavas there is not favourable to formation of visible biotite.

The position of the line appears to correspond roughly with the westernmost occurrences of brown and green biotite in most phyllites as seen in thin section. As the first appearance of red-brown biotite defines the outer boundary of the biotite zone (Turner, 1948, p. 36), the line is the approximate boundary between rocks in the chlorite zone of metamorphism to the southwest and in the biotite zone to the northeast, or, expressed in Turner's classification, between the muscovite-chlorite subfacies and the biotite-chlorite subfacies respectively. Minor biotite, mostly green but some brown, occurs to the southwest of the line, especially in the iron-bearing rocks and ferrogabbro. For instance, brown biotite was seen in a sill near Rougemont lake, more than 5 miles west of the biotite line. Furthermore, muscovite-chlorite phyllites without biotite are common northeast of the biotite line. In many of these rocks, biotite would undoubtedly have formed under slightly more severe consitions of metamorphism.

Other Key Minerals

Garnet is largely restricted to the Thévenet Lake area. It is present a short distance west of the greenschist-amphibolite boundary, but becomes abundant only to the east of it. Staurolite and kyanite appear east of Rachel lake, in the amphibolite facies, with a few occurrences of staurolite west of the westernmost occurrences of kyanite.

Time of Metamorphism

Metamorphism cannot be earlier than the folding because aligned, generally undeformed, metamorphic minerals are found in shear zones, cleavage planes, and well foliated rocks caused by deformation related to tectonic folding. Some crystals grey during deformation or were partly grown before deformation stopped, as shown by "snow ball" structure in garnets, by schistosity wrapping around garnets, and by bent or slightly broken crystals of mica and chlorite. Most crystals are not broken however and may have stopped growing in late stages of deformation or, perhaps, shortly thereafter.

There is no evidence that metamorphism was later than, or unrelated to, tectonic deformation. It is true that the structural trends do not parallel the metamorphic zones in detail. For example, the boundary of the amphibolite and greenschist facies cuts across the axial plane of the anticline in Thévenet lake and the biotite line runs west-northwest in the Harveng Lake area. However, on a regional scale, the trend of the metamorphic zones is roughly the same as that of the Labrador Trough and of the major structures. Thus, the above considerations suggest a relation between regional metamorphism and tectonic deformation.

STRUCTURAL GEOLOGY

Major Structures

The rocks of the area are folded along axes trending southeast or south-southeast and commonly plunging gently southeastward. Steep eastern dips are common and many strata are overturned. The main structures are outlined below in west to east order.

Robelin Creek Thrust Fault

The cause of the differences between the eastern and western parts of the Trough is one of the most important and least known structural problems of the area. These differences include: (1) the abrupt passage from complete absence of intrusive rocks in the west to abundance of these rocks in the east and, (2) the possibly lower grade of metamorphism in the west. The lower grade of metamorphism is suggested by: (1), the near absence of metamorphic muscovite; (2), the finer-grained, less recrystallized matrix; and (3), the presence of chalcedony. These differences suggest, but do not necessitate, the presence of a major fault or unconformity.

Actually, the stratigraphic relationships can be readily explained only by the presence of a fault. If no fault is present, the Larch River formation, which underlies the lavas at the western edge of the Gerido Lake area, is roughly equivalent to the Baby formation. Although the Baby rocks are poorly exposed in their western occurrences, they appear quite different from the Larch River rocks. In particular, the arenitic rocks recognized in the Baby formation are nearly all clean quartzites, whereas those of the Larch River are typically greywackes and subgreywackes. Thus, very different modes of formation are indicated. These difficulties disappear if a fault is assumed.

There are also structural indications of a major fault between the eastern and western parts of the Trough. Shearing is intense in the western part of the lavas in the Gerido Lake area and in the westernmost sills of the Léopard Lake area. The westernmost lavas of Gerido Lake area disappear to the south and may be faulted out. The iron-bearing formation, continuous over a distance of 35 miles south of the area (Fahrig, 1955 a), disappears northward in the Léopard Lake area roughly where the fault should be.

Some features can be explained by a major unconformity, with the Larch River rocks lying in a folded basin above the other Kaniapiskau rocks. However, the Hellancourt volcanics would still have to be thrust over the Larch River rocks.

The fault apparently may die out or have little displacement in the northern part of the Harveng Lake area as there is no evidence of it there or farther north in the Leaf Lake area (Bérard 1959) above the Abner dolomite.

The rocks for one mile to two miles east of the presumed fault are cut by numerous shear zones and their structure seems much more complex than in the rocks farther east. It is possible that the structure in this zone is imbricated, and that the small faults are connected to the main fault below. The shearing in the westernmost lavas or gabbros dips 25°-70° east.

Crochet (Hook) Lake Basin

The few sills west of Crochet lake (west half, Gerido Lake area) and Léopard lake dip gently to moderately east and most are right-side-up. East of the eastward dipping sills are the Crochet Lake basin and the Gerido Lake - Léopard Lake complex syncline. The lavas in the central part of the basin form a plateau rising higher than the country for miles around. The surrounding sedimentary rocks dip gently to moderately under the lavas, except on the northeast side where they are in part sheared and possibly faulted. The plunge at the south side of the basin is about 10° north; the plunge to the south at the northern side is slightly steeper. The Crochet Lake basin is on the trend of the Gerido Lake - Léopard Lake complex syncline and may be considered as a depression on the extension of this major structure.

Gerido Lake - Léopard Lake Complex Syncline

The lava belt south of Gerido lake is in a syncline as shown by the appearance of blotchy gabbro, which lies below the lava, on both sides of the belt at many places. But the structure is complex in detail. It is formed by two synclines which plunge 20°-40° southward in the Gerido Lake area. In the northern part of the Léopard Lake area, the eastern limb of the western syncline is cut off by an eastward dipping, high-angle, reverse, longitudinal fault and disappears. The eastern syncline is a nice example of tight fold with a highly sheared, attenuated, overturned limb. The western limb takes up three-fourths of the width of the syncline. It contains many shear zones, but undeformed pillow lavas are abundant. Their tops are to the east and they dip 45°-70° eastward. The eastern limb is highly sheared, the schistosity dips mainly 65°-80° east, or about the same as the bedding in the sedimentary rocks immediately east of the lavas. Pillows are easily recognized, but most are too deformed for top determination. The axial plane of the fold cannot be located accurately, but coincides roughly with the western limit of extensive shearing.

Outcrops of lavas are scarce and the structure is unknown northeast of the middle part of Léopard lake. Recognizable tops of pillows face eastward for the most part. West and south of Livaudière lake, two and perhaps three small synclines separated by anticlines or faults occur within the main synclinal structure. The blotchy gabbro probably occurs in an anticline. Faulting may be important but major faults cannot be recognized among the numerous small shear zones.

Gerido Lake - Livaudière Lake Anticline

The same lava formation occurs on both sides of the valley in which Livaudière lake (Léopard Lake area) and the southern part of Gerido lake lie. Tops are to the west on the west side of the valley and to the east on the east side. The structure is anticlinal but may be complicated by faulting. On the east side, the dips range mainly from 60° to 75° east, with some as low as 40°, and, on the west side, they range from 75° east to vertical. The anticline can be traced as far north as the widest part of Gerido lake, but may extend farther north toward the northwest corner of the Gerido Lake area.

North End of Gerido Lake

West of the north end of Gerido lake (Harveng Lake area) is a canoe-shaped syncline of lavas that terminates to the northeast in a fault. Two other belts of lava occur to the northeast, presumably by faulting. Tops in the middle belt are all to the east but blotchy rocks occur both east and west of it and the belt may be a syncline with a badly sheared eastern limb. The tops of the pillows are also to the east in the eastern belt. Southward, in the northern part of the Gerido Lake area, some badly deformed pillows in the eastern side of the belt have tops probably facing west. Apparently, the belt here is a syncline with a sheared, attenuated, overturned eastern limb and an unsheared, right-side-up western limb. The eastern limb disappears northward, being cut off by the Brunet Lake longitudinal fault.

Brunet Lake Fault

The evidence for the Brunet Lake fault is as follows:- (1) shearing is intense in several places, especially along the western shore of the southern half of Greenbush lake, and the rocks are badly deformed near Brunet lake; (2) the probable eastern limb of the syncline west of the fault disappears northward; (3) the phyllites and gabbros southeast of Brunet lake are transected to the south; (4) faulting is necessary to explain the repetition of the Hellancourt volcanics near Brunet and Bourgault lakes; (5) the lavas are apparently cut off near Brunet lake.

The fault is probably a high-angle reverse one like the Archiac Lake fault (see below) and other major longitudinal faults of the area. Its displacement is large near Brunet lake, but could be small in the Gerido Lake area. The fault possibly extends southward and joins the Archiac Lake fault.

Bourgault Lake Syncline

This syncline is the largest and most obvious of the Harveng Lake area. It plunges about 20° southeastward. Its western limb dips moderately to steeply east, the eastern limb is overturned and dips mainly 50°-80° eastward. In the northern part of the Gerido Lake area, the middle part of the syncline is extremely sheared. The structure becomes awkward to the south. The western limb extends into the east half of the Gerido Lake area, the sheared, central part gives way to the Désery Lake - Archiac Lake fault, and the eastern limb of lavas disappears near Désery lake and is replaced by the meta-gabbros of the Rougemont Lake syncline. The same rocks occur on the east limbs of the Bourgault Lake and Rougemont Lake synclines, but the details of the structure between the two are unknown.

Archiac Lake Thrust Fault

The Archiac Lake (Léopard Lake area) strike fault is one of the main faults of the area. The evidence for its existence follows:- (1) zones of intense shearing are present between the lavas and the meta-gabbros west of the north end of Rougemont lake and near Désery lake; (2) a slight transgression of the lavas by the fault seems probable west of the north end of Rougemont lake; and (3) repetition of the Hellancourt lavas occurs in the Léopard Lake area. Even if the "Hellancourt" lavas were actually from two different formations, a fault would be necessary to explain the presence of lavas west of Rougemont Lake syncline and the absence east of it.

The schistosity of the shear zones commonly dips 65° to 85° eastward. If the fault conforms, it also dips east at a high angle, and is parallel or sub-parallel to the bedding. The very minor transgressions of the formations by the fault in plan suggest a similar concordance in section and thus, the fault may be a bedding-plane type fault. Slickensides in the shear zones are along or nearly along the dip of the schistosity. As the east side of the fault moved up relatively to the west side, the fault is probably high-angle and reverse. The stratigraphic separation of the fault (Billings, 1955, p. 136), measured by the thickness of the section, between the base of the lavas southeast of Dupuy lake to the base of the lavas west of the fault, is about 11,000 feet. Thus, the very minimum net slip of the fault near the eastern limit of the Léopard Lake area is 2 miles, but as the fault is probably at a low angle to the bedding, its net slip is probably several times that figure.

The fault runs from north of Désery lake, to the eastern limit of the Léopard Lake area, a distance of about 28 miles. Judging from Fahrig's map (1955 a), it extends more than 12 miles farther southeast for a total of 40 miles. Another important fault about 1,500 feet west of the Archiac Lake fault transects a blotchy sill near the southwest corner of the east half of the Gerido Lake area. The stratigraphic separation along the fault is about 2,500 feet and its net slip may be several miles. This is possibly the southern extension of the Brunet Lake fault. Shear zones are numerous between these two faults, but stratigraphic evidence of large displacement is lacking. If the Brunet Lake and Archiac Lake breaks are connected, the fault is more than 50 miles long.

Rougemont Lake Syncline

This syncline is steep but is not overturned. It plunges south in its northern part, has a nearly horizontal axis in the southern part of the Gerido Lake area, and plunges about 30° south in the Léopard Lake area.

Large Folds, Irony and Thévenet Lakes

The rocks near Irony and Thévenet lakes and those north of Thévenet lake are relatively open folds plunging southeastward. The main structure is that of an anticlinorium. The Harveng dolomitic schists of the Harveng Lake area are in this anticlinorium.

The iron-bearing rocks near, and southeast of, Irony lake are in an anticline formed of many small anticlines and synclines. Small faults are present, as in the southern occurrences of the iron-bearing rocks. The thick sill above the iron-bearing member is also contorted, although much less than the iron-bearing rocks and thin sills. The plunge is 25°-35° southeastward.

A large syncline near Hellancourt lake plunges 20°-35° southeastward. Near Bowen lake, it is clear that the incompetent, thin sills and phyllites are tightly folded, whereas the competent, thick sills are in much broader folds.

The Thévenet Lake anticline plunges 35°-40° southeast to the south of Thévenet lake and plunges also southeast to the west of Lafortune lake. Between these two places, the fold forms a saddle with some gentle northwestward plunges between Thévenet and St-Pierre lakes.

A syncline and an anticline occur near Weepniam and Gelinas lakes, respectively, and also plunge southeast. An interesting feature is that the eastern limit of the lavas in these folds and in the east limb of the Thévenet anticline is fairly straight.

Phillips Lake Fault

A thrust fault with a large displacement is clearly present east of Phillips lake in the Freneuse Lake area (Sauvé, 1956). This fault must pass about 3/4-mile east of the north of Gelinas lake. There is a narrow valley from there to Rachel lake and the fault possibly extends to that lake or even farther south.

Rachel Lake Structural Complex

Exposures east of Rachel lake are abundant, but commonly small and not sufficient for a good understanding of the extremely complex structure. The main structural characteristics are a disordered map-pattern, irregular but steep plunges of the fold axes, intense shearing, and flexed axial planes of folds. In many ways, the structure may be likened to salt dome tectonics. The direction of plunges of minor fold axes and other b- lineation east of the southern part of Rachel lake vary from north to east but average N.50°-65°. The plunges become nearly vertical near Raymond lake and about 70° southeastward near Barrie lake. The axes of minor folds are commonly sub-parallel within small areas. In some places, notably in the schists south of the southern occurrence of microcline gneiss, the axial planes of minor folds may be grouped in two main widely-diverging sets. One set is aligned with the trend of the formations.

Attenuation by shearing is very important in some rock units. Many amphibolite sills end abruptly, and may be sheared off. Stretching parallel to the schistosity and thinning perpendicular to it are seen in deformed pillow lavas, blotchy gabbro, and volcanic-pebble conglomerate. In some instances pillows are so sheared as to make them difficult to recognize and probably many have been completely masked. Amphibolite is thick in the nose of the fold east of Barrie lake and thin on the limbs. This is not due to flowage from the limbs to the nose of the folds, but rather to shearing and great thinning on the limbs. The pillow lavas at the nose are well preserved and not sheared.

Folding of the axial plane of some major folds may be important. The tops of pillows that could be determined in the volcanic belt northwest of Barrie lake face northwestward and well-formed pillows east of the lake face southeastward. Thus, there probably is a major anticline near Barrie lake. Northeast of the lake, the axial plane of the fold is cross-folded through a 90° bend around a steeply dipping axis. The axial plane of the cross-fold strikes southeasterly. East of the lake, the cross-fold appears to be a syncline plunging steeply southeast. North of the lake, it is a steeply plunging, upside-down anticline (the older formations being in the core of the fold) but it is like a syncline in that the fold is concave upward.

If the northwestward-facing tops in the lavas northwest of Barrie lake are not representative of the belt, the concept of a major anticline here must be replaced by that of small folds within the volcanic belt. These folds would be sub-parallel to the trend of the belt and folded by the aforementioned cross-fold north of the lake.

The syncline plunging almost vertically west of Raymond lake may be another cross-fold. The complex pattern in the schists and gneisses southeast of Raymond lake can also be explained by curved folds with north-, northeast-, and east-striking axial planes and a major cross-fold with northwest-striking axial plane. This is highly speculative, however, and, in summary, a similar map-pattern would be produced if a series of nearly isoclinal folds were sharply cross-folded around steeply dipping axes. However, the mechanism and sequence of deformation may have been quite different. Scotford (1956) reported a similarly complex fold pattern in a highly metamorphosed area in New York, and aptly named it "axial-plane folding".

Summary and Conclusions

The axial planes of the main folds west of Rachel lake dip steeply and are commonly slightly overturned westward. The folds commonly plunge southeastward and have steeply dipping limbs. Many synclines have overturned eastern limbs which are badly sheared and attenuated in some instances. A few longitudinal faults are apparently reverse faults dipping steeply eastward. The displacement is up to several miles on some faults. The high-angle thrust faults and the folds probably formed during the same tectonic period, as indicated by the following evidence: (1) shearing of overturned limbs, which must have resulted from folding, grades into faults; (2) both folds and faults contributed to local shrinkage of the earth's crust in an east-northeast direction and to thickening of the Trough strata; they were caused by a similar stress pattern in which the main compressional stresses were oriented roughly east-northeast.

Minor Structures

Cleavage and Foliation

Within the greenschist facies, the folding of the pelitic rocks was accompanied by the development of a very good cleavage in many places. The cleavage is due to the alignment of very small mica flakes which were distributed either throughout the rock or, mainly, along definite planes. The spacing of these planes varies widely. As the mineral constituents between them show little orientation, this cleavage is close to a "fracture" type. However, it grades, by smaller and smaller spacing of the micaceous planes, into a good flow cleavage. The cleavage commonly strikes slightly west of north and dips steeply either to the east or west, although more commonly to the east. It is generally parallel to the axial planes of the small folds and is therefore useful for structural interpretation as it indicates the tops of the beds. In a few places, however, it differs markedly from the axial plane of the large folds. It has a tendency to dip inward in the synclines and outward in the anticlines, especially, it seems, in the vicinity of thick sills. At the nose of the large folds, the cleavage may make a large dihedral angle with the axial plane, as, for instance, in the shales beneath the thick sills northwest of Hellancourt lake. It seems characteristic that these large deviations from an axial plane cleavage occur in shales near their contact with large gabbro sills, that is, in structurally heterogeneous areas.

Schistosity or foliation becomes more general and more intense in rocks of the amphibolite facies. Bedding planes have disappeared, but good layering indicates the former bedding. Schistosity is parallel to bedding wherever the latter could be recognized. The formerly massive sills generally show a good foliation parallel to their contact, even around the noses of folds in some cases at least.

Lineation

Three types of lineation are common in the area: bedding-cleavage intersection, small wrinkles in the bedding or cleavage planes, and axes of small folds. The bedding-cleavage lineation is approximately parallel to the fold axes, even where the attitude of the cleavage differs much from the attitude of the axial plane of the folds. It is therefore a "b- lineation". The wrinkles and small fold axes are also b- lineations. Only rare cases of "a- lineation", consisting of streaks or slightly grooved slickensides on the cleavage or shear planes, were observed.

West of Rachel lake, the azimuth of the b- lineation is commonly west of north or east of south. The plunge varies within a short distance, but seldom exceeds 35°. It may be either to the northwest or the southeast, although the latter is more common. The orientation of the lineation is much different east of Rachel lake, as mentioned above.

Oblique Faults

Linears striking northeast on gabbro ridges are readily recognizable on aerial photographs. The linears are straight, shallow valleys. Some may be due to the passage of glaciers combined with northeast joints in the sills. In some cases, however, single linears may cross two or three consecutive ridges, and joints and shears parallel to the linears occur near them. Such linears are probably oblique faults with small horizontal displacement. In one case, an offset of 50 to 100 feet of a small longitudinal valley coincides with a linear. In rare cases, the offsets of the longitudinal valleys can be seen on aerial photographs. A few of these small faults near Hellancourt lake are shown on the map. Cross-faults with somewhat larger displacement are fairly common in the gabbros and lavas of the Harveng Lake area.

Joints

No statistical study of the joints of the area has been made, but, in a few places, well developed joints in gabbro sills show a definite relationship to the attitude of the sills.

From a distance, many sills give the impression of having columnar jointing perpendicular to the attitude of the underlying beds. In some cases at least, this jointing is not true columnar jointing, but consists of two or more sets of joints approximately perpendicular to the attitude of the sill. In some tight folds, the columns or pseudo-columns are inclined less than the perpendicular to the base of the sill.

Some joints approximately parallel the base of a few sills and may be so well developed as to suggest, from a distance, that the sill is arranged in massive beds, particularly near the sill borders. Some strike-joints, with dips perpendicular to that of the sill, also occur.

ECONOMIC GEOLOGY

This chapter describes the general geology and assessment work done on the most important claim groups of the area which were in good standing on January 1st, 1958. No further work was done in the area between this date and January 1st, 1961. This is followed by a short study of the paragenesis of the ore minerals.

Figure 1 is a map of the area, showing the locations of the various claim groups.

Description of Properties

Holannah Mines Limited, Group No. 1

This group consists of 89 claims located at the northern end of Gerido lake. They are numbered C. 68995, claims 1 to 5; C.77538, claims 1 to 5; C. 77581, claims 1 to 5; C.77536, claims 1 to 5; C.77537, claims 1 to 5; C.77584, claims 2 to 5; C.77583, claims 1 to 5; C.77582, claims 1 to 5; C.69015, claims 1 to 5; C.71026, claims 1 to 5; C.68998, claim 1; C.68988, claims 1 to 5; C.67752, claims 1 to 5; C.67754, claims 1 and 2; C.67753, claims 1 to 5; C.80780, claims 1 to 5; C.81876, claims 1 to 5; C.80781, claims 1 to 5; C.80877, claims 1 to 5; and C.80768, claims 1 and 2.

The property is underlain by sedimentary and volcanic rocks intruded by gabbro sills. The sills consist of three main types of gabbro: normal, feldspathic, and blotchy. The general strike of the sedimentary rocks is N.20°W., and the southern part of the group is in a syncline.

Following the prospecting and the mapping of this group at a scale of 1,000 feet to one inch, a number of mineralized zones were investigated by trenches, pack-sack drilling and detailed sampling. The most important mineralized zones are described below:-

(1) Showing No. 1 is found on C.68996, claim 4. The host rock is a medium-grained gabbro with minor lenses of blotchy gabbro and contorted sedimentary rocks or meta-gabbro. Several small lenses of massive sulphides occur within an area 600 feet long and 100 feet wide, parallel to the strike of the sill. The largest lens is 125 feet long and up to 2 feet wide.

The massive mineralization has an average content of 60% pyrrhotite, 3% chalcopyrite, and up to 10% magnetite. The mineralization appears controlled by strong shearing in a S.20°E., direction.

(2) Showing No. 2 is situated on C.68996, claim 1. The host-rock is the same sill in which showing No. 1 is found. The general zone of mineralization is at least 80 feet wide and 600 feet long. The sulphides of interest are found within several narrow, massive lenses averaging a few feet in width. The main metallic minerals are pyrrhotite and chalcopyrite, with minor magnetite and pyrite. They form aggregates in the massive zones and blebs or streaks in the surrounding gabbro. The mineralization was controlled by shears and joints.

(3) Showing No. 3 is located within a blotchy gabbro which disappears to the north under a small lake in the south part of C.77536, claim 1, and C.77581, claim 1. The extent of the mineralized zone is poorly known owing to lack of exposures. The metallic minerals, which locally make up to 50% of the host rock, consists of disseminated and massive pyrrhotite and chalcopyrite. The structural control is a strong shear that strikes due north and dips 70° east.

Holannah Mines Limited, Group No. 2

Group No. 2 is located about 3 miles northeast of the northern end of Gerido lake and consists of 15 claims numbered C.68990, claims 1 to 5; C.69011, claims 1 to 5; and C.68986, claims 1 to 5.

The property is underlain by lavas, gabbro, and blotchy gabbro, with some shales and slates. Chalcopyrite is found within the sedimentary rocks at the contact with the blotchy gabbro. Work on this property consisted of detailed geological mapping and prospecting.

Holannah Mines Limited, Group No. 3

This group of claims straddles Gerido lake at about latitude 58°15' and consists of 35 claims numbered: C.77589, claims 1 to 5; C.77590, claims 1 to 5; C.77591, claims 1 to 5; C.68991, claims 1 to 5; C.68998, claims 2 to 5; C.69012, claims 1 to 3; C.67754, claims 3 to 5; and C.67755, claims 1 to 5.

Within this group two showings, Prud'homme Nos. 1 and 2, are of particular interest, the first being the more important. Prud'homme comprises an area of 4,500 feet by 2,500 feet on the east shore of Gerido lake about 7 miles south of its northern end and covered by claims 67754 (3), 68891 (1), and 68998 (3). This property is underlain in the west and in the centre by sedimentary rocks totally or partly replaced by massive sulphides. Outcrops of bedrock are relatively scarce in comparison to the surrounding country.

The sedimentary rocks dip 45° east. A northeast striking fault crosses the property and many minor faults are indicated by geophysical work. Massive sulphides have replaced the sedimentary rocks. They consist of pyrite, pyrrhotite, chalcopyrite, and sphalerite. White pyrite is the dominant mineral. Grab samples assayed as much as 5% copper and $2.00 of gold per ton.

The property was mapped at the scale of 1 inch to 200 feet in 1955, and 559 feet of packsack drilling was done. In 1956, 11 holes were drilled for a total footage of 2,591 feet. A magnetometer survey was made over the property in 1955 and, in 1956, an electromagnetic study and a detailed magnetometer survey were made over part of the showing.

This work suggests that the sulphide body is contained in a crescent-shaped fold tapering northwest and southeast. The company has issued no data concerning the tonnage and the tenors of copper and gold of this ore body.

<u>Prud'homme No. 2</u> showing is covered by a group of 12 claims forming a rectangle along the west shore of the north half of Gerido lake. Grab samples assaying more than 3% copper were taken by the writers while mapping the area in 1953.

Bedrock exposures are relatively abundant in this area and are almost entirely basic intrusive rocks of which about 25% is blotchy gabbro. The rocks are folded into a syncline with an axial plane striking N.10°W. and dipping about 60° west. The plunge of the fold is 10°-20° north. Faults are common and the mineralized zones occur in shears trending northward.

Two massive sulphide zones have been studied by the company. One is in a narrow band of sedimentary rock in contact with the blotchy gabbro and the second is in the blotchy gabbro itself. Pyrrhotite is the most important sulphide mineral, and some chalcopyrite is disseminated within the pyrrhotite.

Development work consisted of trenching and of 289 feet of diamond drilling, following mapping at a scale of 200 feet to one inch.

Holannah Mines Limited, Group No. 4

This group comprises 160 claims located along the west shore of Gerido lake at the south end of the lake. These claims are numbered: C.89758, claim 1; C.89759, claims I to 5; C.89760, claims 1 to 5; C.89761, claims 1 to 5; C.80783, claims 1 to 5; C.80782, claims 1 to 4; C.68992, claims 1 to 5; C.80765, claims 1 to 5; C.68997, claims 1 to 5; C.77588, claims 4 and 5; C.80764, claims 4 and 5; C.67581, claims 4 and 5; C.77552, claims 1 and 2; C.69017, claims 1 to 5; C.69016, claims 1 to 5; C.90782, claim 5; C.64586, claims 1 to 4; C.68987, claims 1 to 5; C.68999, claims 1 to 5; C.69018, claims 1 to 5; C.71028, claims 1 to 5; C.80767, claims 1 to 5; C.80898, claims 1 to 5; C.79904, claims 1 to 5; C.64572, claims 1 to 5; C.G.4585, claims 1 to 5; C.G. 4582, claims 1 to 5; C.G. 4583, claims 1 to 5; C.71034, claims 1 to 5; C.G. 4574, claims 1 to 3; C.69000, claims 1 to 5; C.69006, claims 1 to 5; and C.80764, claims 1 to 3.

Within this group of claims, two showings in particular were closely investigated by the company. They are the Leslie No. 2 and the Erickson No. 1 which occur in the blotchy gabbro on the western and eastern arms, respectively, of the syncline south of Sauvé lake. The geology of the two is therefore the same, except that in the Erickson No. 1 showing the strata are overturned.

The blotchy gabbro sill overlies a slate bed and is in turn overlain by a second sedimentary bed. The mineralization occurs near the base of the sill and consists of chalcopyrite and slightly nickeliferous pyrrhotite replacing the matrix of the spotted gabbro. The total sulphide content is 20%-40% by volume; chalcopyrite seldom exceeds 10% and is commonly much less. In a few cases the contact of the gabbro with the underlying slate shows extensive sulphide replacement. The mineralization is localized by fractures which do not conform to an obvious pattern.

The Leslie No. 2 showing strikes N.30°W. and outcrops almost continuously over a length of 7,700 feet. Scattered rusty outcrops extend southeast beyond this length. The width of the zone ranges from 30 to 200 feet and averages about 100 feet.

The Erickson No. 1 showing is not as well exposed and consists of two mineralized zones. The first is 4,000 feet long and 75 feet wide on the average. The second extends for 2,000 feet about one mile south of the first, is 2,000 feet long and, at least 35 feet wide.

Following detailed mapping and sampling in 1953 and 1954 and magnetometer and electromagnetic surveys in 1954 and 1955, bulk sampling from freshly blasted trenches was carried out on the two showings during the summer of 1955. Two field crushing plants were assembled, one on each of the two properties, for the purpose of reducing 150-pound bulk samples to representative 2-pound samples.

On the Erickson No. 1 showing, 8 trenches were drilled, blasted, and sampled; 350 linear feet of rock-trenching was completed; 1,166 cubic yards of rock was removed; 9,050 lbs. of rock was reduced to ±30 mesh; and 57 samples were sent for analysis. The trenching required 1,169 feet of packsack drilling. The total work done on the Leslie No. 2 showing was as follows: 11 trenches drilled, blasted, and sampled; 991 linear feet of rock-trenching completed; 3,303 cubic yards of rock removed; 26,450 lbs. of rock reduced to ±30 mesh; and 173 samples sent for analysis. The trenching required 4,037 feet of packsack drilling.

As a result of this work, the company reported that the assays from the surface mineralization did not indicate that these zones were of commercial value. However, an ore zone at depth could be outlined by diamond drilling. The mineralized rocks would be a suitable mill product.

Consequently, a drilling program was carried out in 1955; 29 holes were drilled on the Leslie No. 2 showing for a total of 6,841 feet and 24 holes on the Erickson No. 1 showing for a total of 5,902 feet. The results of the drilling were generally not favourable according to the company.

Holannah Mines Limited, Group No. 5

This group is along the west shore of Prinzèles lake and comprises 9 claims numbered C.69013, claims 1 to 5, and C.69001, claims 1 to 4.

The property is underlain by volcanic rocks and sedimentaries intruded by gabbro sills. The main mineralized zone is approximately 2,100 feet long and 80 feet wide. The mineralization consists of fine-grained pyrite, pyrrhotite, and chalcopyrite, with pyrrhotite being the most abundant. The sulphides replace the blotchy gabbro, and, from visual inspection, chalcopyrite appears to make up 1-2% of the rock.

Development work consisted of detailed geological mapping, trenching and sampling, and of 150 feet of packsack drilling.

Holannah Mines Limited, Group No. 6

This group, known as the Erickson No. 3 showing, is along the southwest shore of Livaudière lake near its southern end. It comprises 22 claims numbered C.69014, claims 2 to 5; C.71035, claims 1 to 4; C.69007, claims 1 to 5; C.77556, claims 1 to 5; and C.75555, claims 5. The northwestern part of this group of claims is within the Léopard Lake area.

The property is underlain by volcanic and intrusive rocks with minor slate and tuff beds. The mineralization is within a blotchy gabbro and appears to be associated with the most intensely deformed parts of the sill. The sulphides present, in order of abundance, are pyrrhotite, chalcopyrite, pentlandite, and pyrite. Traces of native copper are found. The mineralization has progressed along fractures and shears, first replacing the ferromagnesian minerals within the blotchy gabbro and then the entire rock. Copper generally assays less than 1%; zones in which assays run better than 1% copper are not wide, and assays of more than 2% copper are rare. Nickel rarely assays more than 1%.

Development work consisted of detailed geological mapping, trenching and drilling. A total of 811 feet of drilling was done on 14 trenches whose total length was approximately 698 feet. In addition to the drilling of trench holes, 5 holes were drilled for sampling and exploration purposes for a total length of 153 feet. Thus, a total of 964 feet of diamond drilling was done.

Gerido Lake Mines Limited

The company holds a group of 50 claims about 2 miles southwest of the southern end of Gerido lake. The claims are numbered: C. 74427, claims 1 to 5; C.74428, claims 1 to 5; C.74423, claims 1 to 5; C.74425, claims 1 to 5; C.74424, claims 1 to 5; C.74426, claims 1 to 5; C.74429, claims 1 to 5; C.74430, claims 1 to 5; C.74431, claims 1 to 5; and C.73994, claims 1 to 5.

The central and eastern parts of the claim group is underlain by volcanic rocks. In the western part several sills of normal gabbro and two of blotchy gabbro are separated by narrow belts of sedimentary and volcanic rocks. The general strike of the formations is N.35^{o}W. and the dip is 65^{o} east. The over-all structure of the area appears to be a syncline with a plunge to the south. The most important rock type is the blotchy gabbro, as it is the host for the copper mineralization on the claim group. Two bands of this rock, designated as zone "A" and zone "B", ranging from 450 to 600 feet, can be traced the entire length of the claim group and for a considerable distance on adjoining properties.

Zone "A" is near the west boundary of the property. Small amounts of pyrrhotite and pyrite occur at a few places in the blotchy gabbro. The most extensive area carrying patches of sulphide mineralization is 400 feet long and 9 to 20 feet wide and is along the west boundary of claim 4, C.74428. In this area a small amount of chalcopyrite is found with the other sulphides.

In zone "B" the main mineralized zone occurs about 100 feet west of the large lake on claim 3, C.74426. Pyrrhotite, the dominant sulphide, with lesser amounts of pyrite and chalcopyrite occur along an exposed length of 26 feet and over widths of 9 to 25 feet. Seven chip and three grab samples representative of the mineralization were taken at intervals along the zone and tested for copper. The best assay gave 0.31%. However, diamond drilling showed, in most cases, a higher content of copper in the fresh mineralization than in the surface samples.

Work done on the property from 1955 to 1957 comprised: geological mapping, airborne electromagnetic and magnetometric surveys, ground magnetic data on five profiles across the property, detailed electromagnetic data along the conductive zones, and drilling. The drilling consisted in 1956 of 4 holes for a total depth of 136 feet and, in 1957, of 14 holes for a total of 462 feet. Most of the core samples carried about 0.5% copper.

<u>New Athona Mines Limited</u>

This company has retained 5 claims of a group of 64 located along the east shore of Gerido lake about 5 miles northwest of the south end of Gerido lake. These five claims are numbered: C. 84775, claims 1,2,3, and 5, and C.84767, claim 5.

The general area claimed is underlain by sedimentary and volcanic rocks intruded by gabbro sills of the normal and blotchy types. The claims cover a few showings where mineralization of three types is found:- (1) Pyrrhotite, pyrite, and varying amounts of chalcopyrite associated with the blotchy gabbro; these sulphides occur usually as elongated patches, or zones, which seem to be towards the base of the sill. (2) Some massive sulphide zones are located along the gabbro-sedimentary contact; the chief mineral is pyrrhotite, with some pyrite and chalcopyrite. (3) Numerous small joints and shear zones in all the rocks mineralized; all carry minor amounts of pyrite and pyrrhotite, but chalcopyrite is also present in places.

Teck Exploration Company Limited

This company holds a group of 30 claims about two miles southeast of the southern end of Gerido lake. These claims are numbered: C.84790, claims 3 to 5; C.84791, claims 3 to 5; C.84792, claims 3 to 5; C.84802, claims 1 to 5; C.83805, claims 3 to 5; C.83806, claims 3 to 5; C.83807, claims 3 to 5; C.83808, claims 3 to 5; C. 83800, claims 3 to 5; and C.84793, claim 1.

This property is underlain by lavas and sedimentary rocks intruded by long sills of gabbro. The whole assemblage strikes N.36°W. Volcanic rocks form well marked uplands. Sedimentary horizons occupy many of the elongated draws or valleys.

Pyrrhotite and pyrite were noted in several sedimentary bands and also in a few isolated spots in volcanic rocks. The type of mineralization varies from disseminations to streaks several inches wide within the sedimentary rocks. No copper mineral was seen in any of the sedimentary showings.

A minor occurrence of chalcopyrite is found in cross-fractures in blotchy gabbro, 1,200 feet south of Prinzèles lake and on or near the west boundary of the property.

Work on the property consisted of an aerial electromagnetic survey, mapping, and detailed prospecting. Stripping was done on several of the sedimentary mineralized zones and in the vicinity of the copper mineralization in the blotchy gabbro mentioned above.

Hopes Advance Mines Limited

This company holds a group of 90 claims about 4 miles south of the south end of Gerido lake. These claims are numbered: C.73206, C.73207, C.73208, C.73201, C.73205, C.73209, C.73210, C.73211, C.73202, C.73212, C.73213, C.73214, C.73215, C.73206, C.73216, C.73217, C.73218, and C.73219, claims 1 to 5.

The property is underlain by sedimentary and volcanic rocks injected by gabbro sills. Numerous and extensive gossan areas with pyrrhotite, subordinate pyrite, and minor amounts of chalcopyrite are evident. The mineralization is in shear zones within the lavas and blotchy gabbro, and, to a much lesser extent, sedimentary rocks. However, outcrops of sedimentary rocks are rare and belts of them are usually inferred from occasional patches of shale and slate observed on steep valley walls.

Work on the property consisted of an aerial electromagnetic survey, mapping, and prospecting of 28 different sulphide occurrences. The assay results of all samples were consistently low.

Belcher Mining Corporation Limited

The company has a group of 60 claims near Livaudière lake. The claims are numbered: C.83787, claims 1 to 5; C.83788, claims 1 to 4; C.83789, claims 1 to 4; C.83790, claims 1 to 4; C.83813, claims 1 to 4; C.83815, claims 1 to 5; C.83791, claims 2 to 5; C.83793, claims 1 to 5; C.83816, claims 1 to 5; C.83792, claims 1 tp 4; C.83394, claim 1; C.83794, claims 1 and 2; C.83369,claims 1 to 5; C.83368, claims 1 to 5; C.83370, claim 3; C.83365, claim 5; and C.83367, claim 5. Only the northern part of this group is within the Léopard Lake area.

This property is also underlain by sedimentary and volcanic formations intruded by gabbro sills. Small zones of blotchy gabbro were discovered, but no interesting mineralization was found in them. Zones of massive sulphides with minor amounts of chalcopyrite occur in many places along the contact between gabbro and sedimentary rocks.

Geological, as well as geophysical, work was carried out on the property during the summer of 1955. The geological work included mainly geological mapping and prospecting. The geophysical work consisted of a reconnaissance magnetometer survey and detailed electromagnetic work over the anomalous zones.

Ungava Copper Corporation Limited, No. 1

This company holds a group of 48 claims covering mineralized zones known as the Soucy Lake showings about 5 miles east of the northern part of Gerido lake. The claims are numbered: C.70885, claims 1 to 5; C.71995, claims 1 to 5; C.70887, claims 1 to 5; C.71997, claims 1 to 5; C.71996, claims 1 to 5; C.71998, claims 1 to 5; C.72008, claims 1 to 5; and C.71999, claims 1 to 3.

The property is underlain by a complex of interbedded schists, slates, and lavas, which has been intruded by sills of gabbro and blotchy gabbro. Mineralization is found at the contact between the gabbros and the invaded rocks and, in a few places, within the blotchy gabbro itself. The main mineralized zone extends the full length of the property, 9 miles. It consists of a fine-grained mixture of pyrite and pyrrhotite that replaces sedimentary rock and is in turn replaced by copper-, zinc- and nickel-bearing minerals.

Following mapping and prospecting of the property and adjoining areas, approximately 13,000 feet of diamond drilling was carried out during the summer of 1954 and a total of 1,850 feet was completed during the fall of 1955. The most important base metal showing, Zone A, is described in some detail below.

The sulphide zone was first exposed by trenching. Surface values across an exposed width of 39 feet averaged: 1.07% copper, 0.77% zinc, and $1.12 gold and $0.15 silver per ton. The ore consists of massive pyrite with pyrrhotite, chalcopyrite, sphalerite and, locally, galena. The gangue minerals are coarse-grained quartz and calcite. Secondary minerals such as malachite and melanterite are present, at the surface, in a few places. For a variable thickness outside the ore zone the black shale is soaked with extremely fine-grained sulphide giving the rock a mouse-grey colour. The mineralized shale is cut by veinlets of coarser sulphides of a later generation which become progressively more abundant as the ore zone is approached until the rock is completely replaced by the massive copper-zinc-bearing sulphide ore.

The ore zone strikes N.25^{o}W. and dips 70^{o}-80^{o} west. A series of 7 drill holes, which are collared east of the surface showing and dip 45^{o} and 60^{o} west, has outlined a curved lens-shaped ore body extending to a depth of 450 feet. This mass of ore is slightly more than 1,000 feet long and its width averages 66 feet. It occupies the axial zone of an overturned fold in the sedimentary rocks.

An estimate of tonnage to a depth of 175 feet gives approximately 1,250,000 tons of ore averaging 1.12% copper, 1.59% zinc, and $1.45 gold and $0.39 silver per ton, spread over an average width of 66 feet. If we consider the intersection of the ore body in one hole at a depth of 400 feet, the total would be some 2,250,000 tons of ore with approximately the same grade as above.

During the summer of 1955, three types of geophysical surveys were conducted on the property, namely; magnetometer, electromagnetic, and spontaneous polarization. The object of this work was to determine by tests on known occurrences the best method of detecting sulphide mineralization and then to use it to explore the belt of favourable formations over the entire length of the property to outline the mineralized lenses. The results of these surveys showed that all three methods are perfectly suitable to outline the type of mineralization encountered on the property. Nevertheless, in that area, the most practical method is the magnetometer survey because the magnetic anomalies are easier to interpret and the electrical methods are hampered by the presence of wet overburden. A large number of anomalies were outlined as a result of this work.

Drilling in 1955 was done mainly on zone C, about 800 feet west of zone A. The drilling suggests a zone 600 feet long and 11.1 feet wide on the average. Possible tonnage to a depth of 370 feet has been established at about 143,000 tons, grading 0.72% copper and 0.22% nickel.

Ungava Copper Corporation Limited, No. 2

The Partington No. 2 showing of Ungava Copper is on the northeast shore of Gerido lake at about latitude 58°15'. It comprises 4 claims numbered: C.71994, claims 1 to 3, and C.70888, claim 1.

Massive sulphides exposed at the surface resulted from the replacement of an east-dipping shaly rock that is in contact with a massive gabbro on the east side and pillow lavas on the west. As exposed at the surface the showing is about 600 feet long and 125 feet wide in its central part. Assays obtained at different places from grab samples gave up to 7.6% copper. Two channel samples at the south end of the showing gave, over a total length of 20 feet, 2.67% copper, 0.10% zinc, 0.01% nickel, and $1.82 gold per ton.

A magnetometer survey was done on the property. Five shallow drill holes were put down with the packsack diamond drill. The core obtained showed massive sulphides containing less than 1% copper except from one hole which gave $0.51 gold and $0.21 silver per ton, 1.46% copper, and 12% zinc over a true width of 31 feet.

Other Sulphide Occurrences

A large pyrite deposit may underlie the lavas in the Crochet Lake structural basin in the central part of the west half of Gerido Lake area. Abundant mineralized outcrops suggest the possibility of a continuous or almost continuous belt of pyrite-rich shales around the lavas. The pyrite makes up from a small part to more than 75% by volume of the rock. The thickness of the pyrite-rich beds is unknown but exceeds 10 feet at places. The deposit, known as "Partington No.1 showing", was staked by Ungava Copper but the claims were allowed to lapse.

Several outcrops of pyrite-rich black shale occur in line over a distance of a few miles about 1/4 mile east of the middle part of Gerido lake. They may form a thin but continuous belt a short distance below the lavas. A small amount of pyrite also occurs in the top part of the Baby formation at several places, but especially in the southern part of the west half of the Gerido Lake area and near the nose of the Hellancourt Lake syncline in the east half of the same area. The pyrite is generally in black shale but also occurs in siliceous, light grey, slightly porous rocks which are apparently bleached. Chalcopyrite also occurs near Hellancourt lake, from whence a grab sample gave 0.60% copper and low nickel values. The sample was from shale just below the lavas on the east limb of the syncline, about 1/2 mile east of the axial plane. The rock is a brecciated black shale and the sulphides are concentrated in the matrix. The grade is low but the sulphides may be leached as the sample comes from the surface. Also, only two exposures of the top part of the Baby formation were found on the east limb of the syncline. Thus, this area is untested and may contain richer mineralization.

Specks of chalcopyrite occur here and there in many sills, as in the middle part of the thick sill west of Hellancourt lake. The best mineralization in gabbro, apart from the blotchy gabbro, was seen in the lower part of the thick sill near the west shore of St-Pierre lake. Chalcopyrite, malachite and a little native copper are present, the last mineral occurring as thin coatings along slipplanes or joints. A grab sample taken west of the north end of the lake contains 0.88% copper and minor nickel, gold, silver, and lead values.

Erythrite, or cobalt bloom, lines a joint surface in gabbro about 1/2 mile north-northeast of Cobalt lake, in the west-central part of the Léopard Lake area. Chemical analysis of a small sample of the gabbro revealed trace amounts only of cobalt.

Iron-bearing Rocks

The exposed part of the iron-bearing rock that outcrops in the east half of the Gerido Lake area probably is too low-grade to be of economic importance at the present time. Some beds are rich in magnetite, but they are commonly thin and widely scattered in magnetite-poor material.

The carbonate iron-bearing rock in the south-western part of the Léopard Lake area appears more interesting but it is very poorly exposed. A few small outcrops are rich in siderite. As mentioned above, a magnetite-bearing facies indicated by a strong magnetic anomaly is apparently not exposed in the area.

Summary and Ore Genesis

The sulphide deposits may be divided into three groups: (1) pyrite deposits in sedimentary rocks; (2) copper-zinc bodies with some gold values; and (3) pyrrhotite-chalcopyrite deposits in gabbros with low to moderate nickel and negligible zinc and gold values.

Pyrite Deposits

Four large pyrite deposits are known or indicated: (a) on the Soucy Lake property of Ungava Copper; (b) on combined claim group No. 2 of Ungava Copper and claim group No. 3 of Holannah Mines; (c) Partington No. 1 "showing" at Crochet lake;and (d) near the east shore of the middle part of Gerido lake. At least three of these deposits (a,c, and d) appear thin but may be several miles long. They parallel the strike of the bedding but their behavior down the dip is not known. They are generally associated with black shale and are all at the top of the Baby formation, below the lavas.

In several rocks, pyrite is in extremely fine grains of rather uniform size averaging roughly 0.003 mm. in diameter. The grains rarely coalesce where they form less than about 50% of the rock. They tend to a round shape with commonly very obtuse angles although angular corners do occur. Fine sedimentary laminae less than 1 mm. thick are perfectly preserved and are even emphasized by different quantities of pyrite in different laminae. The rock with fine pyrite is cut by narrow fractures filled with medium-grained, partly euhedral pyrite and pyrrhotite. Medium-grained pyrite and/or pyrrhotite also occur in irregular patches without obvious relation to veinlets. The writers agree with De Montigny (1955) that the fine pyrite is probably older than the coarser. However, the evidence is weak: differences in grain size and habit of pyrite suggest a different age, and the distribution of the fine pyrite seems unaffected by the fractures which partly controlled the distribution of the medium-grained pyrite. Only medium-

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grained pyrite is observed in several rocks and the relative abundance of each type is unknown. In the few sections examined, pyrrhotite is more abundant in rocks with much medium-grained pyrite than in those with abundant fine pyrite.

The most likely hypotheses for the origin of the pyrite mineralization are the following:

1- A syngenetic or possibly early diagenetic origin by chemical or biochemical precipitation in the sedimentary basin, or deposition from ground-water welling up at the bottom of the basin.
2- Deposition from hydrothermal solutions or gaseous emanations derived from cooling gabbro sills. This would take place before folding and metamorphism.
3- Deposition from hydrothermal solutions derived from a granitic body at depth.
4- Deposition from solutions or emanations expelled from sedimentary rocks during their metamorphism at depth.

In favour of a syngenetic origin is the restriction of the deposits to one stratigraphic level. At several places throughout the area, one stratigraphic level contains a black shaly rock with minor pyrite. Similarly, a ferruginous black schist with some pyrite, garnet, and grunerite is common at the top of the Baby formation in nearby Freneuse Lake area. Pyritiferous shale also occurs below the lava in the Leaf Bay area. Presumably, such pyrite is largely sedimentary and the larger deposits, which are at the same level, could be local concentrations by a similar process. The great length of some deposits also suggests a sedimentary origin. Evidence of replacement could not be found in the fine pyrite and the texture is favourable to the syngenetic hypothesis. An apparently similar texture in the Kupferschiefer of Germany is interpreted as syngenetic and due to mineralized bacteria (Schneiderhöhn, reported in Trask, 1925, and Deans 1950). Also, the fine pyrite of the present area appears similar in habit and grain size to the "fine-grained, first generation pyrite" of Mount Isa, Australia (Grondijs and Schouten,1937), which "is commonly accepted now to be syngenetic" (Murray and Carter, 1959) although there is still much disagreement on the origin of later sulphides. Within this pyrite, Love and Zimmerman (1961) claim to find remnants of rounded micro-organisms slightly smaller than the pyrite granules. They attribute to these organisms the syngenetic or early diagenetic formation of the iron sulphide. The medium-grained pyrite in the present area could have formed by recrystallization and slight mobilization of the fine type during metamorphism.

The pyrite deposits could have formed by hydrothermal or gaseous emanations from the sills, especially from the blotchy sill which contains much sulphides. The proximity of the deposits to this sill, which occurs in the upper part of the Baby formation, could account for the apparent stratigraphic control of the deposits. The pyrite-bearing sedimentary rocks of the Freneuse Lake and Leaf Bay areas probably occur well beyond the limits of occurrence of this sill but they also appear much leaner in pyrite than the rocks near Gerido lake.

The hypothesis of formation by hydrothermal solutions derived from igneous rocks other than the gabbro suffers from the lack of such rocks. Some pegmatite dykes occur roughly 20 miles east of the pyrite deposits. They may indicate an acid intrusion at depth but none has yet been found, even in the highly metamorphosed rocks to the east. The pegmatite appears mainly post-tectonic but related to the metamorphism and orogeny. The mineralizing solution would then have coursed through folded rocks but there is no evidence of structural control. The good stratigraphic control and great length of the deposits are rather difficult to reconcile with such a hydrothermal hypothesis.

The hypothesis of a metamorphic derivation of the mineralizing solutions from a distant source meets the same difficulties as the previous hypothesis. Its only support lies in the occurrence of most of the pyrite and all the reported base-metal mineralization in the greenschist metamorphic facies whereas the more metamorphosed rocks to the east apparently contain only minor pyrite and pyrrhotite. This distribution may suggest a mobilization and transport of sulphides from the highly metamorphosed rocks to less metamorphosed ones. However, this distribution is not proven. Also, the greenschist zone occupies a broad area and the apparent restriction of the sulphides to this zone may be simply a coincidence. The hypothesis of the derivation of the mineralizing solutions from a nearby source will be mentioned below in the case of the copper-zinc mineralization. The possibility of a slight mobilization of syngenetic pyrite has been mentioned above but the importance of the process is unknown.

Copper-zinc Deposits

Only two important copper-zinc occurrences are reported. They are covered by Ungava Copper Corporation Limited claim group No. 1 and by the contiguous claim groups Ungava Copper No. 2 and Holannah No. 3. They are associated with two of the pyrite deposits already described. Minor base metals are also reported elsewhere in the pyrite-bearing rocks. However, the writers have no information on the distribution of copper and zinc except in the first-mentioned occurrence where they appear as a lens within the very long pyrite deposit. According to De Montigny (1955), copper and zinc sulphides with medium-grained pyrite cut the fine pyrite and increase in abundance toward the centre of the lens where replacement of the original rock is almost complete.

Medium-grained pyrite is the most abundant sulphide in the aforementioned lens. Pyrrhotite is also abundant and is in part complexly intergrown with pyrite, forming a skeletal texture. It is possibly partly contemporaneous and partly later than pyrite. Sphalerite crystallized later than pyrite but its relationship to pyrrhotite, with which it is partly associated, is not clear. De Montigny (1955) thinks that it formed after pyrrhotite. Chalcopyrite is later than pyrite and pyrrhotite. It may have formed after much of the sphalerite but small veinlets of sphalerite and minor galena appear younger than the chalcopyrite. Minor magnetite is associated with sphalerite and pyrrhotite. The magnetite grains generally contain small granular inclusions of pyrrhotite. According to De Montigny (1955), gangue minerals consist mainly of quartz and carbonate and have formed late.

The association of the copper-zinc mineralization with the pyrite deposits suggests a genetic connection between all these sulphides although lack of knowledge of the detailed distribution of copper and zinc makes this highly uncertain. Thus, the copper-zinc mineralization is hydrothermal if it is unrelated to the fine pyrite and may be hydrothermal or syngenetic if it is related. In the last case, copper and zinc would have been deposited with the pyrite beds but would have undergone subsequent remobilization and redistribution, perhaps during metamorphism, as chalcopyrite and sphalerite formed later than pyrite and show evidence of replacement.

Whether the copper-zinc mineralization is syngenetic or derived from the blotchy gabbro, the most favourable prospecting ground is the top part of the Baby formation, below the lavas.

Copper-nickel Mineralization

Sulphide mineralization in the gabbros differs greatly from that in the sedimentary rocks. It consists generally of pyrrhotite and chalcopyrite with traces of pentlandite. A sample with 0.54% nickel contains intergrown pentlandite and a mineral slightly paler than pyrrhotite in about equal proportion. The intergrowth is in discrete grains and occurs side by side with pyrrhotite with only traces of pentlandite and of the paler mineral. A few very fine blades of a pale yellow mineral, were detected in chalcopyrite. Sphalerite occurs in minor amount in a few polished sections and is missing in several others. Pyrite is missing in all the sections examined by the writers. The sulphides are accompanied by minor quartz and chlorite. Sulphides and gangue have selectively replaced the ferromagnesian minerals leaving unattacked the clots of altered feldspar except along narrow fractures.

The distribution of this type of mineralization is remarkable in that it is abundant and yet is practically restricted to what is probably a single sill largely made of characteristic blotchy gabbro. Only traces of sulphides have so far been found in other sills. In some cases at least, the mineralization is more intense in the "stratigraphically" lower, non-blotchy part of the sill.

The main objections against a hydrothermal origin for the copper-nickel mineralization lie in its remarkable distribution and its independence of structural controls. Dozens of other sills with similar chemical composition and identical mineralogy lie lower than the blotchy sill and might have been better located to trap rising hydrothermal solutions. A far more attractive theory is that the mineralization is magmatic, that is, derived from the sill itself. This is strengthened by the world-wide association of pyrrhotite-pentlandite-chalcopyrite mineralization with gabbroic rocks. The occurrence of sulphides in the lower part of the blotchy sill recalls the copper-nickel mineralization of Insizwa, South Africa, which supposedly formed by liquid immiscibility (Bateman,1948). A difficulty with the magmatic theory may be seen in the textural evidence of replacement but this may be due to recrystallization and slight redistribution of the sulphides during metamorphism.

A knowledge of the ore genesis is of practical importance for exploration. Obviously, exploration for copper-nickel mineralization should be concentrated on the blotchy sill. Also, if the "early magmatic" theory is correct, sulphides are more likely to occur in original depressions in the floor of the blotchy intrusive rather than in structural traps for hydrothermal solutions. However, tight folding obliterated the original depressions except in rare cases, and only careful mapping might possibly detect them. Also, the chances of "zoning" or, for instance, of a changing nickel to copper ratio with depth, are greatly lessened if the magmatic theory is correct. However, zoning should not be entirely ruled out in view of the unknown effect of metamorphism on the redistribution of the sulphides.

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