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JOHAN BEETZ AREA, ELECTORAL DISTRICT OF SAGUENAY

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GEOLOGICAL REPORT 74

JOHAN BEETZ AREA

ELECTORAL DISTRICT

OF SAGUENAY

by

Gerald E. Cooper

QUEBEC

REDEMPTI PARADIS

PRINTER TO HER MAJESTY THE QUEEN

1957

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ELECTORAL DISTRICT OF SAGUENAY

by Gerald E. Cooper

INTRODUCTION

Location of Area

The Johan Beetz area is situated on the north shore of the Gulf of St. Lawrence between latitudes 50°15'N. and 50°30'N. and longitudes 62°30'W. and 63°00'W. It measures about 22 miles east-west and 17 miles north-south, or approximately 350 square miles.

Johan Beetz, after which this area was named, is a small settlement on the shore, about midway between the east and west boundaries of the area. It is 440 miles downstream from Quebec City and 34 miles east of Havre St. Pierre, one of the principal settlements on the north shore of the Gulf.

Means of Access

In summer, boats of the Clarke Steamship Company, Limited, sailing from Montreal and Quebec, make regular stops at Johan Beetz. The nearest hydroplane base is at Sept-Isles, 165 miles west of Johan Beetz. From Havre St. Pierre, which has an airplane landing strip, the area may be reached by motor-driven fishing boat.

Travel within the area is best accomplished by hydroplane or by motor-equipped canoe. There are numerous lakes suitable for hydroplane landing, so that all parts of the area can be reached by air. The largest rivers are, from east to west: Watshishou river, Quétachou river, Petite Piashti river and Corneille river. These are the most suitable canoe routes inasmuch as they, together, give access to nearly all parts of the map-area. The Petite Piashti River route is connected by several short portages with both the Corneille and the Quétachou routes.

The rivers contain many rapids and chutes which, however, are bypassed by well-worm portages. All the portages are short except the one leading from Cabane-Neuve lake to Prudent lake and the second portage north of Turgeon lake. Several portages have been cut at different places along these main routes to provide access to smaller lakes and rivers.

TABLE I — Portages along the Four Main Canoe Routes within the Area

Route	From	To	Portages	Total length, in feet
Corneille	Coast	Tanguay L.	4	2,800
	Tanguay L.	Turgeon L.	5	7,800
	Turgeon L.	Ferland L.	4	7,500
	Ferland L.	Traverse L.	1	900
Petite Piashti	Johan Beetz	Salé L.	0	
	Salé L.	Petit Piashti L.	2	2,700
	Petit Piashti L.	Turgeon L.	2	2,300
	Petit Piashti L.	Cabane-Brûlée L.	4	2,700
	Petit Piashti L.	Piashti L.	4	2,800
Quétachou	Coast	Cabane-Brûlée L. (outlet)	6	4,000
	River (outlet Cabane Brûlée L.)	Villeneuve L.	3	6,500
	Outlet Cabane-Brûlée L.	Bellanger L.	5	6,000
	Bellanger L.	Napoléon L.	3	2,100
Watshishou	Coast	Véronique	10	5,300
	Véronique L.	Petit Véronique L.	1	1,600
	Véronique L.	Fork in W. River	1	600
	Fork in W. River	Cabane-Neuve L.	7	5,300
	Cabane-Neuve L.	Prudent L.	1	5,100
	Cabane-Neuve L.	Théobule L.	3	1,100

Field Work

Mapping of the area was done at a scale of one inch equals one-half mile by systematic pace-and-compass traverses spaced at intervals of approximately one-half mile. As far as possible, the traverses were arranged to cross the trend of the formations. Shore exposures of the more accessible lakes were examined in detail.

The coastal section of the eastern half of the area was mapped at a scale of one inch equals approximately one-quarter mile, corresponding to the scale of the aerial photographs of that section. The western part of the coast was mapped at the scale of one inch equals one-half mile. A motor-driven fishing barge was used to travel along the coast.

Vertical aerial photographs were useful in determining the structure of the area and in tracing the contacts between different rock types.

Previous Work

Reports of mineral occurrences within the map-area, and in areas not far removed from it, are contained in publications by De Puyjalon (1899)[x] and Walker (1911). A more recent investigation was made by Elenborn (1925) of the feldspar quarry on the east side of Quetachou bay.

In 1943 Longley (1950) carried out a geological reconnaissance survey of the north shore of the Gulf of St. Lawrence between Mingan and Aguanish. The geology of the shoreline of the Johan Beetz area is included in his report.

Claveau (1945) made a brief examination of the quartz deposits of Watshishou Knoll. These deposits were studied in detail by Owens (1951) in 1949.

The area immediately to the north was mapped by Grenier (1950, 1951).

Acknowledgments

Pierre Sauvé was senior assistant in 1951, and Erwin Hamilton in 1952. Their unfailing help is gratefully acknowledged. In 1951 Gordon White acted as junior assistant. In 1952 the junior assistants were Robert Ledoux and Hadelin Bouchard. Other members of the party were William Gaudet and Alexandre Tanguay, canoemen; and Walter Harvey, cook. All performed their duties in a satisfactory manner.

Supplies were brought in at regular intervals from Johan Beetz under the direction of Johnny Bourque of that place.

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[x]References are listed at the end of this report.

Timber Resources

The trees of the area are mainly black spruce, balsam, and poplar. White birch is present in small amount. The best stands of timber are in the valleys bordering the rivers and lakes. For the most part, however, these are of such quality as to be suitable only for pulp. The higher hills are so steep that they support scrub spruce only. Due to the strong winds which blow inland from the Gulf, very little vegetation grows along the shore. Soil is present only locally, and is too lean for agricultural purposes on any important scale.

Fish and Game

The inhabitants of Johan Beetz derive their livelihood chiefly from marine fishing. In addition to their main village they have established an outpost, or fishing village, at the mouth of Watshishou river. Salmon are netted all along the shore, but chiefly at the mouth of the Watshishou. Lobsters are trapped in this vicinity and in Appititatte bay.

Trout and salmon are abundant in Watshishou, Petite Watshishou, and Corneille rivers. Quétachou river contains few trout and, owing to the height of the falls at its mouth, no salmon.

Whales and porpoises are plentiful in the offshore waters and a few seals live among the islands east of Pontbriand bay.

There are no moose or deer in the area and few caribou. Fur-bearing animals, chiefly muskrat and mink, are trapped during the winter months. Spruce partridge, rabbit and porcupine are fairly numerous.

Wild duck are abundant, particularly eider-duck, which nest in large numbers along the coast.

PHYSIOGRAPHY

The area as a whole rises gently northward from sea-level to heights of a little over 600 feet. The highest points are along the gabbro ridge which lies along the east side of Piashti lake. In the eastern part of the area ridge and valley topography prevails. In the western part the surface is a gently sloping plateau. Thus, the area may be divided into three topographic units, with characteristics determined by the nature and structure of the underlying rocks.

Coastline

The coastline is very irregular (Plate I) with numerous bays and peninsulas. The structure of the underlying rocks is the most important factor in determining the shapes of the bays. From Johan Beetz to Watshishou Knoll, the bays are long and narrow, and their long direction trends northeast parallel to the strike of the bedding of the underlying quartzite. They are extensions of valleys of the interior. The peninsulas, which are underlain by pegmatite or gabbro intruded into quartzite, rise to 50 feet above the water.

East of Watshishou Knoll the bays are more open, owing to variations in the trend of the underlying rocks. The irregularities of the shores of the bays, such as Pontbriand bay, are due partly to the strike of the gneiss in that area and partly to a prominent system of joints which strike N.10°E. and S.80°E.

West of Johan Beetz the shore is more regular. Jointing and foliation in the granite east of Corneille river cause minor irregularities, but west of the river the granite is massive and the coast is smooth.

The many low, barren islands along the coast, particularly east of Watshishou Knoll, owe their shape and orientation to the underlying rock structure.

The low coast, with its numerous bays and islands, is a typical "skärgård" coast and is similar to the coasts of the Baltic Sea, particularly the southern coast of Finland.

Ridge and Valley Topography

Long narrow ridges alternating with narrow valleys are characteristic of that part of the area underlain by metasedimentary rocks and gabbro (Plate II). The ridges are underlain by gabbro or gabbro-injected quartzite. They are highest in the north, sloping gently toward the sea. East and west of Villeneuve lake, where there are relatively few intrusions of gabbro, resistant beds of quartzite form low ridges. This part of the area has considerably less relief than the remainder of the map-area. The valleys, which are underlain by metasedimentary rocks, are occupied by lakes and small streams.

The shores of most of the lakes, where they are bordered by quartzite, are about twenty feet above lake-level. In contrast, those lakes bordered by gabbro have steep shores; in many places, cliffs over 100 feet high rise from the water's edge.

All the lakes in the country underlain by the sedimentary rocks and gabbro, with the exception of Bellanger lake and Cabane-Brûlée lake, have striking shapes. They are long and narrow, paralleling the trend of the rock formations. They occupy low portions of persistent depressions formed by selective erosion along the line of contact between quartzite and gabbro. Bellanger lake consists of two parts joined by a narrow passage. The large east bay occupies a low area in a wide band of quartzite; the west bay fills depressions between high gabbro ridges. Cabane-Brûlée lake fills several shallow depressions underlain by sedimentary rocks and surrounded by gabbro. Passage between these depressions has been made possible by erosion in areas where the gabbro is highly jointed.

Besides the major lakes of the area, which occupy low portions of the main valleys or broad basins in the granite plateau, there are many small lakes filling low areas in the gabbro ridges or quartzite hills.

Plateau

That part of the area northwest of Johan Beetz and underlain by granite is a gentle undulating surface sloping southward. Glaciation has removed many of the irregularities which would be expected in a region underlain by well-jointed granite of this type. The deeper depressions are occupied by lakes whose shapes are controlled to a large degree by jointing in the granite.

At corresponding distances from the sea, the plateau is at lower elevations than the gabbro ridges.

Drainage

There is no well-developed drainage system in the area. In most cases, the lakes of any one system are joined by a short series of rapids and cascades. This is particularly true of the Petite Piashti River drainage. All the rivers are shallow, although containing sufficient water for travel by canoe even in dry seasons.

The drainage of the area is directed to the Gulf of St. Lawrence through four main drainage basins:

(1) Corneille river; draining Traverse, Ferland, Turgeon and Tanguay lakes and several small lakes which flow into these.

(2) Petite Piashti river; draining Piashti, Petit Piashti and Salé lakes.

(3) Quétachou river; draining Napoléon and Bellanger lakes, as well as Cabane-Brûlée lake and numerous small lakes emptying into it.

(4) Watshishou river and its west tributary; draining Théobule and Cabane-Neuve lakes.

Besides these main rivers, numerous smaller streams, such as Villeneuve, Petite Watshishou and Pontbriand rivers discharge independently into the Gulf.

GLACIAL GEOLOGY

There is abundant evidence of continental glaciation throughout the region. Glacial striae, erratic boulders and morainic debris are found on practically every hill as well as in the valleys. The intensity of glacial action cannot be calculated fully until more detailed work has been done in the area. It is certain that the greater part of the erosion pattern is of pre-glacial age and that the work of the glaciers consisted of scouring the valleys and rounding the hilltops.

The general direction of movement of the glaciers was south-southwest. Glacial striae, trending between S.8°W. and S.20°W., were observed along the shores of many lakes. Glacial grooves with similar trend are abundant in the amphibolite and are particularly well-developed along the coast. The grooves are six to twelve inches wide and up to twenty feet long. On the relatively low shores of many lakes friction cracks were frequently seen in quartzite. It was not possible to determine the direction of ice movement from this feature.

At many localities large grooves, thirty to forty feet long, were observed in the rock walls of the larger valleys. This indicates that the movement of the glacier was controlled, in part at least, by the topography.

The topography along the coast provides further proofs of glaciation. The outcrops are very smooth, well-rounded and polished. Several resemble small "roches moutonnées".

Actual glacial deposits are few. In most places the bedrock is free from debris, or is covered by a thin mantle of soil. Glacial deposits consist mainly of erratic boulders, unsorted till, and clay. Erratic boulders are common on many of the high hills, but are more numerous in the valleys. A few valleys are covered by unsorted and unstratified till, but their areal extent is small. A band of sandy clay is exposed along Villeneuve river. The clay is massive, light buff in colour, very fine-grained and up to thirty feet thick.

In many places the glacial deposits have been reworked by the present streams. The resulting post-glacial deposits are numerous, but of limited areal extent. Gravel bars are common in the upper reaches of Watshishou river, and many sand and gravel deposits are present along Petite Piashti river.

GENERAL GEOLOGY

Introduction

All the consolidated rocks of the area are of Precambrian age. The oldest formations are metamorphosed sedimentary rocks, grading from quartzite to biotite schist. At three localities in the southern part of the area and at Ferland lake, the metasedimentary rocks have been transformed into migmatite. Intrusive into the metasedimentary rocks is a series of long, tabular, sill-like bodies of altered gabbro. The metasedimentaries and the gabbro are the characteristic rocks of the area as a whole. In the southwestern part of the area a mass of gneissic granite occupying some 55 square miles cuts the metasedimentary rocks, and contains inclusions of quartzite and gabbro. This granite is cut by a younger, medium-grained, generally massive granite. A small stock of coarse-grained granite is exposed at Ferland lake. The youngest rocks of the area comprise an intrusive series of pegmatite dykes and sills which cut the granite, gabbro and quartzite.

Metasedimentary rocks occupy slightly more than one-third of the area, gabbro slightly less than one-third, and granite and migmatite about one-quarter.

Table of Formations

<table>
<tr><td>Cenozoic</td><td colspan="2">Sand, clay, gravel, erratic boulders</td></tr>
<tr><td colspan="3">Great Unconformity</td></tr>
<tr><td rowspan="11">Precambrian</td><td rowspan="7">Intrusive Rocks</td><td>Pegmatite</td></tr>
<tr><td>Intrusive Contact</td></tr>
<tr><td>Medium-grained biotite granite
Coarse-grained biotite granite</td></tr>
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<tr><td rowspan="2">Metasedimentary Rocks</td><td>Micaceous quartzite, quartz-biotite schist, quartz-biotite gneiss</td></tr>
<tr><td>Grey quartzite, calcareous quartzite, crystalline limestone, thin conglomerate lens</td></tr>
</table>

Metasedimentary Rocks

Metamorphosed sedimentary rocks are widely distributed in the area generally and are the predominant type in the eastern half. For the most part they occur in bands of irregular width separated by sills and dykes of altered gabbro. The widest band - up to three miles - reaches from Quetachou bay on the coast past Villeneuve lake to Bellanger lake on the northern border, a distance of some sixteen miles.

The metasedimentaries may be grouped into two broad types or facies on the basis of lithology. The first includes fine-grained, light to dark grey, impure quartzites, constituting by far the most abundant of the metasedimentaries. Interbeds of carbonate-, hematite-, and rutile-bearing quartzite are present in small amount. The second, and minor, facies is composed of micaceous quartzite, quartz-biotite schist and gneiss, and biotite schist, all commonly interbedded with varying amounts of dark grey quartzite. This facies is exposed in a narrow band in the southern part of the area between Quetachou and Appititatte bays and in a few scattered bands to the northeast.

As already implied, the thought here is not that the two general rock types represent different ages but rather that they represent facies changes in one and the same group. Observed gradations between the two types suggest that sedimentation in the southern, coastal part of the area was different from that to the north.

Besides the two groups noted above, a minor amount of coarsely crystalline limestone and a small lens of conglomerate were found.

Primary bedding (Plate III-A), ripple-marks and cross-bedding were observed in the quartzites. The last two features are preserved well enough to indicate the tops of some of the beds.

Grey Quartzite

Grey quartzite is the principal metasedimentary rock of the area. It occurs in beds ranging from a fraction of an inch to three feet in thickness. It is white to dark grey in colour, hard, tough, and fine- to medium- grained. The quartzite has a rough conchoidal fracture, the perfection of which is controlled by the degree of recrystallization of the rock. Usually the surface weathers to a light grey colour. In many places, however, it weathers white. This has resulted from the leaching out of the iron oxides which have been carried away in solution and redeposited lower down as limonite, forming an iron-rich band some distance below the surface.

The white quartzite is exposed in narrow bands between sills and dykes of amphibolite, east of Petite Watshishou river. The rock has a sugary texture. Its mineralogical composition, as determined with the petrographic microscope, is as follows:

Quartz	75-90 per cent
Feldspar	5-15 per cent
Muscovite	3-15 per cent
Epidote	0- 3 per cent
Chlorite	0- 5 per cent
Accessories	Apatite, tourmaline, sphene, biotite, carbonate

The average grain size of this rock is larger than that of the impure types. The quartzite has been recrystallized to such an extent that none of the original outline of quartz grains can be observed. Pore spaces and sandy textures are absent. The quartz grains are highly strained. Both orthoclase and microcline are present. The latter is clear, but the orthoclase has been altered to sericite. Muscovite occurs as small, tabular crystals between grains of quartz or within but near the outer edges of the grains, a feature which suggests that silica has been added to the original quartz of the rock. Chlorite was observed in one thin-section as an alteration product of biotite. Another thin-section showed irregularly scattered epidote.

The more usual grey quartzite is best shown east of Villeneuve lake, where it forms part of a continuous band extending from Bellanger lake to the sea. The average grain size of the grey quartzite is 0.2 millimeter. Its mineralogical composition is:

Quartz	60 - 75 per cent
Feldspar	4 - 20 per cent
Biotite	2 - 10 per cent
Muscovite	8 - 13 per cent
Amphibole	accessory to 20 per cent
Magnetite	accessory to 8 per cent
Accessories	Carbonate, apatite, tourmaline, sphene, epidote, garnet, rutile, pyrite, scapolite

Quartz, the major constituent of the quartzite, occurs as irregularly-shaped, inequigranular crystals whose boundaries are frequently sutured. Under the microscope, it is difficult, if not impossible, to distinguish individual grains in plain light, except where quartz abuts against calcite, mica or feldspar. In such cases, the quartz has a well-rounded outline. Many grains display undulatory extinction, particularly in samples from the southern part of the area, where some of the rocks have been granulated. Inclusions of other minerals are common about the edges of quartz.

In six thin-sections of this rock, a small amount of fine-grained (0.01 mm. in diameter) quartz in clusters 0.2 mm. in diameter was observed between the larger grains. The quartzite of those thin-sections is considerably less deformed than that of the other thin-sections.

Three feldspars are present in the grey quartzite: orthoclase, microcline and albite. One or more may be lacking at any one place, but in many cases all three are found together. Invariably the orthoclase is altered; in many grains the alteration has been intense, producing a fibrous matte of kaolin and sericite. Because of this alteration and the well-rounded grain outline, the orthoclase is considered to be primary. Microcline, on the other hand.is always fresh and shows twinning. As it is found interstitially to and partly enclosing quartz, biotite and orthoclase, it is considered to be a secondary mineral. Very little albite is present. It generally occurs as irregularly shaped, clear grains or it is intergrown with microcline as microperthite.

A small amount of biotite is present in the quartzite. The biotite is lath-shaped, and 0.4 mm. or less in length. The larger grains contain numerous small inclusions of quartz in poikilitic fashion. Other inclusions are magnetite, apatite and zircon. Where the rock is granulated the biotite is altered to chlorite.

Colourless muscovite forms tabular crystals 0.3 mm. long and 0.1 mm. wide, interstitial to and partly surrounding quartz grains. In four thin-sections clots of fine-grained fibrous white mica (possibly primary) form the matrix of the rock. In these sections large crystals of muscovite are rare, if not absent.

The amphibole most commonly present in the quartzite is hornblende, but a small amount of tremolite was also observed. Hornblende usually occurs as elongated crystals between grains of quartz. Some crystals are poikilitic, enclosing numerous quartz grains, and thus suggest that the hornblende is secondary.

Scattered grains of magnetite are distributed throughout nearly all the thin-sections of the quartzite. They have a sub-angular outline. In two thin-sections, magnetite is concentrated in narrow bands, suggesting that it is detrital. A few grains of rutile were observed associated with the magnetite, but this mineral is more abundant in the hematite- and rutile-bearing quartzite described below.

Of the accessory minerals, carbonate, apatite, tourmaline and sphene are the most widespread. Carbonate is present in clusters or single grains. The carbonate is assumed to be calcite because any magnesium present would have been utilized in the formation of amphibole during recrystallization. Sphene occurs as excellent wedge-shaped crystals included in biotite, or as well-rounded grains often associated with magnetite. This latter occurrence suggests a detrital origin for part of the sphene. Apatite and tourmaline are common constituents scattered irregularly throughout the rock. They form subhedral to euhedral crystals included in quartz or occurring between quartz grains. Epidote is a common associate of many quartzites. In one thin-section, epidote and garnet are intricately intergrown. Small crystals of zircon surrounded by pleochroic halos were observed in the biotite. Pyrite was observed in three thin-sections.

Two thin-sections cut from samples taken in the vicinity of the gabbro-quartzite contain scapolite. This mineral forms anhedral crystals partly surrounding quartz grains and contains numerous inclusions of quartz around its outer edge.

A variety of the grey quartzite, hematite- and rutile-bearing quartzite, outcrops locally throughout the map-area. The best exposures are east of Petit Piashti lake, north of Cabane-Brûlée lake, and on the west side of Quetachou bay. The rock is characterized by black bands, averaging 1/32-inch thick, alternating with bands of grey quartzite that are 1/4-inch to six inches thick (Plate III-B). Frequently the black bands exhibit excellent cross-bedding. In a thickness of about twenty feet of grey quartzite, several zones of hematite- and rutile-bearing quartzite, up to three feet thick, can be seen. The zones are lenticular. They are seldom exposed for more than 20 feet along strike, but one zone, 3 feet wide and 100 feet long, was observed two miles north of Cabane-Brûlée lake.

In thin-section the black bands were seen to contain high percentages of magnetite and hematite. Sphene and rutile are also present. The magnetite, hematite and some sphene are in well-rounded grains. Most of the sphene, however, has an irregular crystal outline. Rutile forms acicular crystals.

Beds of calcareous quartzite, three feet or less thick, were observed interbedded with grey quartzite. Good exposures are found south of Bellanger lake, east of Petit Piashti lake, and on the west side of Quetachou bay. The weathered surface of the rock resembles that of the dark grey quartzite with the exception that the former is pitted, owing to the solution of the carbonate.

The average mineralogical composition of this quartzite is as follows:

Quartz	30 - 60 per cent
Carbonate	12 - 25 per cent
Feldspar	5 - 30 per cent
Biotite	10 - 20 per cent
Muscovite	5 - 8 per cent
Magnetite	accessory to 4 per cent
Accessories	Epidote, sphene, apatite, zircon and tourmaline

The rock is fine-grained, with an average grain diameter of 0.1 mm. It is difficult to distinguish the grain boundaries of quartz except where they are in contact with carbonate or feldspar. Here the quartz is sub-rounded. Of the feldspar, secondary microcline is most abundant, but orthoclase and some secondary albite were observed. Biotite is always more abundant than muscovite. Clusters of minute flaky crystals of white mica frequently occur interstitially to the quartz grains. Calcite occurs in clusters or single grains scattered irregularly throughout the rock.

Of the accessory minerals, epidote and apatite are most abundant. Sphene, tourmaline and zircon are frequently included in the biotite, but also occur interstitially to the grains of quartz and feldspar.

Crystalline Limestone

Lenses of coarsely crystalline limestone, intercalated with grey quartzites, outcrop on the northwest side of Quetachou bay. These lenses are from six to eight inches thick and up to twenty feet long. They are distributed in rows along the bedding of the quartzite and are clearly the remnants of originally continuous beds which have been squeezed and drawn out under pressure between thick quartzite beds.

The mineralogical composition of the rock, as determined with the microscope, is as follows:

Calcite	55 - 70 per cent
Diopside	20 - 35 per cent
Quartz	5 - 8 per cent
Feldspar	3 - 5 per cent
Accessories	Sphene, apatite

Calcite, as irregularly-shaped grains ranging from 0.2 mm. to 2 mm. in diameter, is the principal mineral. It is light grey, uniaxial negative, and has high birefringence. Diopside is colourless and forms anhedral to subhedral crystals.

Quartz and feldspar are present in almost equal amounts. The feldspar (orthoclase) is somewhat rounded and generally altered to sericite. Quartz, in round grains which were obviously present in the original sediment, is found recrystallized side by side with calcite. This indicates that the conditions of metamorphism did not always allow the combination of quartz with lime, a reaction which requires the dissociation of the carbonate and the escape of carbon dioxide.

A small amount of apatite and sphene is scattered irregularly throughout the rock.

Thin Conglomerate Lens

Conglomerate is exposed on the northwest side of a small island in the Gulf, one mile and three-quarters west of the mouth of Watshishou river. This exposure is a large inclusion in amphibolite and measures 85 feet in length and 40 feet across at its widest point. Well-rounded pebbles and boulders, up to one foot in diameter, were observed. These have been elongated slightly in the direction of strike and considerably so in the direction of dip. They are composed of medium- to fine-grained quartzite, some of which are bedded. A few cobbles of fine-grained granite were observed, but no fragment of dark rock.

At the south end of Croche lake, two discontinuous bands of "pebbly" quartzite, two to twenty feet wide, are interbedded with a mica-rich quartzite along a shear zone (Plate IV-A). The bands strike N.40°E. parallel to the schistosity of the quartzite. The shear zone, 400 to 600 feet wide, was traced 1,500 feet south of the lake. The "pebbles" range in diameter from one-half inch to three inches. They are flattened slightly in the plane of the bedding. The "pebbles" are composed of very fine mylonitized quartz with a few grains of magnetite and a small amount of fibrous white mica. The matrix of the rock is sheared quartzite, containing a high percentage of biotite and muscovite.

These bands of pseudoconglomerate represent two beds of quartzite which were ruptured during movement. Continued deformation rolled the fragments into their present form. The adjacent quartzite, however, being rich in mica, yielded by differential movement along minute planes (S-surfaces).

Micaceous Quartzite

This quartzite is essentially the same as the grey type, but contains more impurities and is darker in colour. Narrow beds of mica schist, quartz-biotite gneiss and quartz-biotite schist are interbedded with the quartzite. All gradations from micaceous quartzite to schist were observed. The mineralogical composition of the micaceous quartzite is variable, as shown in the table below:

Quartz	20 - 60 per cent
Biotite	25 - 30 per cent
Feldspar	10 - 20 per cent
Muscovite	0 - 40 per cent
Magnetite	accessory to 10 per cent
Accessories	Apatite, carbonate, zircon, epidote, sphene, tourmaline, chlorite, garnet and pyrite

The rock is fine-grained (0.02 mm. to 0.05 mm. in diameter) and inequigranular. Although the micas have a strong preferred orientation in thin-section, hand specimens of the rock show no schistose or gneissic structure.

Quartz is usually strained, particularly where the rock has been granulated. The contacts between quartz crystals in the non-granulated rock are sutured. Orthoclase is altered to sericite, but microcline and albite are fresh. The last two minerals are interstitial to quartz and mica. Pleochroic brown biotite, as lath-shaped grains 0.05 mm. long and 0.01 mm. wide, is the most common mafic mineral. It is generally orientated parallel or nearly parallel to the bedding.

One thin-section contains porphyroblasts of biotite up to 0.3 mm. long. These have an irregular outline and are poikilitic, enclosing numerous small grains of quartz. Zircon, surrounded by pleochroic halos, forms inclusions in biotite. The biotite is altered to chlorite in two thin-sections. Muscovite may form crystals equal in size to biotite, but these are seldom poikilitic. Small rounded grains of magnetite are enclosed by the muscovite. Elsewhere, magnetite is scattered throughout the rock.

Apatite, sphene and tourmaline occur as subhedral crystals. A few grains of carbonate and epidote are present. Garnet was observed in three thin-sections.

Quartz-biotite Schist

Quartz-biotite schist is interbedded with micaceous quartzite and grades into this rock. The thickness of a bed is variable, but is always less than one foot. The rock is fine-grained (less than 0.1 mm. in diameter). The mineral composition of the rock, as determined by a study of thin-sections, is as follows:

Quartz	10 - 40 per cent
Biotite	20 - 60 per cent
Muscovite	20 - 40 per cent
Feldspar	5 - 20 per cent
Accessories	Magnetite, epidote, sphene, hornblende, carbonate, apatite, zircon, tourmaline, chlorite and garnet

Quartz is clear and inequigranular. In three thin-sections, abundant mica is concentrated in narrow bands separated by quartz-rich bands, producing a microscopic gneissic structure. The quartz grains in the layers rich in mica are larger than the grains in the layers poor in mica.

Biotite and muscovite are present together, but never in equal amount. Invariably, the mica minerals are larger than the remaining constituents. One thin-section shows small slender crystals of hornblende up to 0.5 mm. long randomly scattered throughout the rock. The accessory minerals were observed in all the thin-sections, but magnetite and epidote are most abundant. In one thin-section epidote forms three per cent of the rock and is associated with biotite and hornblende.

Biotite schist was observed at two localities in the area. On the west shore of Mine bay, an exposure of biotite schist 600 feet long and 20 to 40 feet wide is between grey quartzite and a large pegmatite dyke. The deformation of the rock has produced an undulating schistosity. Large curved crystals of biotite and a small amount of mylonitized quartz are the main constituents. Several small lenses and stringers of quartz have intruded the rock along the schistosity planes. Brown garnets up to one-half inch in diameter may form as much as 20 per cent of the volume of the rock. The garnet contains flakes of biotite, as well as small grains of magnetite and epidote.

For a distance of a mile and a half east of Appititatte bay, biotite schist is interbedded with micaceous quartzite, quartz-biotite schist and quartz-biotite gneiss. This schist is similar to that described above, but contains only a few crystals of garnet.

Veinlets, lenses and irregular stringers of pegmatite, which pinch and swell along strike, have been injected along the schistosity of the rock.

Quartz-biotite Gneiss

This rock, associated with schist and micaceous quartzite, outcrops throughout the southwest part of the map-area. The rock possesses a pronounced gneissic structure. Individual layers average four millimeters in thickness, but they may exceed one centimeter. They are alternately rich in quartz and mica. The table below gives the average mineral composition of the rock:

Quartz	10 - 50 per cent
Biotite	15 - 55 per cent
Muscovite	accessory to 40 per cent
Feldspar	accessory to 20 per cent
Magnetite	accessory to 5 per cent
Carbonate	accessory to 3 per cent
Amphibole	accessory to 3 per cent
Accessories	Apatite, zircon. sphene, epidote, tourmaline, garnet

There is considerable variation in the grain size of the gneiss. Quartz grains are generally small, 0.2 mm. or less in diameter. Mica ranges from 0.1 mm. to 0.5 mm. in length.

The rock may be considered as a combination of laminae of biotite schist and micaceous quartzite. The association and occurrence of the minerals in the mica-rich bands are similar to that of the quartz-biotite schist. The mica minerals are generally aligned or nearly parallel to the bedding.

Stratigraphy

The distribution of the sedimentary rocks in the area has already been discussed, but it may be restated at this point. The purer types, that is, the light to dark grey quartzites, the hematite- and rutile-bearing quartzite, and the calcareous quartzite, are found predominantly in the north and east parts of the map-area. Progressing south and west, micaceous quartzite becomes more abundant. In the southwest part of the area, mica schist and quartz-biotite gneiss, as well as micaceous quartzite, increase relative to the amount of light grey quartzite. This change in the mineralogical composition of the sedimentaries is gradual and inconsistent across the area. The irregularities indicate that the conditions of sedimentation were continually changing.

The northern sedimentaries, consisting predominantly of quartz with a small amount of feldspar, calcite and other minor impurities, are well-sorted, fine-grained rocks that represent a long period of erosion of a predominantly granite-type landmass. The generally fine grain of the rocks indicates further that either the landmass was one of relatively low relief or the sediments travelled a considerable distance before deposition.

The sedimentary rocks form a series of folds which in the northern half of the area plunge south at angles between 25° and 40°.

Thus, older rocks would be exposed on the axes of the anticlinal folds at the northern boundary of the area, and progressively younger rocks would be exposed to the south. In brief, the northern sedimentaries are older, coarser, and richer in quartz than those to the south. From these facts it may be postulated that the relief of the landmass was being lowered, or that the basin receiving the sediments was gradually sinking. However, the interbedding of mica schist, quartz-biotite schist, quartz-biotite gneiss and micaceous quartzite with grey quartzite, suggests that the floor of the basin receiving the sediment was close to sea-level, at times being deep enough to allow the micaceous impurities to settle. The presence of cross-bedding and ripple marks in the quartzites supports the hypothesis that they were deposited in a shallow basin.

The apparent thickness of the metasedimentary rocks of the Johan Beetz area, as measured across the west limb of the Bellanger Lake anticline, is between 15,000 and 20,000 feet. It is probable that the true thickness of this sedimentary series is much less than this figure and that there has been repetition by faulting. No evidence of faulting was observed within the area. However, strike faults, in particular, would be difficult to observe in a series such as the present in which horizon markers are lacking.

Migmatite (Injection Gneiss)

Migmatites were observed at four localities within the map-area: east of Watshishou Knoll; on Puyjalon island and on the mainland east of the island; one and three-quarter miles west of the mouth of Watshishou river; and in the vicinity of Ferland lake.

At the first two localities, the rock possesses a pronounced gneissose structure, but at the last two foliation is weak. Except for this generality, the migmatites at the four localities are of different types, and must be described separately.

Migmatite East of Watshishou Knoll

The bedrock along the coast east of Watshishou Knoll is composed of gneissic rocks of granitic composition. They extend beyond the east boundary of the map-area.

Within this area are long narrow bands of amphibolite which parallel the gneissose structure. Close to the sea, the amphibolite bodies are smaller and appear on the surface as long, discontinuous lenses and streaks. A few have the form of irregular blocks.

Dykes of granite, and dykes and sills of pegmatite, were observed cutting the gneiss. Many small zones of pegmatite and much infiltrated pegmatitic material is associated with the gneiss near the coast.

In the field, two types of gneiss were distinguished - banded gneiss and augen gneiss.

Banded gneiss is exposed between Watshishou Knoll and Pontbriand bay and north of the bay.

The characteristics of the banded gneiss are excellently displayed on the islands at the mouth of Petite Watshishou river. The gneiss is pink, medium-grained, and granular. Discontinuous seams of mica 1/16 to 1/8 inch thick, which alternate with bands of felsic material 1/8 to 1/4 inch thick, give the rock a pronounced gneissic structure.

The average mineral composition of the banded gneiss, as determined with the petrographic microscope, is as follows:

Quartz	30 per cent
Microcline	30 per cent
Plagioclase	20 per cent
Biotite	15 per cent
Accessories	Magnetite, sphene, apatite, and garnet

The average grain size of the rock is one millimeter. Quartz forms irregular masses interstitial to the remaining grains, partly surrounding biotite and feldspar, and projecting into these minerals in irregularly-shaped tongues and apophyses. Some quartz is intergrown with feldspar in typical myrmekitic fashion. Microcline tends to form equidimensional grains which, however, are very irregular in outline. It is usually fresh and contains irregularly-shaped patches of altered plagioclase. Plagioclase (oligoclase) forms stubby lath-shaped grains, but more commonly the crystals are anhedral. Secondary albite forms a mantle surrounding the inclusions of plagioclase in microcline. Elsewhere, it occurs as small clear patches, interstitial to and replacing plagioclase crystals. Biotite is pleochroic from light yellow to golden brown. Clusters or single crystals of biotite in parallel orientation form narrow discontinuous seams. The outlines of some grains, however, are controlled by the crystal boundaries of quartz and feldspar.

Plagioclase has been altered to secondary mica, some epidote and zoisite, but the alteration is slight. Biotite has been altered to chlorite (penninite), which developed along the cleavages of the biotite. A few crystals of green hornblende and several crystals of garnet are present in some of the thin-sections.

The mineralogical composition of the gneiss changes gradually in a northerly direction. The amount of quartz increases, whereas the content of feldspar and biotite diminishes. The rock retains its gneissic structure, although it is not as pronounced as at the sea. Furthermore, the rock develops a compositional banding due to the concentration of biotite in certain bands and quartz and feldspar in others. The thickness of each band or layer ranges from one to three feet. The contacts between adjacent bands are sharp close to the contact with the quartzite, but become gradational toward the sea, where the gneiss shows its best development.

Augen gneiss underlies that part of the coast between Pontbriand bay and the east boundary of the area. Also, bands of augen gneiss,varying in thickness from a few inches to several feet, were observed on the islands at the mouth of Petite Watshishou river and on the mainland at that place (Plate IV-B). The typical gneiss outcrops on the east shore of Pontbriand bay. Lenses of pink felsic augen are enclosed in a grey banded matrix. The augen are composed of clusters of small microcline crystals and a small amount of quartz or, in many instances, of a single crystal of feldspar. The size of the augen is variable, the largest being two inches long and one inch in diameter (Plate V-A). The matrix enclosing the augen is composed of well-banded gneiss, similar to the banded gneiss described above. The biotite bands of this matrix are arched around the augen. Augen comprise 50 to 80 per cent of the volume of the rock.

Exposures of the gneiss at the mouth of Petite Watshishou river exhibit all gradations between augen gneiss and banded gneiss. Augen gneiss forms long tabular bodies in banded gneiss. The lateral contact between the two rock types is well-defined. Along the strike, however, the characteristic shape of the augen gradually is lost, and the rock becomes essentially a banded gneiss containing innumerable small concordant lenses and stringers of pegmatite. Where the augen are well-developed in these masses, the rock is devoid of pegmatitic material, but the banded gneiss on each side of it contains numerous pegmatitic stringers. Similarly, the augen gneiss on the east side of Pontbriand bay is devoid of pegmatite, except for a few well-defined dykes.

Gneiss West of Watshishou River

A mile and a quarter west of the mouth of Watshishou river, several discontinuous and irregularly-shaped bodies of mixed rocks, separated by bands of impure grey quartzite and amphibolite, are exposed over an area approximately one mile wide and extending from the sea to the north end of Foin lake.

The rock is composed of lenticles or augen of pink, felsic material embedded in a pink or grey, fine-grained matrix. These lenticles are a fraction of an inch to one inch long, and up to one-half inch wide. At a few places, the matrix is distinctly foliated. Most of the rock, however, shows very little structure, except for the characteristic shape of the lenticles.

Under the microscope, the lenticles are composed of an aggregate of fine-grained equidimensional crystals of microcline with a small amount of quartz. The mineralogical composition of the matrix of the rock is strikingly similar to that of the impure grey quartzite. Indeed, all gradations from quartzite to gneiss are present. Where the rock is foliated, its mineralogy and texture are essentially the same as the metasedimentary quartz-biotite gneiss described above. The pink colour, which was observed at many localities, is due to two factors: first, a widespread distribution of numerous small, irregularly-shaped aggregates of microcline crystals, and second, the introduction of microcline to the matrix of the rock as veinlets and interstitial material.

The number of lenticles (or augen) varies from place to place; they may form 20 to 80 per cent of the volume of the rock.

These rocks differ from the augen gneiss described above in mineralogy, grain size and composition of the matrix.

Gneiss at Puyjalon Island

This rock is a biotite-rich, banded gneiss with augen facies. The pronounced gneissic structure results from the close spacing of alternating light and dark layers, - the former composed of quartz and feldspar and the latter of biotite. Here and there, small augen about one-quarter inch wide and one-half inch long are distributed along the light-coloured layers. The augen are composed of an aggregate of coarse feldspar crystals.

In addition to the closely spaced gneissic banding the rock is arranged in broader bands one to two feet wide. These also alternate between light and dark shades due to slight differences in mineralogical composition. The dark bands contain abundant biotite and quartz and only a small amount of feldspar, whereas the light coloured bands contain abundant feldspar and quartz and less biotite.

In thin-section, the estimated mineralogical composition of the dark bands is: quartz, 45 per cent; biotite, 35 per cent; and feldspar, 20 per cent. The biotite forms long, tabular crystals which are oriented parallel to the gneissic structure. Quartz is severely strained, and the contacts between the grains are highly sutured. Many quartz crystals completely enclose crystals of biotite. Both potash and plagioclase feldspars form anhedral crystals, generally interstitial to quartz. Plagioclase (An_{24}) has been altered to sericite, epidote and zoisite, whereas the potash feldspar (microcline) is fresh. A few microscopic grains of feldspar are included in quartz. Magnetite, sphene, apatite and a few crystals of epidote are the accessory minerals.

The light-coloured bands are composed of quartz, 30 per cent; microcline, 30 per cent; plagioclase, 20 per cent; and biotite, 20 per cent. Magnetite, apatite, zircon and sphene are the accessory minerals. The rock is inequigranular, individual grains measuring between 0.1 mm. and 2 cms. in diameter. The quartz grains are clear, highly strained and have very irregular shapes, often surrounding and projecting into feldspar. Irregular patches and globules of quartz are included in plagioclase. In places, microcline forms equidimensional crystals, but more commonly, irregularly-shaped grains of microcline fill the interstices between the other minerals. Anhedral crystals of plagioclase (intermediate oligoclase), some of which are lath-shaped, have been altered to sericite. A few are coated with clear albite. Plagioclase is also intergrown with microcline, forming microperthite. Pleochroic brown biotite in clusters or single crystals form thin discontinuous seams. Magnetite, sphene and zircon are included in biotite. Zircon is surrounded by pleochroic halos. Sphene and magnetite are also present as inclusions in quartz and as small crystals interstitial to the other minerals. Sphene frequently forms a mantle about magnetite.

Dykes and sills of pegmatite and dykes of granite are abundant in the Puyjalon Island area.

Ferland Lake Migmatite

At several places on the shore of Ferland lake, a rock composed essentially of quartz and mica contains large crystals of feldspar. Two well-exposed bands of this rock traverse the point at the southwest corner of the lake. At other places on the lake shore it occurs as inclusions in granite.

Where the amount of feldspar is relatively small, the rock breaks into discontinuous parallel layers one-half to two inches thick. This layering or parting dips toward the lake at from 5^{o} to 10^{o}. The parting is very pronounced and obscures the poorly-developed schistosity, to which it is parallel. The proportion of minerals in the rock is not constant over a large area and is dependent upon the number of porphyroblasts of feldspar present.

Four thin-sections of this rock were examined. Potash and plagioclase feldspars constitute the large grains, whereas the fine-grained matrix is composed of quartz, biotite, some potash feldspar, and accessory minerals such as apatite, sphene, magnetite, zircon, hornblende and pyrite. The composition of the plagioclase varies between An_{12} and An_{26}. Alteration of many crystals has produced abundant sericite, epidote and zoisite. Microcline forms lath-shaped grains which contain patches of altered plagioclase. The twinning and cleavage of these patches are perfectly aligned, which indicates that the microcline has replaced original crystals of plagioclase. Orthoclase, in the form of small rounded grains, is altered to sericite.

The biotite is in random orientation and is present as clusters between the large feldspar crystals or as narrow seams which arch around the feldspar. In many places, the biotite exhibits curved cleavages. In one thin-section, the biotite is altered to chlorite (pennite).

Formation of the Migmatites of Johan Beetz Area

The writer believes that the migmatites of the Johan Beetz area were formed by recrystallization of, and introduction of pegmatitic and granitic solutions to, pre-existing sedimentary rocks, and, to a lesser degree, the amphibolite. In view of the distances between the areas of migmatite, the formation of the migmatite in each area will be described separately.

The contact between the gneiss east of Watshishou Knoll and the sedimentary rocks (quartzite) was observed at two localities: northwest of Petite Watshishou river and east of Pontbriand river. At both places the change from quartzite to gneiss is gradual. Actually, the transition zone from quartzite to typical banded gneiss, such as the gneiss exposed at the sea, is almost a mile wide in some places. However, it is possible to separate the rocks on the bases of mineralogical composition, texture and structure, thus narrowing down the transition zone to several hundred feet.

The mineralogical change from quartzite to gneiss continues southward to the sea. The change is effected by an increase in the amount of microcline and plagioclase. Corresponding to this change, the amount of pegmatitic and granitic material increases. At the contact between the quartzite and the gneiss, there is no pegmatite. Southward, occasional pegmatite stringers, lenses and dykes increase in abundance and, at the sea, they are very numerous (Plates V-B, VI-A). Pegmatite dykes which cut the gneiss do not have a sharp contact, but at their edges they "feather" along the gneissose structure. This "feathering" is most pronounced in those bands containing abundant biotite, because these bands offer easier channels for the solutions than the massive bands poor in biotite. The mobility of the granitic solutions is shown by dykes of granite which cut the rocks without obliterating the gneissose structure.

These dykes and sills of pegmatite and granite are considered to represent excess material which was intruded into the rocks during and following the recrystallization and the transformation of the sedimentary rocks to gneiss.

The compositional banding in the gneiss is visible even where the typical granite gneiss is exposed, although in these areas it is much less distinct.

The gneiss contains sills of amphibolite which range in thickness from a few feet to over 2,000 feet. These amphibolites do not represent "basic fronts", but are intrusive bodies. They can be traced to large amphibolite bodies (metamorphic derivatives of the gabbro) which cut the sedimentary rocks north of the area of migmatite. Furthermore, the amphibolites have been deformed and intruded by pegmatite and granite. The formation of the gneiss, therefore, took place after the intrusion of the gabbro sills and dykes. The alteration of the amphibolite has been most intense where the gneiss is best developed. Near contacts between quartzite and gneiss, the amphibolite has suffered no alteration other than intense shearing. Where the typical gneiss is exposed, the narrow sills have been drawn out into long lens-shaped bodies and streaks, whereas the larger sills were ruptured and the gneiss flowed into the intervening spaces. Much of the hornblende and biotite of the small masses has been altered to chlorite. In addition, the plagioclase has been intensely saussuritized and largely replaced by secondary albite. Potash feldspar and quartz have been added.

Nowhere in the area is there any evidence that the rocks reached a molten state. The compositional banding, a relic structure of the original bedding, has been preserved even at the sea where the effects of the solutions have been most intense. Nor did the amphibolites, although ruptured and deformed, become molten. No areas of homogeneous granite grading to gneiss were observed.

The discussion in the preceding pages shows that the effects of granitization increase toward the southeast and east. A brief examination of the region east of the map-area showed that the gneiss grades into gneissic granite and hence to massive granite. It is suggested therefore that the present area represents the outer limit of a large area of migmatites formed by the granitization of pre-existing sedimentary rocks. Whether or not the granitization was caused by intrusion of granite or the partial melting of the bedrock is not known.

On Puyjalon island, a similar gradation from sedimentary

Plate I

A - Low irregular shoreline east of Watshishou knoll.

B - Low irregular shoreline west of Watshishou knoll.

Plate II

A - High ridges of gabbro northwest of Bellanger lake.

B - Gabbro ridges southeast of Ledoux lake.

Plate III

A - Primary bedding in grey quartzite, Quétachou bay.

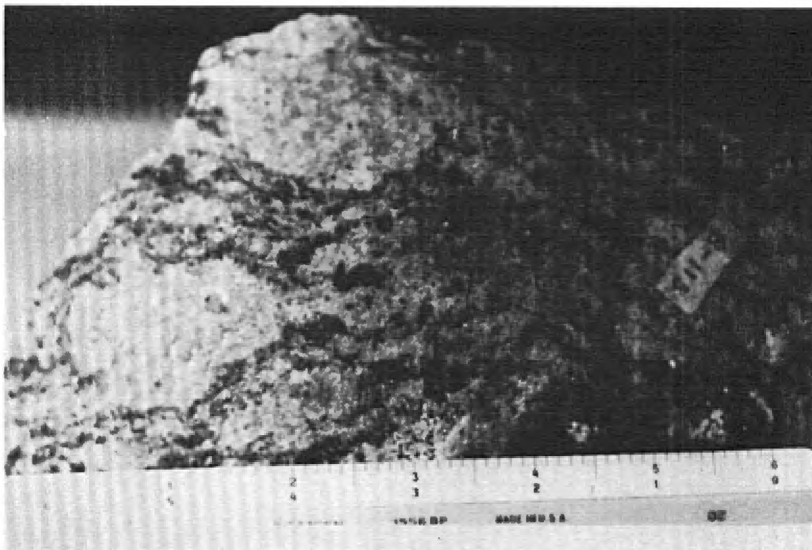
B - Hand specimen of hematite- and rutile- bearing quartzite. Upper scale in inches.

Plate IV

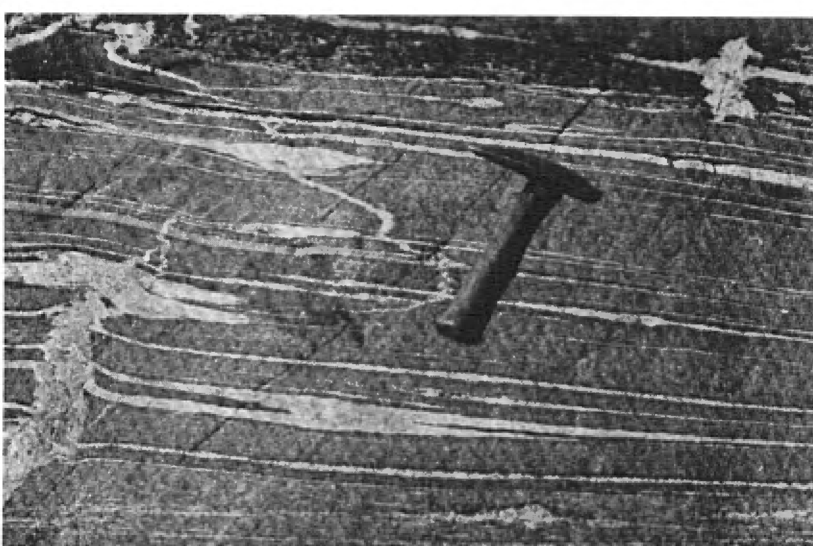
A - Pseudoconglomerate south of Croche lake.

B - Bands of augen gneiss in banded gneiss, one-half mile east of the mouth of Petite Watshishou river.

Plate V

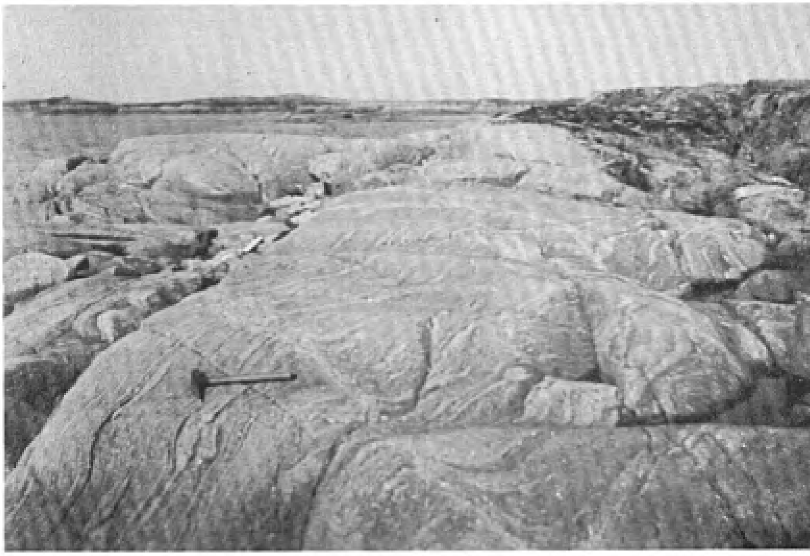


A - Hand specimen of augen gneiss. (Scale is 6 inches long).



B - Irregular dykes and stringers of pegmatite in banded gneiss at the mouth of Petite Watshishou river.

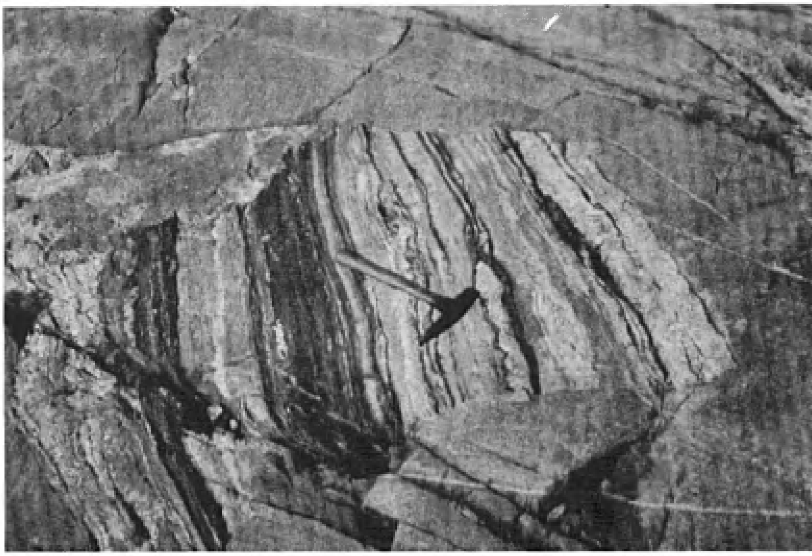
Plate VI



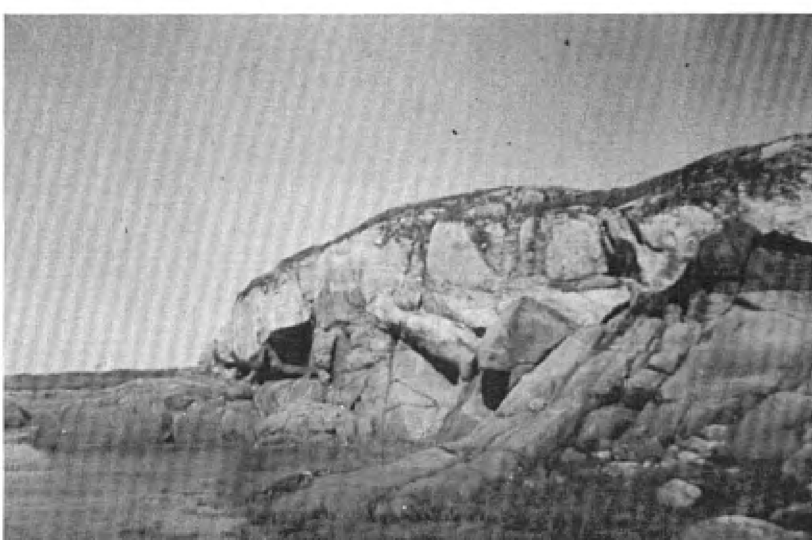
A – Small irregular lenses of pegmatite in banded gneiss at the mouth of Petite Watshishou river.

B – Deformed pegmatite sills forming boudinage structure.

Plate VII



A - Inclusion of quartzite and schist cut by pegmatite in granite. Note sharp contact.



B - Pegmatite dyke cutting quartzite, one and one-quarter miles east of Gull Island. Note shallow dip of dyke.

rocks to gneiss was observed. The sedimentary rocks of this locality are mica schists and quartz-biotite gneisses, interbedded with a minor amount of micaceous quartzite, and intruded by thin amphibolite sills. This assemblage has been injected by pegmatitic material and, with increasing amounts of pegmatite, grades into granite gneisses. Where the amount of pegmatitic material is small, the original compositional banding of the sedimentary rock is easily visible on the surface. As the amount of pegmatite increases the banding is more difficult to recognize, and where the sedimentaries have been completely saturated with the pegmatite the resulting rock is a banded gneiss containing numerous small pegmatite lenses and stringers. At certain places, quartz and feldspar have crystallized together as small augen which, during their growth, forced the schist lamellae to arch around them.

The amphibolite sills in this area have been deformed in a manner similar to that described above, but the deformation was not so intense.

The degree of migmatization increases toward the medium-grained granite and gneissic granite masses in the area. This suggests that the process was related genetically to one of these granites.

The medium-grained biotite granite contains inclusions of migmatite and gneissic granite. The contact between the inclusions and the granite is sharp. Other bodies of medium-grained, massive granite in the area are not associated with migmatites, their contacts being well-defined. Furthermore, dykes of medium-grained granite cut the migmatites with sharp contacts. These facts are evidence that this granite was not the source of the migmatizing solutions.

In the case of the gneissic granite (exposed between Johan Beetz and Appititatte bay), there are two possibilities - either this granite is the result of granitization or it is intrusive and supplied the solutions which transformed the sedimentary rocks to gneiss. All the field evidence indicates that this granite is intrusive. The sedimentary rocks north and east of this body consist predominantly of fairly pure quartzite. They have been intruded by many pegmatite sills and dykes, but have not formed migmatites. Inclusions of sedimentary rocks and gabbro in the gneissic granite are highly digested and granitized. Moreover, the gneissic granite is not cut by as many pegmatites as the surrounding rocks, and the pegmatites that do cut it have sharp contacts. The writer concludes from the above facts that the sedimentary schists, which would offer an easy passage to solutions in comparison with the massive quartzites, were transformed to migmatite during the emplacement of the gneiss granite. Possibly the migmatite is a large roof-pendant in the granite.

In the Ferland Lake migmatite the porphyroblasts developed in the mica schist are composed of feldspars similar in composition to feldspars in the granite of the area. These zones of migmatites are enclosed in granite and are therefore, large inclusions. The schists gave easy passage to the granite material and allowed the formation of porphyroblasts of plagioclase, now partly replaced by microcline. The growth of the porphyroblasts was accomplished by forcing the adjacent lamellae of biotite to one side so that, in the final product, the foliation arches around the porphyroblasts. In contrast to the above are the relatively impervious and, therefore, little altered inclusions of quartzite and gabbro in the granite.

The migmatite west of the mouth of Watshishou river is composed of augen of microcline and quartz enclosed in a matrix of micaceous quartzite. The augen have developed only in quartzites containing a relatively large proportion of mica. In the parts representing the initial stage, where there are relatively few augen, the rock has all the characteristics of a sedimentary. As the number of augen increases, all semblance to the quartzite is lost and the rock would appear to be igneous. The resulting rocks contain approximately the same proportion of biotite and muscovite as the micaceous quartzites of the metasedimentary series. The quartzites of this area are relatively poor in feldspar. Thus, the transformation to migmatite requires the introduction of sodium and potassium to form microcline. This material was introduced in two ways: firstly, as small veinlets of microcline; secondly, through the interstitial spaces of the rock. In thin section, veinlets of microcline traverse the slide, pinch out, and still others act as feeders to the augen. The augen have developed by replacement of the original quartz of the rock. There is no evidence that the growth of the augen was controlled by a nucleus. It is possible, however, that the nucleus was an original feldspar grain in the sediment about which the lenticles grew.

The source of the solutions which formed the migmatites is unknown. These migmatites are cut by large pegmatite dykes and sills believed to be related to the intrusion of the medium-grained granite. It is possible that the migmatites formed at the same time as the older granites. Just why this particular area was affected by migmatization is not known.

Uralite Gabbro and Derivatives

The oldest intrusive rocks consist of a widespread series of altered gabbro sheets making up about one-third of the rocks of the area. Individual sheets vary from a quarter of a mile to over a mile wide. Some pinch out within the map-area, but the majority extend beyond its boundaries. These have been mapped north of the area for a distance of more than 35 miles (Grenier, 1950, 1951; Claveau, 1949).

The individual sheets are not uniform in thickness, but pinch and swell along the strike. In the southeast part of the area, the gabbro (amphibolite) is interfingered with the quartzite. Many of the gabbro sheets are concordant with the intruded metasedimentary rocks. Many others, however, cut the bedding of the metasedimentaries at a small angle. At several localities, such as south of Cabane-Brûlée lake and northwest of Croche lake, the gabbro masses are irregular in shape. However, even here, although the gabbro is discordant in detail, the long direction is parallel to the bedding of the sedimentary rocks.

Four types of rock have been distinguished on the basis of degree of alteration in the gabbro series. These are: Uralite gabbro, Amphibolite, Amphibole gneiss, and Hybrid rocks. None of these types contain pyroxene, the mafic mineral present being amphibole. The change from gabbro to amphibolite and from this to gneiss and finally to hybrid rocks is gradual. Uralite gabbro is found in the northern two-thirds of the area and amphibolite in the southern third. The remaining two types are much more local and form phases of the series in the vicinity of granite, where the alteration was more intense. Amphibole gneiss occurs on the east side of the main granite mass, and hybrid rocks on the south side.

The age relations of the gabbro series and the granite are very clear. Granite truncates gabbro sheets and projects into them as tongues, dykes, and small stringers. Also, there are many altered and partly digested inclusions of gabbro in the granite.

Uralite Gabbro

The northern masses of the gabbro series in this area are usually so altered that, although the rock retains the general appearance of a gabbro, it no longer is a normal gabbro petrographically. Basing the distinction on the composition of plagioclase, the rock could be classed as diorite (Johannsen, 1937, Pt. III, p. 146). In many cases this rock has an ophitic texture which, in coarser-grained varieties, may be seen without the microscope. Some of these northern masses are the southern extensions of olivine gabbro-diabase sills mapped by Claveau (1949), who determined the plagioclase to be labradorite. The term "uralite gabbro" indicates that the composition of the rock is the result of alteration of both mafic minerals and plagioclase.

The least altered gabbros are exposed west of Piashti lake, northwest of Cabane-Brûlée lake, and between Théobule and Prudent lakes.

The rock is massive, extremely hard, dark grey to black, and medium- to coarse-grained. The distribution of grain size in any individual body is extremely irregular, except in the thin sills and dykes where the outside edges are finer grained.

In thin-section, the rock shows an ophitic texture. The plagioclase is relatively fresh and lath-shaped. Amphibole occurs as single crystals or aggregates of crystals between the plagioclase. The variation in the composition of the gabbro is shown in the following table:

Amphibole	45 - 60 per cent
Plagioclase	40 - 55 per cent
Biotite	0 - 7 per cent
Magnetite	accessory - 3 per cent
Ilmenite	accessory - 1 per cent
Accessories	Apatite, tourmaline, sphene, epidote and carbonate

Only a few large crystals of a pale green hornblende were observed. The most common amphibole is tremolite which forms clusters of acicular to stubby prismatic crystals showing a random orientation. However, fibrous and compact needle-shaped crystals of tremolite (and a small amount of actinolite) in parallel orientation were also observed in thin-section. In some thin-sections, the large crystals of hornblende grade into the tremolite.

Many thin-sections contain crystals of bluish-green hornblende. Fibrous tremolite grades into this hornblende where the two are in contact with plagioclase. The hornblende is considered to be soda-bearing (Iddings, 1906, p. 364).

Plagioclase is invariably lath-shaped. Normal zoning was observed in many crystals, the composition of the core being An_{47} and that of the outer edge An_{34}. The unzoned plagioclase has the composition An_{37} and shows no alteration. The cores of the zoned crystals are altered, whereas their outer edges are fresh. The alteration has produced epidote, zoisite and a small amount of sericite. Where the alteration of the gabbro has been intense, the plagioclase contains numerous inclusions of amphibole. Small veinlets of amphibole were also observed cutting across several plagioclase crystals. Secondary albite forms growths around the original plagioclase or replaces it in homogeneous patches and veinlets.

At certain places, magnetite occurs as criss-crossing blades within skeletal crystals of biotite. Magnetite is also associated with large hornblende crystals, and forms blade-like inclusions along the cleavage planes of that mineral. Elsewhere, it is present as irregular grains or clusters of small crystals associated with biotite. Ilmenite is present in amounts up to one per cent. In some places, it is coated with a mantle of small crystals of sphene. Chlorite occurs as the alteration product of biotite and amphibole, generally along the cleavage planes of these minerals.

Other minerals present include small crystals of carbonate, epidote, tourmaline, and apatite. Epidote is present in one thin-section only. Apatite and tourmaline increase in abundance toward the granite masses.

Amphibolite

Amphibolite outcrops throughout the southern third of the map-area, but particularly southeast of Véronique lake. Northward, it grades into massive uralite gabbro where the regional trend changes from north-south to northeast-southwest. A few long thin sills of amphibolite, many of which are sheared and ruptured, were observed in the area underlain by migmatite east of Ferland lake. Southward, these latter bodies grade into hybrid types.

The amphibolite is black, tough, and fine- to medium-grained. At many places, the rock is distinctly foliated, owing to the parallel arrangement of biotite.

In thin-section, the texture of the amphibolite is hypidiomorphic-inequigranular. Amphibole, biotite and plagioclase are the essential minerals. Apatite, sphene, carbonate and magnetite are accessory. The most common amphibole is a pleochroic green hornblende. In two thin-sections, several stubby, prismatic crystals of a colourless amphibole (cummingtonite) were observed.

Feldspar forms stubby, lath-shaped crystals which invariably are altered. This alteration has produced a dark grey, opaque, fibrous mass, some epidote and zoisite. The less-altered plagioclase has the composition An_{34}. Biotite, containing inclusions of magnetite, is present in amounts up to 20 per cent.

Sphene is included in amphibole and magnetite and also forms small anhedral crystals interstitial to amphibole. Where the amount of sphene is high, magnetite is present in relatively large amounts.

Amphibole Gneiss

Amphibole gneiss is scarce and occurs principally close to the Turgeon Lake granite. Other exposures were observed along the coast between Quetachou bay and Watshishou Knoll. The typical amphibole gneiss contains compact aggregates of elongate crystals of amphibole, separated by aggregates of plagioclase crystals. The minerals of rock show a strong preferred orientation. This structure is attributed to the deformation of parts of the sills, particularly near their contacts with the sedimentary rock, during the intrusion of the granite. The gneiss contains amphibole (60 per cent), plagioclase (30 per cent) and biotite (10 per cent). Elongate prismatic crystals of hornblende are concentrated along well-defined layers, separated by layers rich in plagioclase. Several crystals contain numerous small quartz crystals in poikilitic fashion.

The plagioclase is lath-shaped and is relatively fresh. The composition was determined to be oligoclase (An_{21}). Biotite is everywhere associated with hornblende.

In one thin-section, biotite and amphibole compose 30 per cent each of the volume of the rock. They occur together, forming poorly-defined bands separated by plagioclase-rich layers. The plagioclase is considerably more altered in this gneiss, the alteration having produced sericite with some patches of zoisite, epidote and calcite. Chlorite (penninite) has formed along the cleavage planes of some biotite crystals.

Hybrid Rocks

Many exposures of gabbro close to the contact of the granite masses show various degrees of alteration. New constituents were added, and in many exposures a complete redistribution of the original material apparently has taken place. Exposures of such hybrid rocks were found between the Ferland Lake granite and the Turgeon Lake granite, and between the Turgeon Lake granite and the granites exposed along the coast. Other exposures were found in the area underlain by the migmatites and within the granites.

The alteration of the gabbro in these areas has not been uniform in any one granite body, or between one body and the next. Indeed, many of the large gabbro inclusions in the Turgeon Lake granite show relatively few effects of the intrusion of the granite. The contact between the granite and the gabbro is sharp and an ophitic texture is clearly visible on the weathered surface of the gabbro inclusions. Inclusions of gabbro in the Ferland Lake granite and the gneissic granite, however, show varying degrees of digestion by the granite. As a result, the rock has little resemblance to the original gabbro.

One type of hybrid rock, observed between Ferland and Turgeon lakes, is black and very heavy. Ferromagnesian minerals are the essential constituents, but small clots of felsic minerals, up to one-half inch in diameter, are present in all the exposures. Common green hornblende is the most abundant mafic mineral. It forms short prismatic crystals in compact clusters and at random orientation. Abundant magnetite and small amounts of biotite and ilmenite are present. The felsic clots are composed of aggregates of small crystals of plagioclase and quartz.

A second type of hybrid rock, exposed south of Tanguay lake, has the composition of a quartz diorite. It is composed of hornblende, plagioclase, biotite and quartz. Apatite, tourmaline and magnetite are the accessory minerals. The hornblende is anhedral, needle-shaped and is dispersed irregularly throughout the rock. The plagioclase (sodic andesine) and quartz are present in almost equal amounts. Biotite and hornblende occur together.

The most highly altered varieties of the gabbro are found in the areas underlain by the migmatites and in particular, where the migmatite is best developed. They form discontinuous, elongated masses which parallel the strike of the granite gneiss and represent formerly continuous sheets which were drawn out and ruptured during the formation of the gneiss. A few bodies are highly sheared.

In thin-section, the rock consists of pleochroic green hornblende, chlorite, magnetite, epidote and plagioclase. Much of the chlorite has formed as an alteration product of hornblende. A few crystals of chlorite, however, have the outline of biotite and are probably the alteration product of that mineral. The feldspars are intensely altered and are coated with a grey, opaque, fibrous matte of kaolin and sericite. Additional minerals include quartz, apatite and sphene.

Alteration of the Gabbro

The writer believes that the gabbro intruded the sedimentary rocks as a series of multiple sills and dykes during the late stages of the initial folding, but that later movements deformed the rock in the southern part of the area. In the northern part of the area, there is no evidence that the gabbro was involved in large-scale tectonic movement. The only sills which are sheared are those bordering the granite, as for example, east of Ferland lake. Elsewhere the rock is massive and is not ruptured or faulted. Examination of the gabbro in thin-section failed to show any deformation effects other than the chemical redistribution of the original constituents and the addition of new material. The gabbro has an ophitic texture and the minerals are randomly orientated. In the adjacent metasedimentary rocks, however, biotite has a pronounced preferred orientation. In addition, a schistosity has been produced in the mica-rich beds.

In the southern part of the area, the gabbro has recrystallized to such a degree that the ophitic texture has been completely obliterated. Furthermore, the rock has a pronounced foliation, owing to the parallel arrangement of platy minerals, such as biotite. Many sills are highly sheared, and in the area underlain by the gneiss the amphibolite derivatives of the gabbro are frequently drawn out and ruptured.

Although no pyroxene was observed in any of the thin-sections examined by the writer, the former presence of that mineral is indicated by the excellent ophitic texture of the least-altered parts of the gabbro and by the secondary origin of the amphiboles. All the large hornblende crystals contain minute blades of magnetite along the cleavage planes indicating that the magnetite is a released product of the transformation of pyroxene into amphibole. Furthermore, several sills in the eastern part of the area can be traced north of the area, where they have the composition of olivine gabbro. The present mineral composition of the gabbro is, therefore, considered to be due to the uralization of pyroxene formerly present in the gabbro.

In view of the variation and complexity of the chemical composition of the amphiboles, the alteration of the rock cannot be represented by simple chemical equations. This alteration was probably complex, involving continual redistribution of original constituents, as well as addition of new material. In some places, a single amphibole crystal occupies the former position of pyroxene, whereas elsewhere compact, fibrous and slender prismatic crystals of amphibole, in both parallel and random orientation, are present between plagioclase laths.

Some of the fibrous amphibole was formed by the replacement of the large hornblende crystals.

As a result of alteration, the amount of amphibole increased and the amount of plagioclase decreased. This is shown by the replacement of plagioclase by amphibole and the greater amount of amphibole in the more highly altered types. At the same time, the amphiboles reacted with plagioclase to produce the soda-rich hornblende that forms a mantle around both the large hornblende crystals and the fibrous masses. A further effect of the alteration was the formation of abundant sphene in the more highly altered gabbro. Sphene is intergrown with, and forms a mantle around, ilmenite. This association indicates that the sphene is derived from the ilmenite. That new material has been introduced is shown by the presence of biotite in the more highly altered varieties. Biotite does not occur in the less altered gabbro, and its presence, therefore, indicates that potassium and water have been introduced. Apatite and tourmaline are additional minerals which, although present in the least altered varieties, are more abundant in the highly altered gabbro near the granite.

The prevailing medium- to fine-grained texture, and the presence of fine-grained chilled borders in the gabbro sills, indicate that the sills cooled quickly. Very coarse-grained facies only occur, and rarely, in the central part of the large bodies. The effect of the intrusion on the sedimentary rocks is moderate. Epidotization and amphibolitization are confined to within a few inches of the contact. Scapolite formed over a greater distance, but only in small amount. No high temperature minerals, such as diopside and wollastonite, were observed in the calcareous quartzite. It appears highly improbable, therefore, that the alteration of the gabbro was produced at a late magmatic or deuteric stage.

The evidence given below, in summary, makes it clear that the granites were responsible for the alteration of the gabbro. Firstly, the most altered gabbros are found close to, or between, granite masses. Secondly, biotite, quartz, apatite, and tourmaline all increase in amount as granite is approached. These minerals, and particularly biotite and quartz, are too abundant to be explained entirely by a rearrangement of the original constituents. Hence, some of the material needed to form them must have been introduced, and the only likely source of this material is the granite.

Gneissic Granite and Pegmatite

Gneissic granite is exposed west of Johan Beetz, between Corneille river and Longue Pointe. West of Corneille river, a band of this granite, one-quarter to one-half mile wide, extends westward to Appititatte bay.

The lithology of the gneissic granite is fairly uniform. In general, the rock is pink or light grey, coarse-grained, and strongly gneissic. The gneissose structure is clearly shown by thin, discontinuous seams of biotite alternating with thin bands composed of elongated crystals of feldspar and quartz.

In thin-section, the rock is coarse-grained, xenomorphic and equigranular. The essential mineral constituents are quartz, 35 per cent; potash feldspar, 35 per cent; plagioclase, 17 per cent; biotite, 13 per cent. The average grain size of the minerals is 0.9 mm.

Quartz is xenomorphic. Invariably it is strained and some grains are fractured. Equidimensional crystals and small, irregular patches of microcline were observed filling the interstices between plagioclase and quartz. Microcline is slightly altered to sericite. Plagioclase forms short, lath-shaped crystals which have been altered to sericite. Where the alteration has been intense, secondary albite forms a clear mantle around the crystals. The composition of the plagioclase is An_{17}. Irregular long narrow stringers and patches of plagioclase are intergrown with microcline, forming microperthite. Clusters of biotite crystals in parallel orientation as long, thin seams, give the rock a distinct foliation.

Alteration of the biotite has been intense, producing chlorite along the cleavage planes. Small wedge-shaped crystals of sphene and subhedral crystals of apatite are included in biotite.

All field evidence indicates that the gneissic granite is younger than the sedimentary rocks and the gabbro, but older than the medium-grained, massive, biotite granite. The contact between the sedimentary rocks and the north and east boundaries of the gneissic granite is abrupt and sharp. The gneissic granite contains partly digested inclusions of quartzite, schist, and gabbro. Dykes of medium-grained, massive granite cut across the gneissic granite at a large angle to the foliation. Also, two stocks of massive granite intrude, and contain inclusions of, the gneissic granite.

The foliation of the gneissic granite is parallel to the schistosity and bedding of the surrounding metasedimentary rocks, and thus indicates that the emplacement of this granite took place before the completion of regional metamorphism. The pattern produced by the foliation is remarkably consistent with the attitude of the intruded sedimentary rocks. The term "mantled dome" (Eskola, 1949) could be applied to this feature.

There is ample evidence in the area of two ages of pegmatites. The older group, probably related to the gneissic granite, generally forms narrow sills and dykes, which cut the metasedimentary rocks and migmatite. These pegmatites feather out along the foliation of the migmatites and the schistosity of the schist members of the metasedimentary rocks. The younger group cuts indiscriminately across the older pegmatites and has well-defined sharp contacts with the enclosing rocks. They are usually coarser-grained and larger than the older group. Furthermore, the older pegmatites have been deformed (Plate VI-B), whereas the younger pegmatites are undeformed. The first group of pegmatites were intruded before the emplacement of the young granite. Dykes of medium- to fine-grained granite were observed cutting pegmatite and, in turn, both these rock types are cut by later pegmatites. The medium-grained granite contains inclusions of quartzite and schist injected by pegmatites (Plate VII-A). These inclusions have sharp contacts with the enclosing granite. The granite has been intruded by later, large, coarse-grained pegmatites.

Ferland Lake Granite

An area of approximately ten square miles in the northwest corner of the map-area is underlain by coarse-grained granite. This rock varies from reddish-pink to grey and is generally massive. The distinctive feature of the rock is the large size of the feldspar crystals in comparison to the remaining minerals. In some exposures, the feldspars are lath-shaped and have a preferred orientation parallel to the contact of the granite. Joints in the granite are very pronounced, one set strikes approximately at right angles to the contact and a second set is parallel to it.

In thin-section, the granite is coarse-grained, hypidiomorphic and inequigranular. The average mineralogical composition of three thin-sections of this granite is:

Quartz	25 per cent
Potash feldspar	40 per cent
Plagioclase feldspar	20 per cent
Biotite	15 per cent
Accessories	Magnetite, sphene, apatite, zircon

The large feldspar crystals impart a porphyritic texture to the rock. Crystals of microcline and plagioclase feldspar, two centimeters long and more than one centimeter wide, are enclosed in a matrix of quartz, biotite and feldspar. The plagioclase is invariably altered to sericite, whereas the microcline is relatively fresh. The composition of the plagioclase is An_{19}. Many lath-shaped microcline crystals contain altered remnants of plagioclase. Tongues and apophyses of fresh microcline were observed spreading into large plagioclase crystals, indicating that this latter mineral has been partly replaced by microcline.

Quartz is clear and has undulatory extinction. Platy crystals of biotite form clusters in the matrix and single grains are present between quartz and feldspar. All but a few crystals have been altered to chlorite (penninite).

Both potash and plagioclase feldspar are present in the matrix. Potash feldspar (microcline) is highly altered to sericite and kaolin, whereas the alteration of the plagioclase is moderate. In one thin section, quartz and microcline are intergrown in granophyric fashion.

Among the accessory minerals, magnetite and sphene are present only in the matrix. Zircon forms inclusions in biotite, and apatite occurs as inclusions in all the essential minerals.

The presence of many inclusions of gabbro and metasedimentary rocks in the granite is clear evidence of the relative age of the granite. The inclusions have a wide range in size and are irregular in shape. The attitude of the bedding of the quartzite varies from one inclusion to another and differs from the attitude of the quartzite of the country rock.

This granite is separated from the Turgeon Lake granite by a wide band of metasedimentary rocks and gabbro. Consequently, the age relationship between the two bodies is unknown. Petrographically, the Turgeon Lake granite is finer-grained and fairly homogeneous. Southwest of Ferland lake, two narrow dykes of medium-grained pink granite, which, in hand specimen, resemble the southern granite, cut the Ferland Lake mass. This suggests that the Ferland Lake granite is older than the Turgeon Lake granite.

Medium-Grained Pink Biotite Granite

Four more or less distinct units of medium-grained, pink, biotite granite are exposed in the map-area. The largest of these, the

Turgeon Lake granite, underlies approximately 55 square miles in the western half of the map-area and extends beyond the western limit of the area.

Two small intrusions are exposed along the coast. At Johan Beetz, biotite granite extends from Mine bay to a point two miles and a half northwest of the village. It is divided into two parts by a band of quartzite and schist, which outcrops east of the village. The second mass extends westward along the coast from the mouth of Corneille river to about a mile east of Appititatte bay, a distance of four miles. It has a maximum exposed width of one mile.

The fourth granite unit outcrops over an area of less than one square mile around the northwest bay of Villeneuve lake. Smaller areas of similar granite also occur on a small island two and three-quarter miles east of Johan Beetz, and on the east side of Watshishou Knoll.

In general, the composition and texture of all these granite masses are similar. Quartz, potash feldspar, plagioclase feldspar and biotite are the essential constituents, but the proportion of these minerals varies slightly in each unit. The Turgeon Lake granite contains more plagioclase and less potash feldspar than any of the other bodies. The granites are medium-grained and massive. Slight differences in texture were noted within each mass as well as between any two separate bodies. For example, west of Petit Piashti lake crystals of microcline feldspar, measuring from one-half to two inches in length and one-half inch in width, impart a porphyritic texture to the granite. Northwest of Tanguay lake, the parallel orientation of biotite flakes gives the granite a slight gneissic structure. Most of the Corneille River granite is massive, but in some places an obscure foliation was observed. The Johan Beetz and Villeneuve Lake stocks are massive.

In thin-section, the granite is medium-grained, hypidiomorphic and inequigranular. The mineralogical composition of the rock is shown in the following table below:

Quartz	25 - 35 per cent
Potash feldspar	30 - 45 per cent
Plagioclase	15 - 25 per cent
Biotite	5 - 15 per cent
Accessories	Magnetite, apatite, sphene, zircon and epidote

The average grain size of the granite is 0.5 mm. Quartz forms interlocking anhedral crystals, which contain small gas bubbles and flakes of mica. Most of the grains show undulatory extinction. Small oval-shaped grains of quartz are intergrown with microcline in myrmekitic fashion. The predominant feldspar of the rock is microcline, in equidimensional as well as lath-shaped crystals. In three thin-sections of the Turgeon Lake granite the lath-shaped crystals contain small irregular patches of altered plagioclase. Small, irregular crystals of microcline were observed between the larger minerals. Where they are in contact with plagioclase, tongues and small apophyses of microcline partly replace that mineral. The composition of the plagioclase varies between An_{14} and An_{17}. Invariably, the plagioclase is lath-shaped; a few crystals have curved cleavages.

Biotite occurs in elongated, tabular-shaped crystals completely enclosed by microcline, and interstitial to all other minerals. Magnetite, apatite, sphene and zircon form small inclusions in biotite, but any one or all of these minerals may be absent. Zircon (not always present) is surrounded by pleochroic halos. Elsewhere, the accessory minerals occur as small subhedral to euhedral crystals scattered through the rock. Microscopic crystals of sphene frequently coat magnetite. Muscovite (intergrown with biotite) and epidote were observed in one thin-section. Several small crystals of epidote occur between quartz and feldspar.

The feldspars and biotite in the granite have been altered, and particularly so in the Villeneuve Lake mass. Plagioclase and, to a lesser extent, microcline have been altered to sericite and kaolin. Several plagioclase crystals are coated with a thin film of albite which, in some crystals, has partly replaced that mineral. Chlorite has formed along the cleavage planes of, and partly replaces, biotite.

Dykes of fine-grained, pink granite are numerous throughout the southern part of the area. They have a mineralogical composition similar to that of the larger granite masses but contain considerably more secondary albite. Albite has filled the interstices between the feldspars, and veinlets of albite have replaced both the microcline and the plagioclase. The greater part of this replacement is at the outer edges of the crystals, giving rise to a saw-tooth type of perthite.

The intrusive character of the granite is evident. All the granite bodies exhibit cross-cutting relations with the surrounding rocks and large tongues of granite cut indiscriminately across both the metasedimentary rocks and the gabbro. The grain size of the granite is variable but, in general, the smaller bodies and granite dykes are finer grained. The contacts between granite and contained inclusions are sharp. The inclusions are frequently angular. They lack preferred orientation. The contact between the large granite bodies and the quartzite is well-defined. These facts support the hypothesis that the granite crystallized from a silica-rich melt.

This granite is the youngest rock of the area, except for a pegmatite. The cross-cutting relations between the granite and the metasedimentary rocks and gabbro have been described. Inclusions of granite gneiss and gneissic granite were observed in the Corneille River granite. Large pegmatite dykes and irregular masses of pegmatite cut all the granite masses, except the Villeneuve Lake body. At several localities north of Turgeon Lake, thin pegmatite dykes fill fractures in the granite.

The textural and mineralogical similarity of the Turgeon Lake, Corneille River and Johan Beetz granites, and their relationships to other rocks in the area, suggest that they are genetically related and probably contemporaneous. They probably join to form a single body at depth. The Villeneuve Lake granite is believed to be an outlier of the main intrusion.

Pegmatite

Sills and dykes of pegmatite cut all other Precambrian rocks in the area, and contain inclusions of quartzite, schist, gneiss and gabbro.

Although pegmatite dykes are common throughout the area, they are most abundant and of greatest size in the vicinity of Quetachou bay, where many dykes are more than 1,000 feee wide. Large pegmatites are also exposed between Quetachou bay and Watshishou Knoll and east of Petit Piashti lake. Several dykes and numerous streaks of pegmatite are common along the coast. All the dykes are characterized by frequent pinching and swelling along their strike.

The pegmatites vary greatly in grain size. The most coarsely crystalline types were observed in the vicinity of Quetachou bay, where crystals of feldspar up to three feet by two feet occur. These very coarse-grained pegmatites are composed predominantly of microcline and orthoclase. Quartz occurs interstitially to, as well as in graphic intergrowth with, the feldspar. This latter feature is clearly visible in hand specimens. Some feldspar crystals are relatively free of quartz, but they constitute only a small percentage of the pegmatites. Biotite and muscovite are present, the latter being abundant locally. The muscovite crystals are of large size, but have been shattered by tectonic deformation to such an extent that it is impossible to obtain a sheet more than four inches across.

The finer-grained pegmatites are composed essentially of quartz, potash feldspar (microcline and orthoclase), and a small amount of muscovite. Tourmaline crystals are rare; some up to one inch long and one-quarter inch wide were observed in dykes near Quetachou bay and Ferland lake, but their amount is small. Many dykes contain streaks of fine-grained granular quartzitic material rich in garnet. Other minerals locally present include magnetite and, more rarely, beryl.

The contact between pegmatite and gabbro is sharp, but between pegmatite and quartzite it may be gradational, particularly where the dykes pinch out. This feature is considered to be due to assimilation of the quartzite by pegmatite.

Most of the dykes have a steep dip. One mile east of Quetachou bay, pegmatite forms the mid-line of a large peninsula; quartzite and gabbro are exposed around the shore. Where the contact is exposed the pegmatite lies with gentle dip on the quartzite and gabbro (Plate VII-B).

Watshishou Knoll headland is underlain partly by pegmatitic masses which trend northeast and dip 60° northwest. The pegmatite here differs from that in other parts of the area. This rock, as well as the quartzite and amphibolite which it includes, has been thoroughly brecciated and recemented with opaque, milky white quartz occurring as an intricate mesh of small veinlets. In places, more than half the volume of the rock is quartz. Considerable hydrothermal alteration, probably related to the introduction of the quartz, has affected this zone.

Quartz ridges extend northeastward along the line of strike of the pegmatite zone for a distance of two miles and a half. Owens (1951) believes that the introduction of the quartz was controlled by folding, recrystallization and fracturing of a large band of quartzite during the formation of the anticline east of Watshishou Knoll. This quartzite lies between sills of amphibolite. The quartzite, being more brittle than the adjacent amphibolite, was easily fractured and later penetrated by quartz, whereas the smaller quartzite beds were protected by bands of amphibolite which acted as a barrier to the migrating solutions.

The distribution of the pegmatite dykes in the area suggests that the dykes were injected in part along a zone of weakness, coinciding with the line of contact between the quartzite and gabbro.

STRUCTURAL GEOLOGY

The general structural trends of the rocks of the area are clearly reflected by the distribution of multiple sills and dykes of gabbro, as shown on the accompanying map. In the northern part of the area, the general trend is north-south. This changes abruptly in the southern part of the area and south of Ferland lake to southwest. South of the main granite mass the trend is nearly east-west. Locally, ripple marks and cross-bedding give reliable indications of the direction of tops in the metasedimentary group.

In the southern part of the area the metasedimentary rocks and the gabbro have been sheared. All the rock types are traversed by joints. No definite evidence of faults was observed.

Folding

Two anticlines and two synclines are suggested in the northern part of the map-area. The strike of the formations is generally due north, except between Ledoux lake and Bellanger lake where it varies between N.15°E. and N.40°W. Dips are variable in direction and amount. East of Ferland lake all the rocks dip west, whereas west of Piashti lake they dip between 30° and 70° east. From these observations it is inferred that the rocks in this area form an anticline. The exact location of the axis of this fold is not known because of the large body of gabbro which separates the two limbs. The attitude of the bedding in the large band of quartzite in the centre of the gabbro sill suggests that the axis passes through the western part of the band in a north-south direction.

At Goéland lake a syncline appears to plunge south-southeast at approximately 20°. This fold could not be traced southward, owing to erratic dips of the metasedimentary rocks south and east of Cabane-Brûlée lake.

Between Goéland lake and Bellanger lake the metasedimentary rocks dip west. Determinations of stratigraphic tops in grey quartzite, using cross-bedding and ripple marks, show that the strata face west. Between the east and west bays of Bellanger lake and south of this lake the dips are as commonly to the east as to the west. Some, and perhaps all, of the west-dipping beds are overturned. These structures, along with drag folds on the south shore of Bellanger lake plunging at about 20° in a S.10°E. direction, suggest a major anticline plunging south-southeast. The east limb of this fold would be overturned. The axis probably passes through the west bay of Bellanger lake and may be traced about two miles to the south.

South of the east bay of Bellanger lake and east of this lake, most of the beds dip west. Top determinations in this area indicate that the formations are not overturned, except at the south end of Théobule lake where east dipping strata face west. The metasedimentary rocks of this area, therefore, belong to the east limb of a syncline. The west limb of this fold is the overturned east limb of the anticline described above.

In the southern part of the area, most of the beds strike northeast and dip northwest. There is one exception near Pierre lake, where a northeasterly trending anticline is indicated.

The quartzites of Quetachou bay are synclinally arranged. This belt of metasedimentary rocks extends northward to Bellanger lake. It is possible, therefore, that the Quetachou Bay syncline is the southern extension of the Bellanger Lake syncline. Structure readings in the intervening area, however, are not sufficient to correlate the two folds.

One of the most clearly defined structures in the area is the east-west trending syncline found between the coast and the granite mass to the north.

Several minor folds are shown in the migmatites east of Watshishou Knoll. West of Pontbriand bay the gneissic structures form an anticline, plunging north; east of the bay, an overturned syncline plunging north is indicated.

Schistosity

The mica-rich members of the metasedimentary series show a well-developed schistosity. These rocks are most numerous in the southern part of the area where they form thin layers intercalated with grey quartzite. In all cases, the schistosity is parallel to the adjacent more resistant quartzite and to the bedding wherever observed.

The gabbro in the southern part of the area generally has a poorly developed schistosity. In places, however, shearing has been intense and has transformed the rock to biotite and amphibole schist. The strike of schistosity is parallel to the strike of the sills and to the enclosing metasedimentary rocks. The schistosity is attributed to deformation during warping of the gabbro masses from a north-south to southeast and east-west directions.

In the large gabbro sill east of Ferland lake schistosity is developed only in a mile-wide zone bordering the granite. It strikes parallel to the contact and dips toward the granite. The origin of the schistosity in this case is attributed to the effects of the emplacement of the granite.

Jointing

All the rocks of the area, and particularly the granites, are traversed by joints. Joints in the metasedimentary rocks have various trends, but no regular pattern. One set, with vertical dip, strikes perpendicular to the bedding. Another set, not discernible in the field but detectable on the aerial photographs, trends northeast. These joints are reflected in the drainage pattern and the shapes of lakes such as, for example, the lakes and streams east of Villeneuve lake. The origin of the joints is obscure and probably diverse. Some may be related to regional folding. The joints with vertical dip may be tension joints resulting from slight elongation parallel to the fold axis. Near the granite, joints in the quartzite have diverse orientations; these probably are related to the intrusion of the granite.

Two prominent sets of joints were observed in the gabbro. One set strikes parallel and the other perpendicular to the length of the sills. Both sets have steep to vertical dips. These joints are probably related to contraction in the gabbro during cooling and crystallization. Various other joints are present in the gabbro near the Turgeon Lake granite. These vary in strike and dip. Their origin probably is related to the emplacement of the granite.

Joints are prominent in all the granitic rocks. East of Pontbriand bay, two sets of vertical joints were observed. One set strikes N.10°E., the other, S.80°E. West of the bay the joints strike approximately perpendicular to the foliation of the gneiss and are vertical. They may be tension joints. In the gneissic granite most of the joints are vertical, but the strike is variable. Two sets of joints were observed in the Turgeon lake granite. One set strikes northeast, the other northwest. The dip of the former varies between 70°SE. and vertical and that of the latter between 85°NE. and vertical. The Ferland lake granite is traversed by numerous joints which have various orientations and dips. It was not possible to obtain sufficient readings of the joints in the various rock masses to analyse their pattern or to determine their origin. It is probable that most are tension joints resulting from contraction during cooling of the various masses.

Faulting

There is little evidence of faulting in this area. This does not eliminate the possibility that faults exist, particularly longitudinal or bedding faults which would be difficult to recognize. However, the writer did not observe any long zones of intense shearing or mylonitization in the area.

A steep cliff of medium-grained gabbro forms part of the west shore of the north bay of Cabane-Brûlée lake. At several places in the gabbro slickensides were seen, but they could not be traced for any distance, nor could the direction of movement be determined.

On the southeast tip of the headland at Watshishou Knoll, a pronounced valley trends N.50°E. It is underlain by quartzite intruded by thin sills of amphibolite. Both rock types have been highly sheared and contorted. A fault possibly runs through the valley.

A prominent topographic feature of the west central part of the map-area is a long, well-defined, east-west trending valley. This is occupied by a series of long narrow lakes, including Turgeon lake, the east and west arms of Petit Piashti lake and the west bay of Cabane-Brûlée lake. Such a topographic feature may indicate the presence of a fault zone. However, no evidence of shearing, rupturing, offsetting of ridges or formations was observed anywhere along the length of this valley.

ECONOMIC GEOLOGY

Occurrences of copper-bearing minerals, feldspar, silica, beryl and mica have been known for several years within the area and have been reported and described by earlier investigators. These, and additional occurrences of metallic minerals observed by the author, are described below.

Metallic Minerals

Copper. On the northwest tip of a small point in Quetachou bay, three-quarters of a mile southwest of the mouth of Quétachou river, chalcocite fills a fracture in impure quartzite. The fracture, one-quarter inch wide, is exposed and mineralized for a length of eight feet. Chalcocite is also disseminated in the quartzite through a width of two inches on each side of the fracture. Some malachite and azurite occur with the chalcocite. A grab-sample, assayed in the laboratories of the Quebec Department of Mines, yielded 7.59 per cent copper.

Three-quarters of a mile west of the mouth of Watshishou river, on the northwest corner of a small island, a gabbro dyke is cut by a narrow pegmatite. At the contact, bornite with some chalcopyrite occurs in small irregular pockets and fractures in the pegmatite. No mineralization was found in the gabbro. The exposed zone of mineralization is twelve feet long and two feet wide. This mineralization does not continue either to the north or south. A grab-sample from this zone yielded 0.742 oz. silver per ton and 6 per cent copper (Longley, 1950).

Very small quantities of chalcopyrite in fine grains disseminated through the gabbro were seen at several localities, particularly in the sheared gabbro near the coast. Chalcopyrite occurs in scattered specks and irregular small patches in massive and sheared granite on the east side of Watshishou Knoll.

A little pyrite occurs as small irregular grains or well-formed cubes disseminated in the fine-grained facies of uralite gabbro at a few localities. A few quartz veins and shear zones in the meta-sedimentary rocks exposed in Appititate bay are sparsely mineralized with pyrite and occasionally with chalcopyrite.

Lead On the southeast shore of a small bay in Quetachou bay, a mile and a half southwest of the mouth of Quétachou river, galena occurs in a one-foot quartz vein and at the contact between the vein and carbonate-bearing quartzite. It was not possible to determine the trend or possible extent of the mineralized zone, as it is exposed only at low tide in a small round patch of about four square feet. A grab-sample in this zone, assayed in the laboratories of the Quebec Department of Mines, yielded 17.55 per cent lead.

Iron and Titanium Magnetite occurs in small dykes of pegmatite in the vicinity of Pontbriand bay, near the mouth of Corneille river, and west of Turgeon lake. Well-defined crystals of magnetite are disseminated through impure grey quartzite on the east side of the head of Quetachou bay. In some places 20 per cent of the rock is magnetite.

Thin, iron-bearing bands (Plate III-B) are well exposed east of Villeneuve lake, north of Cabane-Brûlée lake, east of Petit Piashti lake, and on the west side of Quetachou bay. The bands range in thickness from 1/64 - to 1/4-inch and average 1/32-inch. They alternate with bands of grey quartzite ranging from a half to six inches thick. They occur in zones that vary in thickness from one-half to three feet; two or three such zones may occur in twenty stratigraphic feet of quartzite. Magnetite, hematite and rutile are abundant in these black bands. Most of these iron- and titanium-bearing zones are lens-shaped and do not extend, along their strike, for more than 25 or 30 feet. One three-foot zone, two miles north of Cabane-Brûlée lake, is more than 100 feet long.

Molybdenite: Small, irregularly scattered flakes of molybdenite were seen in a narrow dyke of pegmatite cutting gabbro on the east side of the east point of Quetachou bay. The gabbro is a large inclusion in the pegmatite which underlies most of the point. It is cut by a narrow, irregular dyke of fine-grained pegmatite, composed of white plagioclase (oligoclase) with small amounts of quartz and biotite. The trend of the dyke is N.55°E., parallel to the length of the gabbro inclusions. Scattered grains of molybdenite occur in the dyke particularly near its contact. No mineralization was observed in the country rocks.

Non-Metallic Minerals

Beryl: Crystals of beryl, previously reported by Claveau (1943) and Longley (1950), occur on the point east of the mouth of Watshishou river. The writer saw more than a dozen crystals on the tip of the point, and several others on an island of pegmatite on the west side of the river. The crystals average one-half inch in diameter. Several crystals were observed in pegmatite dykes cutting granite on the east side of Ferland lake. These crystals are small, the largest measuring one inch in length and one-quarter inch in diameter. At both localities the crystals occur in a muscovite-rich band in pegmatite.

Feldspar: The largest pegmatite dykes of this area are found on each side of Quetachou bay. They strike northeasterly. The dykes consist mainly of microcline and orthoclase feldspars and quartz, with some biotite and muscovite. Although the average grain size of the pegmatite is between a quarter and a half inch, there are many zones with crystals of feldspar measuring three feet by two feet. These zones of coarse-grained feldspar are dispersed along a belt in the large pegmatite on the east side of Quetachou bay. The belt trends about N.60°E. and is approximately 300 feet wide for a length of at least a half mile. The most favourable exposures were quarried at various times between 1914 and 1927. These operations were unsuccessful due to the presence of quartz, which occurs as an intergrowth with, and interstitial to, the feldspar crystals.

Garnet: Many pegmatites contain streaks of fine-grained, granular, quartzitic material very rich in garnet. The garnets are generally less than a quarter inch in diameter. Most of the garnets are present in biotite schist on the east side of Mine bay. Here, they range up to a half inch in diameter and make up as much as 20 per cent of the volume of the rock.

Mica: Pegmatites of the area contain both muscovite and biotite mica. The largest exposure of mica is located on the tip of a point east of the mouth of Watshishou river. Other exposures occur in pegmatite east-southeast of Ferland lake. Muscovite, originally in large crystals, has been so shattered that it is impossible to obtain a sheet more than four inches across. Deposits of ore grade were not observed.

Silica: A series of low hills, composed in part of large pegmatite dykes, strikes northeast from Watshishou Knoll. At the southwest end of the point, pegmatite has been brecciated and recemented with a milky white quartz which, in some places, constitutes over 50 per cent of the rock. To the northeast, the percentage of quartz increases until a hill two miles northeast of the "Knoll", is reached. Here, quartz occurs in a body more than 2,000 feet long and 200 feet wide at its widest point. A large tonnage of high-grade silica is indicated for this deposit. Analyses of grab-samples, taken across the deposit at four localities, gave the following results (Claveau, 1945):

Sample Line	Fe_2O_3	SiO_2	TiO_2	CaO	MgO	P_2O_5
1	0.03	98.73	0.009	nil	0.02	nil
2	0.06	97.67	0.014	nil	0.043	nil
3	0.015	99.35	0.006	nil	0.007	nil
4	0.03	98.81	0.007	nil	0.02	nil

Fluorite: There are small deposits of fluorite on the west side of the bay immediately west of Longue Pointe, a mile and a quarter southwest of Johan Beetz. These have been described by Longley (1950, pp. 20, 26). The deposits are in veins up to four inches and averaging one inch wide. The vein material is mostly calcite and quartz. The host rock is gneiss cut by small dykes of pegmatite.

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