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QUINZE LAKE-BARRIERE LAKE AREA, TEMISCAMINGUE COUNTY

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Honorable Paul-E. Allard, Minister

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QUINZE LAKE - BARRIÈRE LAKE AREA

Témiscamingue County

by

Jean-Y. Chagnon

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GEOLOGICAL EXPLORATION SERVICE

TABLE OF CONTENTS

Page

Page

TABLES

FIGURES

MAP AND ILLUSTRATIONS

MAP

PLATES

QUINZE LAKE - BARRIÈRE LAKE AREA

TÉMISCAMINGUE COUNTY

by

Jean-Y. Chagnon

INTRODUCTION

General Statement

This area of about 1,400 square miles includes the northern end of Lake Témiscamingue, borders on the Province of Ontario for 34 miles, and extends eastward 35 miles to longitude 79°00'. Its northern and southern boundaries are respectively latitudes 48°00' and 47°30', except in the southeast corner where it extends to latitude 47°25'. It corresponds to the National Topographic Series maps 31-M/6, -M/11,-M/14, and to the west halves of 31-M/7, -M/10, and -M/15.

The geological mapping was done during the summers of 1960-63 as part of a general program of mapping by Quebec northeast and east of Lake Témiscamingue that was begun in 1954 (Freeman, 1957).

Except for a little Ordovician exposed in the Lake Témiscamingue basin the area is underlain by Precambrian (mainly Archean) rocks. The oldest group consists mainly of rocks altered to the lower amphibolite or to the upper greenschist facies but which are obviously volcanic except for a hornblende rock, which may be intrusive. The group includes interlayered lenses of sedimentary rocks (graywacke, iron-formation, siltstone). The whole is isoclinally folded and dips steeply south.

The oldest group is overlain conformably by the Pontiac Group (part of, or equivalent to, the more northern Abitibi Group), which includes graywacke, amphibolite, quartz-feldspar gneiss, and quartz-feldspar-biotite schist. The graywacke and schist are equivalents, and the gneiss may be a granitized equivalent. The schist is the dominant and most widespread component of the group. The present mapping widens the Pontiac Group from 10 miles to approximately 60 miles (including rocks in Robert's area (1963) to the south) and from a region of "Keewatin-type" rocks to one of "Grenville-type" rocks. The grade of metamorphism of the group is that of the staurolite-quartz subfacies of the almandine-amphibolite facies.

The two preceding groups were intruded by various acidic igneous rocks ranging in composition from hornblende syenite to highly potassic granites. Oligoclase-microcline granite underlies about two-thirds of the area. This granite, as well as hornblende granite, hornblende syenite, and hornblende-pyroxene syenite, carries large microcline porphyroblasts in places as evidence of a period of potassic metasomatism, perhaps related to the intrusion of pegmatites and aplites.

Proterozoic (Huronian) rocks are represented in the northwestern part of the area by Cobalt conglomerate and argillite, and by Lorrain quartzite and arkose in the southwest.

Diabase dikes, generally trending N.15°E. or east, cut all the other Precambrian rocks.

Five northerly trending (northwest to north-northeast) major folds were recognized, characterizing the general northerly trend of the rocks. The northeasterly trend of the oldest, volcanic-sedimentary group in the southwest is in marked contrast.

The map-area is part of the Grenville B subprovince (Osborne and Morin, 1962) as is suggested by the structural pattern, metamorphic grade, and location. The area is located within the transition zone between the Grenville and the Superior Provinces, and some formations, such as the members of the Pontiac Group, are shared by both Provinces. In other words, the Grenville "front" here is a gradational metamorphic transition, the grade of metamorphism increasing toward the south.

Location

The area is roughly divided between Rouyn-Noranda and Témiscamingue counties. It includes parts of Brodeur, Latulipe, Baby, Guigues and Blondeau townships and all of Bauneville, Villars, Guérin and Nédelec townships in Témiscamingue county; and parts of Basserode and Clérion townships and all of Caire, Beaumesnil, Rémigny, Desandrouins, Pontleroy, and Montreuil townships in Rouyn-Noranda county. The largest village in the area is Notre-Dame-du-Nord in the southwest corner.

Access

The area, as a whole, is easily accessible along an extensive network of roads linked to Route 46, the main highway between the towns of Ville-Marie and Rouyn-Noranda, respectively 14 miles to the south and 30 miles to the north of the area.

The northeastern and south-central parts are most easily reached by a few long lakes, which are served by roads. All the major lakes are suitable for hydroplanes.

Field Work

The outcrops shown on the map were located by pace-and-compass traverses spaced at 1/2-mile intervals. A few traverses were irregularly spaced, especially where outcrops are scarce, and extensive use was made of aerial photographs. Also, traverses were made along roads, navigable streams, and lakes.

Topographic maps at the scale of 1/2 mile to the inch based on the National Topographic Series maps were used as a base. Sheets 31 M 11 and 14 and the accompanying mosaic from "Operation Overthrust", published by Hunting Technical and Exploration Services Limited, were used as a source of information.

In all, 803 rock samples were collected in the field and 293 thin-sections were obtained from them.

Acknowledgements

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Previous work

The earliest geological work within this area was an investigation of the Ottawa, as far as the "third Rapid" on Quinze river, by Logan (1845). McOuat (1873) examined a "portion of the country on the Ottawa to the northward and eastward of lake Timiskaming"; this included Quinze river and lake. Barlow (1897) described the geology along the shores of Quinze river and the southwestern part of Quinze lake. Wilson (1910) reported on "an area adjoining the east side of lake Timiskaming", including the southwestern part of the present map-area. Wilson (1913) also did a broad reconnaissance survey of the Kewagama Lake area, which includes parts of the northern extremity of the present area. Henderson (1936) traversed parts of Brodeur township.

In later years, more detailed geological work was done on areas adjacent to the present area, by Denis (1936; 1938), Auger (1952), Freeman (1957) and Wilson (1962).

PHYSIOGRAPHY

The area is within the limits of the "clay belt" of western Quebec and eastern Ontario, formerly occupied by glacial lake Barlow-Ojibway. The topography, therefore, reflects the double nature of the underlying Precambrian rocks and of the overlying unconsolidated, glacial and Recent deposits. The hummocky, gently undulating surface and irregular drainage features of the area are the result of this double control. The development of the physiography of this part of the Shield has been elaborated by numerous authors including Wilson (1913; 1918), Cooke, James and Mawdsley (1931), and Dresser and Denis (1944).

Topography

The topography varies from relatively flat to hilly, being influenced by changes in the character of the bedrock. Areas underlain by the Pontiac biotite schists are gently undulating and have a maximum relief of 50 feet. Areas underlain by granitic rocks have a general relief of about 100 feet and a maximum relief of 300 feet. The volcanic rocks toward the southwest corner of the area present a relief of approximately 200 feet and are sharply dissected into small knobs and hills that contrast with the flatlands north of the volcanic-schist contact. The Lorrain Quartzite near the shore of Lake Témiscamingue forms a high, south-trending ridge with steep slopes. Foliation and joints usually exert a strong influence upon the general trend of the hills and ridges.

A large proportion of the area below 865-900 feet elevation is covered by the glacial lake deposits of the clay belt. These form gently rolling plains dissected by streams and rivers deeply entrenched in valleys with steep banks. The absolute thickness of the clay is unknown but is believed to be about 50 feet except in deep, clay-filled valleys. Ridges of glacial deposits protrude through the clay.

The maximum elevation of the area near the south end of Caron lake is about 1,300 feet above sealevel; the minimum, at Lake Témiscamingue, is 575 feet; and the average elevation is 1,000 feet. The general slope of the ground is to the southwest, towards Lake Témiscamingue. The uniform elevation of the hills, especially in the north, suggests the former presence of a plateau, now dissected.

Drainage

The drainage of the area is to the Ottawa, which flows south and southwest to Lake Témiscamingue.

The general drainage pattern is dendritic, although locally it is rectangular, as in the southeast where the structural pattern exerts a strong influence. The drainage is consequent and superimposed, the water flowing over lake clay and glacial drift and in places reaching the rock formations of the basement. Rapids, cascades, gorges, and swift currents are common and are characteristic of streams at an early stage of development.

Narrow, elongated lakes occupying gouge-like depressions in the bedrock are distinctive features. They form a pattern of linear elements believed to reflect bedrock structure. Some lakes of the "clay belt", such as Simard (Expanse) lake,have a very irregular shoreline, are shallow, and have steep clay banks. Many of the islands in Simard and Quinze lakes are low ridges composed only of gravel. Lake Quinze is a reservoir held back by a dam at its outlet.

Raised beaches along the shore of Lake Témiscamingue extend 2 1/2 miles inland, or slightly past the 650-foot contour, recording a change in level of at least 60 feet. The ridges are faintly apparent in the field and are best seen on aerial photographs. The highest beach is followed by a sharp, 100-foot rise to a terrace-like accumulation of glacial gravel and sand that extends east for at least 8 miles to the first rock exposures.

GENERAL GEOLOGY

Regional Geology of Northwestern Quebec

A historical review of the geology of northwestern Quebec is given by Podolsky (1950) and Freeman (1957c). The more recent concepts are given below.

The present area is at the northern extremity of the Grenville Province, almost athwart the transition to the Superior Province (Gill, 1949). The Superior Province to the north of the area has been mapped in detail and major rock units have been identified. The Abitibi Group (Wilson, 1962), otherwise known as "Keewatin series", is a volcanic-sedimentary assemblage tightly folded along east-west axes. The Pontiac

Group, which extends from the north into the present area, is believed by Wilson (1943; 1962, p. 6) to be part of the Abitibi Group. It consists of mica schists and metamorphosed graywackes with some interstratified lavas and pyroclastic beds. It is folded parallel to the Abitibi Group, but, to the south, "Pontiac strata now form Z-shaped buckles that plunge steeply north" (Podolsky, 1950, p. 30). The Abitibi and Pontiac groups are separated from the "Timiskaming series" sedimentary rocks by a great structural unconformity (Wilson, 1956; 1962). The existence of this unconformity is questioned by Bass (1961), who believes that it records epochal events only. The "Timiskaming series" also parallels the Abitibi Group.

Wilson (1956), supported by Freeman (1957c), suggests that the source of the sedimentary rocks of the Pontiac Group and of the "Timiskaming series" is to the south, but Bass (1961) claims that since the sediments were the products of comminution of Keewatin volcanics and intrusives, no single source prevailed because the debris was spread radially from volcanic centers. The Abitibi and Pontiac groups and the "Timiskaming series" are intruded by the granitic rocks of the zone of banded gneisses separating the Grenville from the Superior Provinces. All these rocks are overlain unconformably by the Huronian Cobalt Group.

Rocks of the Grenville Province are found in the map-area and extend south and east of it. Osborne and Morin (1962) have divided the Grenville Province into two parts, designated by the letters A and B - "a division based on the different tectonic patterns, kind of plutonites and grades of metamorphism in the two parts" (p. 118-119). The Grenville A subprovince to the southeast is characterized by north-trending structures, high grade of metamorphism, and the presence of "green rocks" or hypersthene-augite-bearing series. The Grenville A passes to the northwest into the Grenville B subprovince "near the 'green-rock line', which is where the hypersthene augite-bearing series disappears on the northwest. This line is approximately the demarcation between the granulite and the amphibolite facies" (Osborne and Morin, 1962, p. 119).

The Grenville B subprovince is characterized by irregularly northeast-trending structures superimposed over north- and east-trending older structures. "The newer structures trend generally northeast but are exceedingly irregular, giving the impression of anastamosing zones passing around blocks of somewhat greater resistance than adjacent blocks" (Osborne and Morin, 1962, p. 119). The metamorphism is of the amphibolite facies and no "green rocks" are present. The present area is in the northwest part of the Grenville B subprovince.

In the southern part of the area and in adjacent areas to the south and southeast, volcanic rocks are folded along easterly trending axes and are overlain by sedimentary rocks, mica schists and gneisses. Henderson (1936, p. 14) mentions that the sedimentary rocks overlie the volcanic rocks conformably. According to Osborne and Morin (1962, p. 132) "the metasedimentary rocks close to the greenstones conform to their structure in a general way but going southwest the 'waviness' in the pattern resulting from folds with a north trend becomes increasingly apparent and finally the Kipawa syncline with a well-defined north trend is reached. Between Kipawa and Val d'Or similar but less obvious relationships are found in rocks assigned to the Pontiac group." The metasedimentary rocks of the Ville-Marie and Guillet Lake areas (Henderson, 1936) have been correlated with the Pontiac Group by Freeman (1957c).

Between the Grenville B subprovince and the Superior Province is a zone of gneisses and granitic intrusions that is marked by a gravity low and is believed (Wilson, 1956) to be the core of a mountain chain ("Ottawa mountains"). The present area is in the middle of this zone.

The transition between the Grenville and Superior provinces, or "Grenville front", appears to be narrow and abrupt in places, whereas it is wide and indefinite elsewhere. Phemister (1960) reports that in the Sudbury district of Ontario the boundary is a metamorphic transition zone 100 yards wide. Johnston (1959) reports that a complex zone of thrust faults of major tectonic significance forms the boundary in the Temagami Lake area, Ontario. Déland (1956) suggested a transitional zone corresponding to a change in the grade of metamorphism in the Surprise Lake area. Osborne and Morin (1962, p. 133) regard the Grenville B subprovince as a zone of transition between the Grenville and the Superior provinces, and Robert (1963a) writes that the Grenville front corresponds to the staurolite isograd of the amphibolite facies and that the front coincides with the Pontiac Group.

Age determinations by the K-Ar method on rocks of the Superior Province indicate that they were formed more than 2,000 million years ago, and age determinations on samples from the Grenville Province indicate that a period of orogeny accompanied by regional metamorphism occurred about 1,000 million years ago (Snelling, 1962). Osborne (1962) proposed the term "Millenary" for this period to avoid the genetic implication of terms such as "Grenville orogeny" and "Grenville event", and suggested that the "Millenary" event was thermal.

In summary, some of the more important points pertaining to the regional geology of northwestern Quebec and the present area are:-

A- The nature of the "Grenville front", although positively recognized as abrupt (of a tectonic nature) or gradual in some areas, is not defined in this area; presumably it is a transition zone;

Table of Formations

Cenozoic			Pleistocene and Recent	Sand, Gravel, Clay, Varved clay, Till
Paleozoic			Ordovician	Conglomerate, Sandstone, Limestone
PRECAMBRIAN	Proterozoic			Diabase, Gabbro
		Huronian	Lorrain Formation	Arkose, Quartzite
			Cobalt Group	Argillite Conglomerate
	Archean			Serpentinite Pyroxenite Lamprophyre Pegmatite, Aplite Oligoclase-microcline granite, Porphyritic oligoclase-microcline granite Biotite granite Gray granite gneiss Hornblende granite, Porphyritic hornblende granite Plagioclase-hornblende gneiss Hornblende syenite Hornblende-pyroxene syenite, Porphy-ritic hornblende-pyroxene syenite Nodular pyroxene syenite Pyroxene-biotite rock
			Pontiac Group	Quartz-feldspar-biotite schist, Quartz-feldspar-biotite hornblende gneiss; Quartz-feldspar gneiss Amphibolite Graywacke, Arkose
				Paragneiss, Metavolcanics Metamorphosed sedimentary rocks (Quartzite, Graywacke) Iron-formation Hornblende schist, Hornblende gneiss Rhyolite, Quartz-feldspar porphyry Agglomerate, Tuff Hornblende rock Andesite, Dacite, Chlorite schist

B- The Pontiac Group, originally thought to be approximately 10 miles wide, now appears to be much more extensive and is even believed to be implicated in the "Grenville front";

C- The nature of the "Ottawa mountain gneisses" or "Ottawa gneisses", presumably occurring in the present area, has to be defined;

D- The relation of the volcanic zone in the southern part of the area to the Keewatin volcanics to the north (Rouyn - Val-d'Or belt) should be investigated.

DESCRIPTION OF FORMATIONS

Volcanic and Associated Sedimentary Rocks

Volcanic rocks, associated with tuffs, hornblende rock, iron-formation, and graywackes, occur toward the southwest corner of the area. They form a northeast-trending zone about 9 miles long and 7 miles wide. The zone is covered to the west and southwest by glacial and Recent deposits and is interrupted to the east by granitic rocks which have intruded and transformed the volcanics into fine-grained hornblende schists and gneisses. It extends south into the Ville-Marie and Guillet (Mud) Lake map-areas (Henderson, 1936), and is in contact to the north with the biotite schist of the Pontiac Group. A few small, isolated outcrops of andesite also occur along the southeast shore of Simard lake, just east of the area.

The lavas range from basic to acid, forming a series from dark basalt to pale rhyolite. Intermediate and basic types are the most widespread and are mainly to the north; rhyolite and porphyritic rhyolite associated with dacite occur mainly along the southern border of the map-area.

The volcanic rocks are usually altered to various degrees, and some so much that it is difficult to impossible to classify and separate them precisely. Three major groups have been recognized: a) Andesite, dacite, and chlorite schist, b) Agglomerate, tuff, c) Rhyolite, quartz-feldspar porphyry.

Andesite, Dacite, Chlorite Schist

The andesite and dacite are gradational and not easily differentiated in the field. Andesite is more abundant, particularly as the term is used loosely here and applies to rocks of basic as well as of intermediate composition. The dacite occurs as thin lenses in the andesite and, in places, is associated with rhyolite. Chlorite schist represents zones of intense dynamic metamorphism and occurs as thin lenses in the andesite and dacite.

The rocks are usually massive and preserve such original features as flow textures and pillow structures. They are light brown to dark green on weathered surfaces and extremely fine to medium grained. Porphyritic varieties are common, especially in the dacites. Amygdaloidal lavas were observed at only one locality.

The andesite and dacite are almost completely altered to a mixture of secondary minerals. Thin-section examination of the least altered phases of the andesite reveals the presence of small prisms and phenocrysts of plagioclase (An_{30}) embedded in a groundmass of plagioclase, blue-green hornblende, actinolite, epidote, chlorite and zoisite. Quartz, where present, occurs only in the matrix as equidimensional granules. Phenocrysts of plagioclase and hornblende are common and average 2 mm. in diameter. The plagioclase crystals are in various stages of alteration to sericite, epidote and zoisite, and hornblende is altered to chlorite, biotite and epidote. Chlorite, hornblende and epidote are the dominant minerals of the groundmass with clinozoisite, carbonates, magnetite and pyrite as accessory minerals. The vesicles of the amygdaloidal lavas are filled with carbonates and fine-grained granular quartz. No potassic feldspar was observed or detected with the use of staining techniques. Flow textures characterize the porphyritic varieties, and flow lines around phenocrysts are common on the groundmass.

The dacite is confined to the southern edge of the volcanic zone in the area, where it is associated with andesite and in places with rhyolite. It is pale to medium gray and generally porphyritic. The weathered surface is very rough owing to the resistance of quartz and feldapsr phenocrysts. The phenocrysts, commonly 2 mm. long, are slightly elongated and have a parallel orientation which gives the rock a trachytic texture. Thin-sections show the feldspar phenocrysts to be idiomorphic crystals of plagioclase (An_{30}), constituting up to 40% of the rock. In places there are phenocrysts of blue-green hornblende. The matrix is fine grained and granulose, and is made up of plagioclase, quartz, actinolite, clinozoisite, muscovite, sericite and carbonates. Accessory minerals are magnetite, pyrite and epidote. The dacite associated with the rhyolite is composed of very abundant phenocrysts of plagioclase (An_{15-20}) in a groundmass of plagioclase, quartz, biotite, muscovite and clinozoisite. The dacite is much less altered than the andesite and the components are relatively fresh, only the phenocrysts showing much alteration.

Intense dynamic metamorphism transformed andesite, mainly along shears and faults, into chlorite schist by recrystallization of chlorite along the foliation planes. The chlorite schist is composed principally of chlorite with traces of tremolite-actinolite, and is cut by numerous veins of carbonates and quartz.

Pillow structures occur mainly near Quinze river and Baby lake, and are rare elsewhere. The pillows are 1-4 feet long and 1-2 feet wide. They are commonly slightly deformed and are of various shapes, the balloon-shaped, medium-sized type being the most common. The boundaries of the pillows are marked by chlorite-rich layers. Amygdule and variolite zones are absent and therefore top determinations can be obtained only on those pillows that show convex upper sides and an obvious "tail". Few such determinations were made, but those along Quinze river indicate that the top of the lavas faces south, while those near Baby lake indicate northward-facing flows, suggesting a synclinal structure.

The amygdules have a maximum diameter of 1/4 inch, are usually elliptical, and are filled with calcite and granular quartz. No amygdules were noted in pillowed andesites.

Bands 1/2 to 1/4 of an inch wide occur locally, near tuffaceous layers.

The contact between the andesite and the biotite schist is described with the Pontiac Group.

Hornblende Rock

Elongated lenticular masses of hornblende rock occur just south of Quinze river in the andesite, and there are large irregular masses near Baby lake. The latter includes the most typical examples of this rock type, and although the masses appear to be fairly continuous they are interrupted here and there by narrow or wide lenses of fine-grained, commonly pillowed andesite.

Two main types have been distinguished, on the bases of color (darker and lighter), weathering, and mineralogical composition. However they share similar characteristics such as texture, associations, and relations, and are believed to be of similar origin.

The hornblende rock is massive, medium to coarse grained, dark green, with green to black weathered surfaces which are usually rough and clotted due to the protrusion of hornblende grains. The darker type is porphyroblastic in places, with hornblende porphyroblasts up to 1/2 inch across. The lighter-colored type has a deep, soft and bleached weathered zone and is not porphyroblastic.

The dark variety is composed mainly of hornblende (60%) and plagioclase (30%). Both components are highly altered,—hornblende to chlorite and epidote; plagioclase to sericite, calcite, epidote and zoisite. The plagioclase (An_{35-40}) occurs in lath-shaped crystals, giving the rock a pseudo-ophitic texture, and also occurs as almost completely altered coarse grains similar in outline to the hornblende grains. Hornblende is generally in large, euhedral crystals. The groundmass consists of quartz, chlorite, calcite, epidote, clinozoisite, magnetite and ilmenite. The hornblende has the optical properties: $2V_x = 75\text{-}80^\circ$, $Z \wedge c = 22^\circ$; absorption formula: X = pale light green, Y = yellowish green, Z = bluish green. It is shredded in the more altered examples and, in these, cumulophyric actinolite is common.

The light-colored variety is composed mostly of plagioclase (40%) and amphibole (40%) with chlorite, epidote, calcite and quartz as accessory components. As with the dark variety, the rock is much altered and secondary epidote from the alteration of plagioclase and hornblende may constitute up to 30% of the rock. The plagioclase, in all thin-sections examined, was too altered to be determined.

The hornblende rock occurs only within the volcanic zone and is closely associated with the andesite into which it grades in many places. However, it also appears to intersect the lavas here and there, but no contacts have been observed.

Retty (1931), Denis (1936, 1938), Henderson (1936) and Auger (1952) have designated similar rocks in the eastern and southeastern projection of the zone as amphibolite, diorite, and spotted green rock. Wilson (1962) also dealt with similar formations (diorite) in the Rouyn-Beauchastel area. Henderson and Retty believed the rocks in question to be intrusive. Denis referred to the "diorites" as coarse facies of the Keewatin volcanic series. Auger distinguished extrusive and intrusive diorites although the origin of the latter was considered less certain than the origin of the former. Wilson distinguished extrusive and intrusive diorites but noted similarities between the two types.

The dark variety of hornblende rock undoubtedly is part of the volcanic sequence and is believed from field evidence to represent the coarser mid-portions of thick lava flows. The light-colored variety may be a facies of the same rock, as is believed here, or may not be related to the volcanic rocks.

Agglomerate - Tuff

Agglomerate and tuff occur in two distinct zones. One is narrow and extends east from Baby lake for 1 1/2 miles. The other, west of Angliers, is 4 miles long and trends approximately N.60°E. The width (up to one mile but averaging closer to half a mile) includes associated sedimentary rocks, iron formation and andesite. The true width of agglomerate and tuff is probably no more than 500 feet.

The typical agglomerate consists of rounded and subrounded fragments, 1/2-5 inches in diameter, embedded in a dark gray matrix. The fragments are fine grained, pale gray and uniformly composed of oligoclase phenocrysts (60%) in a groundmass of plagioclase, chlorite, epidote, clinozoisite, blue-green hornblende, granular quartz, and biotite. The parallel orientation of the phenocrysts defines a fluidal or trachytic texture further enhanced by the analogous trend of the mafic components. The matrix of the agglomerate is similar in composition to the fragments but is finer grained, richer in chlorite and clinozoisite, and lacks phenocrysts. The overall mineralogical composition of the rock is that of a quartz latite or dacite. The fragments are slightly elongated and are aligned parallel to the foliation of adjacent rocks.

The Baby Lake agglomerate is composed of irregularly shaped and distributed pebbles of andesite in a tuffaceous matrix. It occurs in pillow andesite (Plate I-A) as thin layers in banded tuff.

The tuff is of variable composition, texture and appearance. Typically it is very fine grained, soft weathering, medium to dark gray and banded. The alternating layers may be very fine grained or medium grained. The mineralogical composition of the fine-grained layers is difficult to determine in thin-sections. The coarser layers consist of a mixture of fragmental plagioclase, biotite, muscovite, fine granular quartz, pyrite, epidote and calcite. As the rock is much altered it is impossible to determine the exact proportions of the minerals, which, in any event, vary from one layer to another. The alteration of the plagioclase is so complete that, in places, even the outline of the original feldspar disappears and the mixture of epidote, sericite and calcite is the sole remaining evidence of its former existence in the rock.

Well-bedded, very fine-grained, light gray to white weathering acidic tuffs are a distinguishing feature of the Baby Lake occurrence. The beds are 1/4-1/2 inch thick and relatively uniform in composition. The tuff occurs in zones 50 feet wide associated with pillowed andesite and agglomerate. Although pillows indicate that the flows face north, the tuffs dip steeply south; thus, an overturned sequence is indicated.

Rhyolite - Quartz-feldspar Porphyry

Rhyolite and quartz-feldspar porphyry outcrop west of Long lake, near the southern limit of the area, as lenses and irregular masses interstratified with the andesite and hornblende rock, and constitute a minor part of the volcanic assemblage. They are more abundant in the Ville-Marie and Guillet (Mud) Lake map-areas (Henderson, 1936).

The rhyolite is usually porphyritic, fine grained to very fine grained, and gray or brown. It weathers light gray with a rough surface on which the quartz phenocrysts protrude in places. Rare, dark varieties also occur. The phenocrysts are rounded or elliptical, 1/8-1/4 inch in diameter, and consist of quartz, feldspar and, in some places, ferromagnesian minerals. Some quartz phenocrysts are not simple but are made up of aggregates of clear quartz with sutured borders. Feldspar phenocrysts may be either irregular in outline or idiomorphic, and the plagioclase (oligoclase) is usually altered to sericite or, in extreme phases, to sericite, calcite, epidote and quartz. A phenocryst of untwinned potassic feldspar was observed in one thin-section; with this exception, potassic feldspar appears to be lacking. Mafic phenocrysts are rare and consist of biotite, chlorite and epidote, _ probably alteration products of hornblende. Phenocrysts may make up to 50% of the rock, but 25% is more usual. The matrix material is fine granular quartz, muscovite, sericite, plagioclase, chlorite, epidote and, here and there, calcite; a little potassic feldspar was revealed by staining. Flow lines around the phenocrysts are defined by alignment of the mafics.

The quartz-feldspar porphyry is similar to the rhyolite, except for the greater amount of feldspar phenocrysts. The two rock types are intermixed and were not mapped separately. The rhyolite has the characteristic features of extrusive rocks but the quartz-feldspar porphyry appears to intrude the andesite locally. Small dike-like bodies of quartz-feldspar porphyry which intersect the andesite and the hornblende schist may be related to the rhyolite.

Hornblende Schist - Hornblende Gneiss

Hornblende schist and hornblende gneiss occur at the eastern end of the zone of volcanic rocks in the contact zone with hornblende granite.

The rock is dark green and fine grained to very fine grained (grains of 0.5 to 0.05 mm.). Foliation is defined by parallel hornblende grains and, locally, by strong compositional banding. A lineation, apparent on the foliation plane, is formed by the orientation of some hornblende grains. The rock is relatively unaltered but is recrystallized. The hornblende is fresh, highly pleochroic, in idiomorphic, rod-like fragments. Its properties are: $2V = 60^{\circ}$, $Z \wedge c = 23^{\circ}$, X = light greeish brown, Y = brownish green, Z = smoky blue-green. It is the prevalent mineral of most thin-sections, constituting up to 70% of the rock. In one thin-section from a sample near the contact zone with the granite, the hornblende crystals are bordered by bleached rims enclosing dark zones, and the hornblende alters to biotite which it encloses poikilitically. This peculiar alteration may result from the action of granitic solutions. Feldspar is altered (except in some thin-sections from samples near the granitic rocks), usually untwinned, and appears to be oligoclase-andesine. Quartz occurs as very fine, granular, equidimensional grains intimately mixed with feldspar.

Other components are chlorite, epidote, biotite, apatite, magnetite, pyrite and, in one thin-section, microcline.

The hornblende schist and hornblende gneiss are metamorphic equivalents of the intermediate volcanic rocks to the west (see also Wilson 1910, p. 16 - who described these rocks as "metamorphosed greenstones"). They are in gradational contact with the hornblende granite.

Iron-Formation

The iron-formation of the volcanic-sedimentary sequence may be separated into general northern and southern types on the bases of location, composition, association, and width. The northern type is exposed discontinuously along a N.60°E.-trending zone 7 miles long. The zone is cut by the Ottawa (Quinze) river at the right angle bend just below the dam. At its southwestern end the zone goes under overburden and to the northeast it is interrupted by hornblende granite. A possible continuation of this zone lies in hornblende gneiss 3 to 4 miles to the northeast near Quinze lake.

This (northern) iron-formation is commonly associated with pillow-lava and with hornblende rock, and is in banded zones (Plate I-B) commonly 40, but up to 150, feet wide. They are very contorted and, in places, brecciated (Plate I-C). The rock consists of alternating magnetite-rich and quartz-rich layers 1/4-1/2 inch thick. The magnetite-rich layers are dark gray and dense and are composed of magnetite, quartz and actinolite. The actinolite is usually on the borders of the magnetite layers but some is within these layers; it is oriented parallel to the layering. Magnetite makes up approximately 30% of the rock.

The quartz-rich layers are light gray to bluish gray; some consist of fine-grained granular quartz and others consist of coarse-grained quartz with sutured texture. Shreds and acicular crystals of actinolite are present in small amounts and have no preferred orientation. Small grains of magnetite are finely disseminated, and epidote and calcium carbonate are common secondary minerals.

The southern type of iron-formation occurs in zones roughly parallel to, and south of, the northern type. One zone is 3 miles long. The zones are generally less than 10 feet wide, but may be as much as 30 feet. They are relatively undisturbed, lying conformably within the sedimentary and tuffaceous layers with which they are interbedded. Folding and brecciation were observed at only one place.

The rock consists of magnetite-rich layers, rarely more than 1/4 inch thick, interbedded with layers up to 6 inches thick of sedimentary and tuffaceous rocks. The magnetite-rich layers consist of fine-grained magnetite (about 15%), granular quartz, and small crystals of actinolite. In many places, layers of bluish green hornblende crystals, with their long axes at an angle of 35° to the foliation direction and with scattered magnetite, are in contact with the magnetite-rich layers.

Metamorphosed Sedimentary Rocks (Quartzite, Siltstone, Graywacke)

The rocks described here occupy an undetermined stratigraphic position, and may belong to the Pontiac Group. However, as they are interlayered with andesite, tuff, agglomerate and iron-formation, and lie well within the volcanic-sedimentary area, it is probable that they belong to this sequence. The principal occurrences are northeast of Saint-Eugène-de-Guigues in a zone 3 miles long.

Apart from rare layers of graywacke, the sedimentary rocks here are siltstone and impure quartzite. The latter two types are dense, very fine grained, dark gray where fresh and light gray weathering. Sedimentary characteristics such as bedding and graded bedding are common. The beds are in laminae 1 - 4 mm. thick. The rocks have been recrystallized to various degrees and in many places are schistose. The quartzite consists of thin layers made up of quartz (70%) and mafics (30%). Magnetite is prominent in some layers, especially where near iron-formation. The siltstone consists of indurated, silt-sized particles of ferromagnesian minerals, quartz, feldspars, and carbonates. Thin, dark, mafic-rich layers alternate with quartz-plagioclase layers.

Paragneiss - Metavolcanics

Metamorphosed basic volcanic rocks interlayered with metasedimentary bands occur along an east-trending zone toward the southeast corner of the area, south of Klock bay and just south of the road to Laforce. The zone is 1 1/2 miles long and 1,000 feet wide, and extends east to where Denis (1936) mapped it as part of a volcanic complex. This zone lies along a syenite-granite contact, and is separated from the volcanic-sedimentary series, to which it seems to belong, by some 20 miles of granitic rocks.

The metavolcanics form an east-trending ridge 20-50 feet high. The rock is fine grained, dark gray and gneissose. In places, there are zones of 1/8-1/2-inch contorted laminae (more apparent on weathered than on fresh surfaces) that suggest paragneiss. Plagioclase and quartz are abundant in the laminae. The volcanics are composed of 50% of green hornblende crystals aligned in the direction of the gneissic structure. Granular, non-aligned epidote is the next most important component. Plagioclase and quartz are minor.

Structure and Metamorphism of the Volcanic-sedimentary Assemblage

Shear zones and faults: Numerous small shear zones were seen in the volcanics. They usually are narrow lenses filled with talc-chlorite schist. Minor faults are rare. Major faults are discussed under Structural Geology.

Folds: Minor folds were observed only in the much contorted and disrupted iron formation. The assemblage dips steeply throughout and almost invariably to the south. However, in the south the tops are to the north. Thus, overturns are indicated and isoclines with axial planes dipping steeply south are suggested; such a structure would be similar to that of the Rouyn - Val-d'Or belt.

Henderson (1936, p. 14) assumed that the assemblage "represents the southern limb of a major fold that has been cut off on the north by the granite ...," and that "the major structure of the greenstone belt may be considered as a broad anticline plunging at an extremely steep angle to the southeast ...". Auger (1952) wrote that the volcanic rocks of the Belleterre area to the east were on the southern flank of an anticline trending and plunging east.

Metamorphism: The volcanic rocks are in general so altered that they rarely contain their original components. Locally they are recrystallized, especially near the hornblende granite, but otherwise the rock is made up of the alteration products of the original components. The mineral assemblage is that of the staurolite-quartz subfacies of the almandine-amphibolite facies (Fyfe, Turner and Verhoogen, 1958), oligoclase associated with epidote being characteristic. However, the presence of albite, quartz,actinolite, biotite and chlorite in some places may indicate that the rocks straddle the boundary between the upper greenschist facies and lower almandine-amphibolite facies. Retrogressive metamorphism related to the numerous masses of granitic rocks which intrude the volcanics may account for the more extreme alterations.

Correlation of the Volcanic-sedimentary Sequence with the "Keewatin" of Adjacent Areas

Henderson (1936) and Denis (1936, 1938) used the term "Keewatin" and Auger (1952) the more restricted term "Keewatin-type" for the volcanic rocks of adjacent areas. This term was used because the lavas share many characteristics, and in places were correlated, with the Keewatin volcanics of the Rouyn-Cadillac belt. Although the author prefers to disregard the use of "Keewatin", as it has special connotations, the use of that term for the volcanic rocks of the present area and of adjoining areas may be justified. The character, mode of occurrence, and associations of the volcanics of the area and those of the volcanics of the Rouyn-Cadillac belt are in many ways similar. Also, the relations of the volcanics to the Pontiac Group are identical. Thus, the volcanics in the two areas may be correlatives.

Pontiac Group

The term "Pontiac group" was used by Wilson (1912, 1913) and Freeman (1957c) to designate a relatively continuous assemblage of sedimentary, metasedimentary and volcanic rocks and amphibolite. Freeman (1957c) wrote an exhaustive description of this group. In the present area the Pontiac Group includes rock types very similar to those described by Wilson and Freeman and which are, in part, the western prolongation of the rocks described by Freeman. The more southern rocks of the area considered to be Pontiac are well south of the main zone in which the group occurs. However, there is some stratigraphic continuity between the northern and southern parts of the group, and the lithology is similar although there are local variations.

A four-fold division of the assemblage can be made on the basis of lithology and origin:

1- Graywacke - Arkose
2- Amphibolites
3- Quartz-feldspar gneiss
4- Quartz-feldspar-biotite schist and quartz-feldspar-biotite-hornblende gneiss

The Pontiac Group is the main part of the "basement" of the area and is the main source of information as to its structural pattern and history. Also, it is the only link between two major divisions of the Canadian Shield. The volcanic and sedimentary rocks of the Superior Province to the north are separated from the metamorphic terranes of the Grenville Province to the south by this group (Figure I).

Graywacke - Arkose

Graywacke and arkose with interlayered beds of quartzite outcrop along Quinze river, north of the Pontiac Group - volcanic rocks contact, and grade into quartz-feldspar-biotite schist.

Most of the rock is dark gray to medium gray, greenish gray weathering, dense, well-bedded, fine-grained graywacke. Bedding is more conspicuous on the weathered than on the fresh surface. Graded bedding, scour-and-fill structures, small-scale crossbedding and intraformational deformation are seen in places.

The graywacke near the quartz-feldspar-biotite schist commonly is schistose, – the schistosity ranging from faint (without recrystallization and some beds not affected) to very strong. In the terminal stages, the rock is schistose throughout and completely recrystallized, and lacks all traces of sedimentary features. The final result is a biotite schist differing greatly in appearance and mineralogical composition from the original graywacke.

The graywacke is commonly folded tightly and in many places it is overturned. This feature, faulting, and the discontinuity of outcrops, prevented determination of the thickness of the unit.

The graywacke consists mainly of poorly rounded to angular fragments of plagioclase, quartz and mafic minerals. Plagioclase (An_{15-25}), making up to 55% of the rock, is generally in poorly rounded grains of variable size; in many thin-sections it grades from coarse down to the size of the matrix. Some grains have corroded borders and a sutured texture. Microcline was seen in one thin-section. Quartz is usually disposed around the plagioclase grains in fine, angular fragments. Actinolite needles were seen in a thin-section of undeformed graywacke. Accessory minerals are biotite, apatite, sphene and zircon.

Where the graywacke is relatively unaltered the secondary minerals are chlorite and epidote. In the more recrystallized phases the mineralogical composition is uniform and the components are equigranular. The graywacke grades into the Pontiac schist, of which it is, therefore, an unmetamorphosed equivalent.

Amphibolites

Various types of rocks are grouped here as "amphibolites", the term being used broadly for rocks "consisting mainly of amphibole and plagioclase" (Howell, AGI, Glossary of Geology, 1960, p. 9). The term includes rocks of diverse origins, modes of occurrence, and associations. Most of these amphibolites belong to the Pontiac Group. Some of doubtful affinity are included for convenience.

Amphibolites are widespread in the area but particularly noteworthy occurrences are northeast of Rollet, southwest and southeast of Guérin, and near Brodeur lake. They generally occur as elongated masses in the intrusive rocks or as intercalated lenses in Pontiac biotite schist. The relationships with the enclosing rocks are not clearly defined, but in some instances they seem to be discordant. The lenses or masses range from a few inches to 1/2 mile wide and are up to 3 miles long.

The amphibolite is dark green to black and consists mostly of hornblende. It may be massive, gneissose, or even schistose, the massive variety being prevalent. Thin bands of finely laminated hornblende schist are intercalated with the biotite schist northeast of Rollet. The texture is generally equigranular, but may be panidiomorphic-granular, porphyritic, or porphyroblastic. Grain size is usually coarse, but fine- and medium-grained varieties are common.

Thin-section study shows that hornblende makes up as much as 95% of the rock, and commonly occurs as stout, euhedral crystals or prisms. Crystals 5 inches long were noted near amphibolite-granite-contacts. The hornblende is almost invariably a blue-green variety displaying strong pleochroism. The chemical composition (one sample analysed in the Department's laboratories) and the optical properties are characteristic of hastingsite, a sodi-calcic hornblende.

In two thin-sections of amphibolite from the northern part of the area, colorless tremolite and pale green actinolite are dominant. Tremolite is also present as an accessory mineral in numerous thin-sections. Pale green, slightly pleochroic diopside occurs in a hornblende gneiss as concentrations characterizing certain layers which alternate with hornblende bands. Augite is also present in some thin-sections but is minor and is usually replaced by hornblende. It is biaxial positive with a 2V of 55^{o}, and $Z_{\wedge}c = 42^{o}$. Plagioclase (An_{13-25}; average An_{15}; An_{42} in one section) is an important component of most amphibolites and is in xenoblastic grains altered in varying degree to sericite and epidote. It is usually twinned, but in some gneissic parts the twinning is less conspicuous and may be lacking. Biotite is a secondary mineral commonly enclosed poikilitically in the hornblende but is rarely abundant. Microcline is present in large quantities in some places as a secondarily introduced component. Other secondary minerals are quartz, epidote, clinozoisite, chlorite, magnetite and calcite. Accessory minerals are sphene, apatite and pyrite.

Modal analyses of seven thin-sections (Table 1) illustrate the above-mentioned diversity of mineralogical composition. Samples VIII and IX are included to illustrate the similarity between the amphibolites of this area and those of adjacent areas. The Chemical analyses (Table 2) are not to be taken as absolute but represent relative values. They indicate the relatively constant chemical composition of the amphibolites; the major variations are in the Na_2O and K_2O content and are caused by the selective appearance of microcline.

Table 1

Modal Analyses of Amphibolites

	I	II	III	IV	V	VI	VII	VIII	IX
Hornblende	77.42	53.10	92.37	55.24	54.83	68.66	33.49	55.3	78.0
Plagioclase	1.99	37.25	-	25.46	19.47	29.96	45.99	22.6	10.0
Pyroxene	15.93	-	-	-	-	-	2.10	-	-
Biotite	0.99	4.87	6.50	-	1.68	-	6.2	4.1	11.0
Chlorite	-	-	-	2.28	0.73	tr.		-	-
Microcline	-	1.91	-	15.27	20.57	-	5.73	-	-
Epidote	tr.	1.34	-	1.06	1.62	tr.	5.16	7.0	2.0
Sphene	-	tr.	-	tr.	tr.	-	tr.	-	-
Apatite	1.69	tr.	tr.	-	tr.	tr.	tr.	-	-
Quartz	-	tr.	-	-	tr.	-	tr.	5.1	-

Sample I - from northeast of Rollet, Plagioclase = An_{20}. Layers of pyroxene.

Sample II - halfway between north end of Caire and Barrière lakes, Plagioclase = An_{16}.

Sample III - west shore of Quinze lake, northeast of Angliers.

Sample IV - west shore of Lebret lake, plagioclase = An_{16}.

Sample V - southwest of Nédelec, Plagioclase = An_{13}.

Sample VI - south of Angliers, Plagioclase = An_{42}.

Sample VII - west of Rond lake, Plagioclase = An_{16}.

Sample VIII - from J.L. Robert, p. 90, 1963 - Average of 6 analyses- Plag. = An_{22}.

Sample IX - from P.V. Freeman, p. 40, 1957 - Plagioclase is albite.

Table 2

Chemical Analyses of Amphibolites

	I	II	III	A	B	C	D
SiO_2	42.44	49.94	49.98	50.20	50.62	49.88	54.02
Al_2O_3	11.40	14.93	14.52	15.90	14.95	13.88	15.67
Fe_2O_3	5.25	3.05	3.09	0.60	2.63	2.55	2.38
FeO	9.71	5.59	5.71	5.09	6.10	11.84	8.46
MgO	12.82	8.69	8.39	5.60	9.02	6.17	4.12
CaO	10.99	8.15	7.89	6.77	7.98	10.19	7.14
Na_2O	1.77	3.38	2.94	2.40	2.92	2.36	4.84
K_2O	1.48	2.81	3.71	0.34	2.78	0.41	0.64
H_2O	2.19	1.66	1.51	3.47	2.18	1.46	0.04

Samples I - II - III - correspond respectively to samples III - IV - V of Table 1.

Column A : Analysis of andesitic basalt from Duverny township, Faessler, 1962 - p. 48, no. 265.

" B : Analysis of diorite from Lévy township, Opemisca intrusion - Faessler, 1962 - p. 60, no. 323.

" C : Analysis of diabase from Desmeloizes township - Normetal Mine - Faessler, 1962 - p. 76, no. 375.

" D : Analysis of andesite from Dufresnoy township, Faessler, p. 45, no. 245, 1962.

The amphibolites are associated with the biotite schist of the Pontiac Group or with younger rocks. They are present in, but intruded by, granitic rocks of all types. In the northwest part of the area amphibolite is invaded by hornblende-pyroxene syenite. North of Roulier, it is intruded by hornblende granite and oligoclase-microcline granite, being brecciated extensively. Near Brodeur lake it is intruded by hornblende syenite, and small elongated lenses of fragmented amphibolite remain as xenoliths in the syenite (Plate II-A). The amphibolites probably are of diverse origins, as outlined below.

A - Amphibolite associated with biotite schist:- Most of the amphibolite belongs to this group and the general description already given applies to it. This amphibolite could have originated from the transformation of tuffaceous rocks, andesites, basalts, diorites and diabases, all of which are present in the Pontiac Group. Samples I to V in Table 1 belong to this group, and are of diverse mineralogical composition. Denis (1938) described some amphibolites occurring in sedimentary rocks and believed that they represented a sedimentary facies. Northeast of Rollet there is a great mass of amphibolite containing some laminated and very schistose layers which could represent tuffaceous rocks. Pillow-like structures present in another part of the same mass could indicate the former presence of andesitic lavas.

Because of their concordant relationships, Robert (1963) supports the view that the amphibolites in the Kipawa Lake area are derived from basic lavas or sills. Wilson (1962) writes: "Within the mica schist are five known occurrences of recrystallized volcanic rock originally probably andesite or in a few places, where banded phases occur, andesite tuff. The original andesite is now amphibolite, amphibolite-schist or a diorite-like rock type ..." (p. 19).

The very coarse-grained, massive, porphyroblastic amphibolite associated with biotite schist west of Nédelec was considered as probably magmatic by Diffenbach (1961). This was because of the large size and stout, euhedral shapes of the hornblende crystals, as well as the presence of pyroxene (the formation of pyroxene would have been prevented under amphibolite-grade metamorphism). However, the size and shape of the hornblende grains do not necessarily point to a magmatic origin, and the presence of pyroxene may indicate that the original rock was basic and was subjected to retrogressive metamorphism. (The pyroxene is largely altered to hornblende, only ill-defined remnants appearing at the cores of some hornblende grains). Nevertheless, the amphibolite occurs as sills and dike-like bodies in the biotite schist, and as much deformed, irregular boudins that seem to intersect the schist. It seems that this amphibolite resulted from the metamorphism of intermediate to basic lavas or intrusions.

B - Amphibolites associated with granitic rocks:- The amphibolites associated with granitic rocks and other acidic intrusions are in every way similar to those mentioned above. Although not in contact with Pontiac rocks they are believed to be portions of the Pontiac that were not assimilated by the granites. Thus, their origin would be much the same as those of the first category.

C - Amphibolite south of Angliers:- This amphibolite forms a large, elongated body near the southern limit of the area. Sample VI of Table 1 is representative of this rock. The plagioclase (andesine) is more calcic than that of any other amphibolite. One thin-section carries remnants of pyroxene in the cores of hornblende grains. A pseudo- or semi-ophitic texture suggests that the rock represents a diabase or a gabbro.

D - Amphibolite near Rondelet lake south of Moffet:- This amphibolite is in small and large masses characterized by the presence of pyroxene and by a porphyritic texture. The amphibolite is altered and little pyroxene now remains, although it was seen in most thin-sections. Phenocrysts of hornblende, 1/16-1/4 inch in size and held in a groundmass of hornblende plagioclase and microcline, are common. The rock is intruded by hornblende syenite and oligoclase-microcline granite and is intensely brecciated in places. Numerous elongated inclusions of amphibolite lie in the syenite near the amphibolite. The occurrence is believed to represent basic intrusions partly assimilated by granitic rocks.

E - Amphibolites near Arenaine (Bull Rock) and Opasatica lakes:- These small highly altered dike- or sill-like masses of amphibolite are composed of a felted mass of colorless tremolite, pale green actinolite, and chlorite and magnetite. The magnetite is in scattered dust. The weathered surfaces display structures resembling pillows or polygons. East of Opasatica lake one mass is near pyroxene dikes and a small serpentinite body and may represent such ultrabasic rocks. This amphibolite is not part of the Pontiac Group.

F - Amphibolite south of Guérin:- This amphibolite is similar in origin to that of "B". It consists of three occurrences along the east-west road south of Guérin. It is characterized by breccia in some places and by a conglomerate-like appearance elsewhere. Rounded pebbles of amphibolite up to 2 inches across are enclosed in a hornblende-biotite matrix, and angular pieces of amphibolite, 1-3 inches long, are enclosed in a hornblende-plagioclase matrix. The brecciation was caused by the intrusion of hornblende granite but the origin of the conglomerate-like part of the rock is unknown. It may be due to deformation prior to, or contemporaneous with, the intrusion.

Metamorphism: The typical mineralogical association of the amphibolites is that of the staurolite-quartz subfacies of the almandine-amphibolite facies. "Here derivatives of basic igneous rocks consist essentially of hornblende and calcium-bearing plagioclase with or without epidote" (Fyfe, Turner and Verhoogen, 1958, p. 228). This classification corresponds to the lower part of Eskola's (1952) amphibolite facies, of which green hornblende is a reliable criterion.

Quartz-feldspar Gneiss (Plate II-B)

Rocks of this group occur in two widely separated parts of the area. The major mass lies between the two diverging branches of Quinze lake. The other showing, north of Rollet, is minor and consists of two lenses. The two areas contain rock types that are not exactly similar and might more accurately be classified separately, but their mode of occurrence and association points to a common origin. The rock is usually in contact with the biotite schist, into which it grades.

The major mass of quartz-feldspar gneiss grades into biotite schist to the north and is injected and mixed with granitic material to the south. It is gray to pink, whitish weathering, and fine to medium grained. Laminations 1/32-1/16 inch thick, defined by concentrations of biotite, alternate more or less regularly with quartz-plagioclase layers, 1/4-1/2 inch thick. The rock consists of essentially anhedral grains forming a granular mosaic with directional structure. Allotriomorphic and slightly elongated grains of quartz are intimately mixed with plagioclase grains in the dominantly acidic layers. The plagioclase (oligoclase, An_{15-18}) is usually untwinned and shows alteration to sericite. Biotite is present in small amounts as aligned euhedral crystals. Microcline is interstitial and is not common. A little bluish green hornblende is present at a few localities. Clinozoisite is rare. The rock is relatively fresh and alteration products are not abundant. Epidote is the most common secondary mineral. Accessory minerals are sphene, apatite, zircon, pyrite and magnetite.

Table 3 gives the results of five modal analyses of quartz-feldspar gneiss (I-III and V from the Quinze Lake mass; IV from the northern showings). The mineralogical composition is relatively uniform.

The gneissic structure is defined by the elongation of quartz and feldspar grains, by the parallel alignment of platy minerals, and by the compositional layering. The rock may be schistose near the biotite schist, or massive near granitic intrusions.

The fact that the quartz-feldspar gneiss grades into biotite schist around both the main (southern) mass and the northern lenses suggests that it developed from the schist. However, as the gneiss also grades into gray granitic gneiss, and as bands of oligoclase-microcline granite are common in the Quinze Lake mass, it is strongly indicated that the southern mass at least is actually a granitic intrusion.

Table 3

Modal Analyses of Quartz-feldspar Gneiss

	I	II	III	IV	V
Quartz	27.77	23.67	23.59	29.77	25.34
Plagioclase	64.54	60.49	67.88	55.39	63.88
Microcline	2.92	7.07	1.81	11.72	1.79
Biotite + chlorite	3.60	3.62	tr.	2.37	1.08
Epidote	tr.	tr.	1.18	-	tr.
Hornblende	-	4.56	4.99	-	6.92
Apatite	tr.	tr.	tr.	tr.	tr.
Sphene	tr.	tr.	tr.	tr.	tr.

Sample I - North end of Gaboury lake. Plagioclase = An_{16}.

Sample II - Small island in Quinze lake, north of Marianne point. Plagioclase = An_{15}.

Sample III - Halfway between Gaboury and Quinze lakes, Plagioclase = An_{16}.

Sample IV - On the highway, about 1 1/2 miles south of northern limit. Plagioclase = An_{18}.

Sample V - From east of Quinze lake, east of Marianne point. Plagioclase = An_{22}.

Quartz-feldspar-biotite Schist and Quartz-feldspar-biotite-hornblende Gneiss

This division of the Pontiac Group is the most important because of its wide distribution and its structural significance (Figure 1).

The biotite schist outcrops widely in the southeast, southwest and northwest parts of the area, but minor occurrences are present elsewhere as irregular lenses in the intrusive rocks. The three principal areas of schists are separated by masses of granitic rocks and are apparent topographically as low curvilinear ridges that parallel the foliation. They consist mostly of quartz-feldspar-biotite schist with minor intercalations of amphibolite. The lenses are most common near the main areas and appear to be structurally continuous with them. They become increasingly tenuous outwards but seem to preserve their structural continuity and to be relatively undisturbed. Quartz-feldspar-biotite-hornblende gneiss occurs sparsely within the biotite schist at a few localities.

Lithology: The biotite schist is light to dark gray and fine to medium grained. In some places it weathers rusty owing to oxidation of pyrite. It consists of biotite rich layers 1/2 inch to 8 feet thick alternating with quartz and plagioclase rich layers 1/2 inch to 2 feet thick. Some layers are massive and homogeneous, whereas others are laminated owing to concentrations of mafics along the foliation; the laminations may be apparent only on weathered surfaces.

Veins, lenses and pods of quartz, commonly elongated along the schistosity, give the rock a ridged appearance on weathered surfaces because of differential weathering. Similar ridges, composed not only of quartz but also of feldspar and biotite as in the surrounding rock, may have resulted from their finer texture (Wilson, 1912, p. 28),or because they actually are more siliceous than the surrounding rock.

Petrography: Under the microscope, the rock consists of a lepidoblastic aggregate of fine grains of biotite, quartz and feldspars. Muscovite and microcline are present here and there in small amounts. Accessory minerals are apatite, sphene, zircon, pyrite and magnetite. Secondary minerals are sericite, chlorite and epidote. Epidote, generally formed at the expense of biotite, appears to be rich in iron. Alteration products are scarce. Biotite commonly displays bleached borders and incipient alteration to chlorite or epidote or both. Quartz occurs as small, undulose, elongated grains, some of which come to extinction simultaneously. In samples from the southern part of the area, angular, coarse to medium quartz grains lie in a fine-grained matrix of quartz, plagioclase and biotite. Plagioclase is usually granular, untwinned, and may show incipient alteration to sericite. The composition of the plagioclase varies from An_{15} to An_{25} from north to south. Layers of granitic material introduced into the biotite schist contain grains of twinned plagioclase (An_{20}).

Biotite occurs as medium-sized grains and has the following properties: $Ny = Nz = 1.632 \pm 0.002$.

Absorption formula: X = pale yellow
Y = reddish brown
Z = dark brown

It usually has a strong preferred orientation except in the more massive layers. Some of the grains are slightly bent to conform with the curvature of grains of feldspar and quartz, and, in the southern part of the area, blastopsammitic grains are enveloped by biotite. In one sample from a locality where nodular pyroxene syenite intrudes the schist, garnets are abundant in the schist and displace the foliation outlined by the parallel alignment of biotite. Coarse, porphyroblastic grains of biotite are present in places, especially where deformation is strong. Common green hornblende occurs locally as medium-sized grains concentrated along layers; biotite is rare and foliation is weak in such layers.

Foliation, apparent in almost all thin-sections, is outlined by the parallel alignment of platy minerals and by the simultaneous extinction of the quartz grains. Usually, layering is suggested by a concentration of ferromagnesian minerals. In samples from the southern part of the area foliation is weak, the texture is not equigranular and the rock is not entirely recrystallized.

Table 4 contains the results of seven modal analyses of biotite schist, five of which are from adjacent map-areas. All the samples are believed to come from the Pontiac Group or correlative equivalents. The Table illustrates the fact that the mineralogical composition varies within a narrow range.

Granitization - Migmatization: In the west central part and in the northeast corner of the area, the biotite schist was granitized and migmatized by the intrusion of oligoclase-microcline granite. Granitization is indicated by the presence of "ghosts" or streaks of schist in the granite and by larger biotite in the schist; muscovite, as a replacement of biotite, is also present. Gradational contacts between schist and granite are very common, and many lenses of partly digested schist are left which show structural continuity although they may be widely separated.

Complex interlayering of the schist with granitic matter is characteristic near the granitic masses, granitic and pegmatitic material occurring as lit-par-lit injections, concordant lenses, or discordant bodies. Nevertheless, the schist, although highly disturbed, preserves its characteristic features.

Table 4

Modal Analyses of Biotite Schist

	I	II	III	IV	V	VI	VII
Quartz	33.01	26.32	26.0	35.0	30.0	60.0	50.0
Plagioclase	44.18	53.07	51.0	48.0	44.0		
Microcline	tr.	-	-	-	-	-	-
Hornblende	-	18.60	-	-	-	-	-
Biotite	21.06	0.61	15.0	8.0	15.0	35.0	16.0
Muscovite	1.28	-	tr.	5.0	5.0	-	34.0
Chlorite	-	-	-	-	-	2.0	tr.
Epidote	-	-	5.0	-	2.0	-	-
Apatite	tr.	tr.	-	-	-	-	-
Magnetite + pyrite	tr.	1.14	-	-	-	3.0	1.0

Sample I - South end of Beaudry (Roger) lake. Plagioclase = An_{20-22}.
Sample II - Two and a half miles west of Opasatica lake, opposite Solitaire bay. Plagioclase = An_{25}.
Sample III - IV - V - Lake Kipawa area, Robert, 1963, p. 46. Biotite-muscovite paragneiss. Plagioclase = An_{21} for all samples.
Sample VI - VII - Malartic district, Kewagama (Pontiac) Group; VI is from unaltered graywacke, VII from graywacke (Eakins, 1962).

Bedding - Original bedding, graded bedding, and small-scale crossbedding are well preserved in the less-deformed schist adjacent to graywacke near Quinze river. In the more typical schist, bedding is apparently represented by compositional layering alternating more or less regularly with, and parallel to, the schistosity throughout (Wilson, 1913; Freeman, 1957c). However, the foliation does intersect the bedding in some places, notably where a fold closes.

Foliation - Foliation defined by the preferred orientation of tabular mica along s-planes is a dominant character of the rock, except in the southern half of the area where it is not strong and some parts of the rock are almost undisturbed. Quartz grains commonly show simultaneous extinction, denoting a preferred lattice orientation of the grains. The schistosity is an axial plane foliation which has probably developed from slaty cleavage with progressive metamorphism.

Lineation - Three different types of lineation were recognized:

A - Faintly defined by the preferred orientation of tabular crystals within the schistosity plane.

B - Outlined by the parallel axes of microcrenulations on the s-surfaces. On a slightly bigger scale, this lineation is also formed by the parallel axes of parasitic folds.

C - Defined by the intersection of bedding and schistosity.

Joints - A joint set is developed perpendicular to the schistosity; where the dip is low this gives rise to cuesta-like ridges. Veins of quartz and of pegmatite commonly occupy joint planes.

Shears and Faults - A few shear zones and many small faults occur in the biotite schist. Many of the faults are the result of deformation contemporaneous with the intrusion of the granitic rocks, as is indicated by their relationships with granitic dikes. Some granitic dikes are displaced, whereas others with similar attitude and composition are not displaced by the same fault. Many acidic dikes occupy faults. Strike faults may be common but they are indicated only in a few instances where acid dikes are displaced along the schistosity. The one major fault observed in the biotite schist is discussed under Structural Geology.

Folds - The biotite schist has been folded intensively into minor and major structures. The latter, discussed under Structural Geology, are defined by the foliation of the schist, and marker horizons that might outline their precise forms are lacking.

The minor folds include "drag folds" (Plate II-C) that range in size from crenulations suggesting small-scale ripple-marks to structures up to 15 feet across; intrafolial folds (Turner and Weiss, 1963, pp. 116-117) that may or may not be tectonic; and ptygmatic folds.

Boudinage - Boudins are common in amphibolite layers intercalated in the biotite schist. Many are fractured by shear planes oblique to the foliation, and, in places, the amphibolite breaks into angular blocks along these planes (Plate III-A).

Metamorphism - The mineral assemblage of the biotite schist is relatively constant throughout the area. The composition of the plagioclase ranges from An_{15} in the north to An_{25} in the south. Exceptions and variations occur where granitic intrusions have transformed the schist and albite has been observed in one thin-section from the northern part of the area.

The biotite schist belongs to the staurolite-quartz subfacies of the almandine-amphibolite facies as defined by Turner (Fyfe, Turner and Verhoogen, 1958, p. 228) and is characteristic of relatively high-grade zones of progressive regional metamorphism. "Prevalence of hydrous silicates (micas and amphiboles) points to high water pressure. Since rocks of this facies commonly grade into migmatites veined with granitic materials, the upper limit of temperature cannot be much less than 700° C" (Fyfe, Turner and Verhoogen, 1958, p. 228). Evidence of retrogressive metamorphism was observed in a few thin-sections, some biotite being altered to chlorite.

<u>Stratigraphic Relations</u> - The Pontiac Group, inclusive of the biotite schist, extends north of the present area to where it is associated with the "Keewatin-Timiskaming" volcanic-sedimentary assemblage. According to Podolsky (1950), the Pontiac Group is separated from the overlying Timiskaming rocks by a structural and erosional unconformity but its relationships to the Keewatin are unknown. Wilson (1962, p. 6) suggests that the Pontiac may belong to the Abitibi Group, and he supports the hypothesis of Gunning and Ambrose (1939) that the Pontiac (Kewagama) Group is part of the south limb of a major syncline. He further writes (p. 18) that "originally the belt must have been considerably more extensive, for it is cut off on the north by the pre-Timiskaming unconformity..." The only observed contact to the north between the Pontiac Group and the Keewatin volcanic rocks is a fault.

In summary, the prevalent views are that the Pontiac Group is overlain unconformably by the Timiskaming, is part of the Abibiti Group, is equivalent to the Kewagama Group, and is upper Keewatin.

To the south, in the southern part of the present area, the Pontiac Group is in contact with a volcanic-sedimentary assemblage that extends south of the area into the Ville-Marie and Guillet map-areas described by Henderson (1936). This contact was seen at one locality only, 1,400 feet north of Quinze river, almost due south of Guérin. Elsewhere, the contact can only be inferred by extrapolation between outcrops of the two rock types and by interpretation of physiographic details. The lavas usually have more relief than the schist and an abrupt change in topography corresponds to the contact zone. The observed contact is abrupt along its length of 50 feet. South of the contact zone, the volcanics are massive and pillowed, but in the contact zone itself, which is up to 4 inches wide, they are schistose. The contact itself is regular and parallel to the foliation of the biotite schist. It is so inconspicuous that it can easily be overlooked because of the similar appearance of the two different rock types. No sedimentary features are preserved at the contact, but 2,000 feet north of it they are apparent and the rock as a whole is not deformed.

The attitude of the sedimentary rocks just northwest of the contact, where sedimentary features are preserved, indicates that the sedimentary rocks (biotite schist) overlie the volcanic rocks. However, we have no determination on the attitude of the lavas near the contact, but farther south pillow structures indicate that the top of the lavas is to the south. We cannot, therefore, determine if the sedimentary rocks overlie the volcanic rocks conformably.

Denis (1938, p. 33) mentions that "light to dark grey schists occur as intercalations near the top of the greenstones" and become more abundant upwards. He also states that "Temiscamian-type metasediments" overlie and parallel the greenstone (pp. 69-70), and that a gradational contact seems probable.

Auger (1952, p. 20) reports similar observations and conclusions. Henderson (1936) states that the sedimentary rocks overlie the greenstones in apparently gradational and conformable contact.

The "Temiscamian-type metasediments" of Denis, the sedimentary rocks of Auger, and the "Keewatin (?) sediments" of Henderson are in every way similar to the biotite schist of the present area and are also in close spatial relationship. Consequently the observations and conclusions of these authors are additional support for the view that the Pontiac Group overlies the volcanic-sedimentary series conformably.

Age and Correlation - The Pontiac Group has been assumed to be of Archean age because of its relationships with Timiskaming formations and their association with Keewatin formations. This is supported by the relationships observed in the present area and also by absolute age determinations. From a sample of biotite schist collected by K.R. Dawson and P.V. Freeman in the area adjacent to the northeast, absolute age determination by the K-Ar method yielded a figure of 2,460 million years (Lowdon, 1960, p. 33). The age obtained for this sample is valid for the rocks of the Pontiac Group in the northern part of the area and corresponds closely with the ages obtained for the Keewatin assemblage. Snelling (1962, p. 13) states that "regional metamorphism of the Pontiac schist (GSC 59-77) occurred 2,460 million years ago and intrusion by granitic rocks (GSC 59-78) about 2,285 million years ago." However, no age determinations were obtained on samples from the southern part of the area and the result of the above-mentioned analysis cannot be used as representative of the whole area. Lower ages would probably be obtained in the south, inasmuch as the effects of the metamorphism of the Grenville orogeny are progressively stronger to the south. Robert (1963a) mentions that the schists in the northern part of the Kipawa Lake area are correlatives of the Pontiac Group. This view, also held by the author, is supported by lithological and structural evidence. The width of the Pontiac rocks is thus extended from "10 or more miles" (Wilson, 1962, p. 18) to approximately 60 miles, including numerous interruptions.

4

Origin: The origin of the Pontiac Group has been extensively discussed by Freeman (1957c) and Wilson (1962). Their views will be condensed and discussed in the light of observations made in the area now under study.

The following features of Pontiac rocks pertain to their origin:

1 - Graded bedding is common in the well preserved parts of the rock.
2 - Crossbedding is rare.
3 - Ripple-marks are absent.
4 - Scour and fill features are common.
5 - The predominance of graywacke is in marked contrast to the absence of pure quartzite and limestone.
6 - The bedding in the graywacke suggests varves.
7 - The abundance of plagioclase in the rock is characteristic.

The first six features are those of Archean sedimentary rocks and are those enumerated by Pettijohn (1943) who concluded that the graywackes of the Canadian Shield are the result of rapid, probably marine, accumulation in a geosyncline near mountains. This opinion is supported by Podolsky (1950) who writes that the Pontiac strata were deposited as typical "poured-in flysch-type" sediments (p. 89) in a rapidly sinking geosynclinal trough. Wilson (1962, p. 27) presents four alternative modes of origin and concludes that "The mica schist, presumably metamorphosed graywacke, of the Pontiac group illustrates a remarkably uniform and extensive belt of sediments of the unsorted type, and if it is the structural equivalent of the relatively thin Cléricy or Kewagama zone of similar rocks in the north limb of the synclinorium, as Gunning and Ambrose believed, then it thins northward away from its southern mountain source, and therefore, has all the characteristics of piedmont deposits laid down either in a large lake or in the sea."

Freeman (1957c) also adds that the relative abundance of acidic plagioclase in the southern graywacke suggests that the southern source was already a mountain-built land in which granites had been emplaced.

The mica schist definitely is the metamorphosed equivalent of the graywacke, into which it grades. This would imply that the graywacke was deposited widely, which presents an objection to a southern mountain source for the sediments (Wilson, 1962). The belt is now known to be much wider than was originally thought, and the source would be much farther south than originally assumed, unless it was in the central part of the area now occupied by granitic rocks. If the source were to the south, it would have been in the Kipawa Lake area or still farther south. That the source was in the central part of the area where granitic rocks now occur, cannot be proven because the intrusions have obliterated any evidence that might have existed. Bass (1961) suggests that there was no single source of sediments but rather many volcanic centers from which the debris spread radially. This idea is plausible because volcanic rocks appear south of the main belt (Rouyn-Malartic) and are interlayered with sedimentary rocks indicating alternations from volcanic to sedimentary.

To summarize: The biotite schist of the Pontiac Group is the equivalent of graywacke; the graywacke has characteristics of geosynclinal sediments derived from acid igneous rocks; the location of the source of sediments is unknown.

Intrusive Rocks

Pyroxene-biotite Rock

Two outcrops of pyroxene-biotite rock were seen near Rémigny lake. The more accessible and the better exposure is on the west shore of the lake, 4 1/2 miles north of the village of Rémigny. The second is 1 1/2 miles east of Rémigny lake, just south of Chabot lake.

The rock is medium grained, dark green where fresh, and dark brown weathering. The weathered surface is pitted where the easily soluble carbonates have been removed by weathering. The texture of the rock is generally allotriomorphic-granular, although the biotite is locally coarse giving the rock a pseudo-porphyritic texture.

Diopside, the principal mineral, is in subhedral grains. Biotite is also a major constituent and, if in phenocrysts, usually has bleached borders. Accessory minerals are apatite, sphene, quartz, hornblende, plagioclase and microcline. Secondary minerals are chlorite, epidote and carbonate (calcite or dolomite).

The pyroxene-biotite rock is cut by dikes 2-5 inches wide of granite and pegmatite. Oligoclase-microcline granite is separated from the pyroxene-biotite rock by a transition zone approximately 2 feet wide. Elongated rock fragments in the transition zone, and intermediate in composition between the two types, probably are parts of the transition zone itself.

The origin of the pyroxene-biotite rock is problematical. It may be a lamprophyre, although this is not evident. It does not appear to be a dike, and the porphyritic texture is neither dominant nor ubiquitous. It may be a relatively dark facies of hornblende granite, rendered basic through assimilation of extraneous material. Hornblende granite, although not seen in direct contact with the pyroxene-biotite rock, occurs nearby. Or, it may be related to the nodular pyroxene syenite which resembles it in composition and mode of occurrence and which outcrops near the pyroxene-biotite rock south of Chabot lake. The texture of the two rock types is similar, apart from the nodules, and much of the central part of the syenite masses is similar in composition to the pyroxene-biotite rock.

Nodular Pyroxene Syenite

Small masses of nodular syenite were seen at many places in the area, some being too small to be shown on the map. The most conspicuous and spectacular examples are just south of Solitaire river (2 miles southeast of Rollet), and along the west shore of Barrière lake (Plate III-B). Other bodies occur at many points along both shores of Barrière lake, on the northeast tip of Bryson island in Simard lake, 1/2-1 mile north of Prévost lake, and south of Chabot lake.

The rock occurs as irregular masses, sills, and dikes and ranges from a few feet to 1,000 feet wide. It is generally green, brownish weathering, and medium grained. The nodular texture is distinctive and is best observed on weathered surfaces where discrete, light-colored patches or nodules of feldspathic material stand out prominently in a dark brown groundmass. The diameter of the nodules averages 1/2 inch and has a range of.1/4-1 inch. The nodules are elongated in length and height, so that they resemble ovoid cylinders. They are an integral part of the rock and do not weather out as separate bodies, like the pebbles of a conglomerate. They are a textural effect, difficult to distinguish on fresh surfaces, and not recognizable in thin-section.

The composition of the rock varies widely not only from one outcrop to another but within a single outcrop. The rock consists mainly of plagioclase, pyroxene, and microcline, although hornblende and biotite are locally important. The plagioclase (An_{15-25}), commonly altered in part to sericite, constitutes 5-41% of the rock. It is in grains slightly larger than those of other minerals, and many contain inclusions of amphibole and pyroxene. The pyroxene is usually augite and occurs as equant grains generally smaller than those of adjacent minerals. The augite alters to hornblende (which commonly rims it) and is twinned; it makes up to 55% of the rock, 25% being common. Microcline occurs as interstitial grains and as replacement patches and veinlets (along cleavage lines). It constitutes up to 35% of the rock, the average being 10%. Hornblende (up to 44% and averaging 25% of the rock) may be primary or secondary and has the following optical properties:

$$Nx = 1.669 \pm 0.002,\ Nz = 1.688 \pm 0.002,$$
$$2V = 62^\circ,\ Z \wedge c = 22^\circ,$$

Absorption formula: X = light green, Y = yellowish green, Z = bluish green. These properties are similar to those of hastingsite. The hornblende usually occurs as large automorphic grains, some of which are four times as large as the pyroxene crystals. Much of it is twinned and alters to chlorite and epidote. Biotite constitutes up to 70% of the rock and is usually primary. It alters readily to chlorite. Quartz is rare, but in one case it makes up to 7% of the rock, occurring as small interstitial grains. Common accessory minerals are apatite, sphene and magnetite.

Table 5 shows the extreme variations in mineralogical composition. The centers of sills and larger masses are generally enriched in pyroxene and the border zones contain much hornblende.

The nodular pyroxene syenite usually outcrops near hornblende granite into which it grades. It is also common near the volcanic rocks west of Quinze lake, north of Angliers. In the northern parts of the area, near Rollet, the syenite is cut in many places by dikes of oligoclase-microcline granite and of pegmatite. Few sharp contacts with adjacent rocks were seen.

The syenite is similar in mode of occurrence to syenite porphyries described by Wilson (1962) and by Cooke, James and Mawdsley (1931) in areas to the north. However the present syenite antedates the granites, whereas, except for basic dikes, it is the youngest intrusive to the north.

Table 5

Modal Analyses of Nodular Pyroxene Syenite

	I	II	III	IV
Plagioclase	36.21	41.31	30.86	31.62
Microcline	10.06	6.56	8.72	16.92
Pyroxene	0.67	2.05	22.22	-
Hornblende	44.68	33.94	18.02	42.65
Quartz	-	-	0.16	-
Chlorite	4.19	13.44	17.69	2.57
Epidote	tr.	tr.	tr.	4.70
Apatite	tr.	tr.	tr.	tr.
Sphene	1.00	1.39	0.80	tr.
Biotite	2.18	---with chlorite		----

I - Sample from an isolated irregular mass along the east shore of the south end of the east branch of Barrière lake. Plagioclase = An_{17-18}.

II - Sample from the outer part of a sill on the southwest shore of Barrière lake, 2 miles south of Solitaire river. Plagioclase = An_{28}.

III - Sample from the central part of the sill (II).

IV - Sample from an isolated outcrop along the road, one mile north of Rémigny. Plagioclase = An_{17}.

The syenite intrudes quartz-feldspar-biotite schist southeast of Rollet and appears to be partly a sill and partly a dike, as indicated by the various compositional bands and by the thermal metamorphism of the host rocks. Bands 1-6 feet wide, of diverse mineralogical composition, alternate irregularly in three or four zones approximately 30 feet wide within a total width of 1,000 feet. The composition of the layers varies from intermediate to basic, some containing as much as 55% pyroxene. Five feet from the contact a garnetiferous zone 30 feet wide has developed in the schist parallel to the contact.

The outcrop of syenite along the west shore of Barrière lake, south of Solitaire river, is a continuation of the above. There a reversal in the nodular texture is evident near the border of the mass, dark patches or nodules being enclosed in a light-colored groundmass. The minerals are the same but the proportions are different. Here also the syenite is intrusive.

Generally however, the syenite does not appear to be intrusive but rather to grade into the hornblende granite with which it is commonly associated, the nodular texture becoming less and less pronounced until only a normal granular texture remains. The syenite here may be the product of metasomatic processes or may represent partly digested xenoliths in the hornblende granite.

Hornblende-pyroxene Syenite, Generally Porphyritic

Hornblende-pyroxene syenite occurs in three parts of the area: west of northern Barrière lake and around Fréchette lake, where it is most abundant, northeast of Caire lake, and south and southeast of Guérin. These occurrences, although widely separated, are remarkably similar in association, relations, appearance, and composition. The syenite forms a large irregularly shaped mass about 5 miles across south and southeast of Fréchette lake, and smaller irregular or lenticular masses elsewhere. It may be massive and homogeneous or porphyritic. Both types are commonly intermixed, although they also occur separately, but the porphyry is predominant.

The syenite generally is gneissic or is lineated through the parallel alignment of feldspar megacrysts, but in places it is massive and hypidiomorphic-granular. It is medium to coarse grained and dark gray to pink, and has a deep and rough weathered surface.

It is composed essentially of plagioclase, microcline, perthite, augite, amphibole and biotite. Secondary minerals are chlorite and epidote, and accessory minerals are apatite, sphene, magnetite and zircon. Anhedral, twinned grains of albite (An_{5-8}) are common in the groundmass of the porphyritic type, but plagioclase of An_{18-22} composition is more typical of the massive variety. The plagioclase is slightly altered to sericite and has albitic outer zones where in contact with microcline. Microcline is in clear, allotriomorphic, unaltered grains; in patches and irregular blebs in the plagioclase; and constitutes most of the augen-like megacrysts in the porphyritic variety. The megacrysts (1/4-1 inch long and 1/16-1/2 inch wide) are commonly subangular and irregular in outline. In places, they are surrounded by a finely granulated matrix of plagioclase, fresh microcline, and augite, giving the rock a mortar structure. Idiomorphic and allotriomorphic grains of colorless and commonly twinned augite, partly altered to hornblende and biotite, are minor components of the syenite. The optical properties of the augite ($Nx = 1.698 \pm 0.002$; $Ny = 1.706 \pm 0.002$; $Nz = 1.728 \pm 0.002$; $2V = 61^{\circ}$, $Z \wedge c = 40^{\circ}$) and the chemical composition are those of a sodian variety. Blue-green hornblende is common as a secondary mineral resulting from the alteration of pyroxene; its optical properties and chemical composition are those of common hornblende.

Olive-green biotite occurs as euhedral grains generally in contact with, or close to, the augite or is enclosed poikilitically in augite. Perthite is present in the megacrysts of the porphyritic type as film, braid, stringlet, bead and patch perthite (Plate III-C). Microcline and plagioclase usually are in optical continuity. In most cases, microcline is the prevalent component of the perthite, especially in the film, braid, stringlet and bead varieties; in patch perthites plagioclase may be dominant and microcline rare. The cross-hatching of microcline is conspicuous but the albite twinning of plagioclase is generally indistinct. Some megacrysts are composed of two or more units of perthite; in other words, optical continuity does not extend through the grains and sharp boundaries separate the units which, nevertheless, form a single euhedral megacryst. In two samples, microcline appears only along concentric zones separated by plagioclase, much like ordinary compositional zoning in plagioclase. The groundmass material is usually free of perthite but replacement relationships are commonplace in all the thin-sections.

Table 6 gives six modal analyses of syenite. Column A is a modal analysis of a rock believed to be identical to the syenite. The chemical analyses given in Table 7 correspond to the modal analyses of Table 6 and illustrate the relative constancy of the chemical composition of the syenites. The amounts of K_2O and Na_2O may be slightly in error because of the perthite present in some samples and the impossibility to measure them accurately in modal analyses. However, although the alkali content of the rock is high, it is not abnormally so for a syenite.

No modal analyses of porphyritic syenite were made because the perthite and the megacrysts would unbalance the results. Most of the perthite is believed to have resulted from the replacement of microcline by plagioclase.

Table 6

Modal Analyses of Pyroxene Syenite	I	II	III	IV	V	A
Quartz	-	-	-	tr.	4.90	-
Microcline	15.44	23.58	6.46	28.00	24.58	27.00
Plagioclase	59.61	53.18	84.26	58.99	38.96	45.00
Hornblende	tr.	-	1.23	6.66	24.09	15.00
Pyroxene	14.03	7.16	7.28	3.41	-	10.00
Biotite	9.24	14.58	-	-	6.03	1.00
Epidote	tr.	tr.	tr.	tr.	tr.	-
Chlorite	tr.	-	-	-	-	-
Apatite	tr.	tr.	tr.	tr.	tr.	1.00
Magnetite	tr.	tr.	tr.	1.05	tr.	1.00
Sphene	-	tr.	tr.	tr.	tr.	-

I - Sample from Fréchette Lake area. Massive. Plagioclase = An_8.

II - Sample from Fréchette Lake area. Massive. Plagioclase = An_6.

III - Sample from north of Rollet, along route 46. Massive. Plagioclase = An_6.

IV - Sample from the west shore, north end of Barrière lake. Massive. Plagioclase = An_6.

V - Sample from the west shore, one mile south of Solitaire river, Barrière lake. Massive. Plagioclase = An_{22}.

A - From Bellecombe township, west of Caron lake. Augite-syeno-diorite orthogneiss (Gussow, 1937). Oligoclase.

The hornblende-pyroxene syenite cuts the Pontiac biotite schist and amphibolite, and is usually gneissic near the contact. The numerous inclusions of schist and amphibolite in contact zones appear to trend parallel to the foliation of the syenite. Reaction with the syenite is indicated by hornblende crystals disposed radially along the edges of the inclusions. The contact with the amphibolite may be sharp or gradational.

The syenite is intruded by oligoclase-microcline granite and by pegmatite dikes, and inclusions of syenite are common in the granite. Near Renard lake the syenite is in contact with hornblende granite, into which it seems to grade. Therefore, the syenite is younger than the Pontiac Group, older or equivalent to the hornblende granite, and older than the oligoclase-microcline granite.

Table 7

Chemical Analyses of Syenite

	I	II	III	A
SiO_2	59.93	64.51	62.10	57.12
Al_2O_3	16.45	18.21	17.22	15.16
Fe_2O_3	1.61	1.11	2.03	2.49
FeO	4.17	1.21	1.36	4.81
MgO	2.15	1.20	1.57	3.82
CaO	4.08	2.83	2.46	5.05
Na_2O	6.44	9.29	6.59	4.90
K_2O	3.35	1.06	4.52	4.62
H_2O+	0.14	0.03	0.18	0.85
H_2O-				0.30
TiO_2				0.48
MnO				0.09
P_2O_5				0.44
F				0.04
S				tr.
Total	98.32	99.45	98.03	100.17

I - II - III - correspond to I - III - IV - of Table 6 and are derived from the modal analyses.

A - Analysis of syénodiorite orthogneiss (Gussow, 1937). Analyst: W.H. Herdsman.

Numerous masses of syenitic rocks have been mapped north and northeast of the present area. The Hub Lake syenite (Cooke, James and Mawdsley, 1931) and Aldermac syenite (Gunning, 1927) are similar in composition, mode of occurrence and appearance to the hornblende-pyroxene syenite and appear to be related to it. James' (1924) large mass of syenite porphyry and augite syenite immediately north of the present map-area is probably part of our Fréchette Lake mass. Wilson (1962) describes syenitic dikes or sills.

The syenite to the north is believed by many to be the youngest intrusive rock, excluding the diabase, but this opinion is questionable. Wilson (1962, p. 31) classes it as Early Precambrian but points out that it is only known to intrude the Timiskaming and to be intruded by diabase of Late Precambrian age. Gussow (1937, p. 160) states that a dike of the porphyry intrudes albite granite in Beauchastel township. This observation may signify either that the albite granite to the north is older than the hornblende granite near Renard lake or that the syenite to the north is unrelated to the syenite of the present area. The writer agrees with James

(1924) that the syenite is a member of the granitic group of rocks. It provided a host for the development of the microcline megacrysts that resulted from potash metasomatism after it was emplaced.

Hornblende Syenite

Hornblende syenite forms a major mass between Simard and Quinze lakes as well as a few smaller bodies farther south. It tends to outcrop in elongated masses that characteristically form lofty lenticular ridges. Bryson island in Simard lake, elongated north-northeast, is typical. The syenite is associated with hornblende granite and amphibolite, into which it grades in places, and also with biotite granite, oligoclase-microcline granite, and paragneisses. It contains numerous basic inclusions and dark schlieren (Plate II-A) which appear to be related to the andesite and biotite schist. Near Klock (Blanchard) bay, in Simard lake, inclusions of relatively fresh andesite (Plate IV-A) are common and some are about 20 feet in diameter. The thin band of paragneiss and metavolcanics, just south of Klock bay, trends longitudinally along the syenite into which it vanishes to the west. No pegmatite dikes and little granitic material cut the syenite.

The hornblende syenite is commonly massive but locally gneissic, fine to medium grained, pink, and light gray to white weathering. The gneissic structure is defined by parallel platy minerals and by a faint compositional layering. The parallel arrangement of hornblende laths outlines a strongly apparent, ubiquitous lineation. The texture varies from allotriomorphic-granular to hypidiomorphic-granular, and is porphyritic in places.

The rock is composed principally of hornblende, plagioclase and microcline, with minor amounts of quartz and, in some instances, pyroxene. Secondary minerals are albite, quartz, biotite, chlorite and epidote, and accessory minerals are sphene, apatite, pyrite, iron oxide, zircon and allanite. Hornblende occurs as euhedral laths slightly bigger than most of the other components. Most of it has the following optical properties: $Z \wedge c = 14^\circ$, $2V = 57^\circ$,

$Nx = 1.642 \pm 0.002$ Absorption formula: X = pale yellow-green
Y = dark green
$Nz = 1.654 \pm 0.002$ Z = light blue-green

Hornblende with different optical properties was seen in a few thin-sections. This other type has: $2V = 64^\circ$, $Z \wedge c = 28^\circ$, X = pale green, Y = dark green, Z = medium brownish green. Fibrous, colorless tremolite is typical of the more altered rock; lamellar twinning was observed in a few samples. Hornblende alters to epidote, to epidote and chlorite, or to biotite which it encloses poikilitically.

Plagioclase (An_{18-22}) makes up to 60% of the rock and secondary albite is common. Plagioclase occurs as coarse, rounded or euhedral grains displaying a finely spaced albite twinning and,in rare instances, chessboard structure. In places, where there is evidence of deformation of the rock, the extinction of the plagioclase is undulatory and poorly defined. In some thin-sections, light-colored albitic rims fringe the plagioclase where it is in contact with microcline and, rarely, there are myrmekitic intergrowths of quartz and plagioclase at such contacts. The plagioclase is commonly altered to sericite or paragonite and epidote along poorly defined zones or at the cores of the grains, and blebs of microcline are present in many grains, especially along the cleavages.

Microcline, the only potassic feldspar of this rock, occurs as interstitial anhedral grains or as large euhedral crystals. The quantity of microcline averages 25%, but ranges between 5% and 40%. It is usually relatively unaltered in comparison with the plagioclase. Microcline was the latest mineral to form in the syenite, as it is interstitial, replaces plagioclase and contains inclusions of plagioclase, biotite, hornblende and epidote. In some cases, however, plagioclase seems to replace microcline. The porphyritic syenite contains rectangular megacrysts of microcline and perthitic microcline. The perthite of the string and patch type, is rare and probably resulted from the replacement of plagioclase by microcline.

Quartz is a minor component of most thin-sections and is primary, especially in the more granitic facies of the rock, but may be secondary elsewhere. Pyroxene (augite) is rare and occurs as large anhedral grains replaced almost entirely by hornblende. Epidote is a secondary mineral after hornblende and also a constituent of numerous small veins and brecciated zones.

Classification of the rocks from the modal analyses (Table 8), according to the method described by Jung and Brousse (1959), yields mainly subalkaline syenites but also monzonites, granodiorites, diorites, and syenodiorites. This is because An_{20} is used in this system as a demarcation line between alkaline and calcic plagioclase. The chemical analyses (Table 9) show the remarkable variability of K_2O, but otherwise the composition of the rock is that of an ordinary syenite.

Structure: The lineation (linear parallelism of hornblende) trends northwest and, in places, north. It plunges at 20°-40°, very much like the lineation on the bedding planes of paragneiss and metavolcanic rocks south of Klock bay. The gneissic structure generally trends east to the south and northeast to the north. These trends may represent the trends of rocks intruded by the syenite, but are more likely the results of regional stresses accompanying the intrusion. Thus, they could represent circumferential stretching of the walls of the intrusive mass.

Table 8

Modal Analyses of Hornblende Syenite	1	2	3	4	5	6	7	8	9
Plagioclase	52.84	42.34	56.96	48.81	56.72	52.69	29.51	59.08	26.26
Microcline	25.43	32.59	14.90	2.91	17.82	26.94	36.49	15.60	25.36
Hornblende	11.82	22.73	25.96	44.21	15.13	10.61	28.66	22.71	29.09
Quartz	8.35	-	tr.	tr.	9.49	1.20	tr.	1.71	5.23
Epidote	tr.	tr.	1.08	1.66	tr.	3.19	3.84	tr.	12.68
Chlorite	-	-	tr.	tr.	-	4.67	tr.	-	tr.
Sphene + Apatite	tr.	tr.	tr.	1.60	tr.	tr.	1.00	tr.	1.10
Magnetite	tr.	tr.	-	-	-	tr.	-	-	tr.
Biotite	-	-	-	tr.	tr.	-	-	-	tr.

Samples 1-2-3-4- are from near Brodeur lake. Plagioclase is: 1 - An_{20}, 2 - An_{22} and An_2, 3 - An_{16}, 4 - An_{13}

Samples 5-7-8- are from near Simard lake. Plagioclase is: 5 - An_{15}, 7 - An_{17}, 8 - An_{10}.

Sample 6- is from near Bleu lake. Plagioclase = An_{17}.

Sample 9- is from near Rond lake. Plagioclase = An_5.

Table 9

Chemical Analyses* of Hornblende Syenite	1	2	3	4	5	6
SiO_2	64.14	60.70	59.58	56.46	64.94	61.76
Al_2O_3	15.46	14.53	15.72	12.02	15.79	15.41
Fe_2O_3	0.98	1.98	1.49	2.40	0.83	1.22
FeO	1.51	2.87	2.95	4.79	1.77	2.60
MgO	2.17	3.90	4.59	7.46	2.76	4.06
CaO	3.90	3.06	5.41	6.99	3.70	4.14
Na_2O	5.08	5.28	5.76	5.29	5.79	6.36
K_2O	4.12	4.99	2.43	0.67	2.91	2.55
H_2O	0.32	0.53	0.65	1.04	0.37	0.54
Total	97.68	97.84	98.58	97.12	98.86	98.64

* Analyses obtained from the modal analyses of Table 8. Chemical analyses 1-2-3-4-5-6- correspond respectively to modal analyses 1-2-3-4-5-8- of Table 8.

Many small faults and microfaults are present, and brecciated zones filled with granular plagioclase, microcline, quartz and epidote are numerous but inconspicuous. Evidance of strain is common in thin-sections. Undulatory extinction of, and chess-board structures in, plagioclase are accompanied by much secondary quartz and albite.

The hornblende syenite is believed to represent a magmatic or partly metasomatic rock, such as the oligoclase-microcline granite, modified by the massive assimilation of basic rocks. The many dark, basic schlieren in the syenite, and its proximity to the volcanics to the east, are strongly indicative of the origin. To the north, where the rock is more granitic, the origin is not manifest, but the assimilated material appears to be related to the amphibolite and biotite schist of the Pontiac Group.

Henderson (1936, p. 19) considered basic border phases of granitic rocks in the Ville-Marie and Guillet (Mud) Lake map-areas to have developed by the assimilation of greenstones.

Potassic metasomatism is believed to have transformed the syenite at a late stage of its formation.

Plagioclase-hornblende Gneiss

The plagioclase-hornblende gneiss includes various rocks of similar composition, texture and structure, but of different association and mode of occurrence, hence possibly of different origin. Terms, such as diorite, amphibolite, granodiorite and hornblende granite could be used to designate individual types.

The rock is found in the southeastern quarter of the area, around the southern end of Quinze lake and northeastward to a point between Simard and Roger lakes. Much of it is in lenses in the biotite schist and is associated with amphibole-rich fractions of the schist, but much occurs as elongated bodies in hornblende syenite, quartz-feldspar gneiss, or oligoclase-microcline granite. The apparent isolation of the masses may be an effect of scarcity of outcrops. The gneissosity appears to be concordant with the structural trends of the adjoining formations. Lenticular inclusions of dark, dominantly ferromagnesian, basic rocks are characteristic.

The plagioclase-hornblende gneiss is medium to coarse grained, light pink to gray, and granoblastic (in thin-section, much of the rock is hypidiomorphic-granular). The gneissic structure is well developed and is outlined by the parallel alignment and segregation into layers of the mafic components. This structure is not apparent in thin-sections of the coarse-grained rock.

The gneiss is composed primarily of hornblende and plagioclase, with subordinate amounts of microcline, quartz, biotite, epidote and chlorite. Accessory apatite, sphene and zircon are local. Pleochroic, deep green to light blue-green or pale yellow-green hornblende in euhedral crystals constitutes 10-40% of the rock. The optical properties of the hornblende vary from thin-section to thin-section, reflecting a variety of origins. The extinction angle $Z \wedge c$ ranges from 21° to 30° and the optic angle 2V is usually 70°-80°. Lamellar and contact twins are common. The hornblende generally alters to biotite, which it may enclose poikilitically; in highly altered phases it goes to chlorite and pale yellow epidote. Plagioclase in large subhedral to euhedral crystals makes up to 70% of the rock, the average being 45%. The composition ranges from An_{17} to An_{22}, depending on the rock it is associated with, and in one case is An_8. The plagioclase is commonly highly altered, so much so in places that very little is left. Sericite or paragonite and epidote are the usual alteration products but quartz and albite may result as well. Sericitization occurs at the core or along the grain boundaries and tends to attack selectively certain twin lamellae. In numerous thin-sections, the twin lamellae are bent slightly and have undulatory extinction. Sodic plagioclase occurs as thin, clear rims on plagioclase grains, this feature being best observed where plagioclase is in contact with potassic feldspar. Myrmekitic intergrowths of quartz and plagioclase are rare. Microcline is rare, but whereever it occurs it generally is abundant and may make up to 30% of the rock. It was seen in gneiss associated with oligoclase-microcline granite and hornblende syenite. The microcline replaces and penetrates plagioclase. String perthite with inclusions of hornblende, plagioclase, biotite and apatite was seen in one thin-section. Quartz is rare and occurs as anhedral interstitial grains or as a secondary product.

A few thin-sections carried microfaults, or microbrecciated zones filled with chlorite and epidote or granular fragments of quartz, albite, microcline and sphene.

The plagioclase-hornblende gneiss is believed to have been derived from the assimilation of basic rocks by granitic material. In most instances, granite occurs near the gneiss. In the biotite schist of the Pontiac Group, lit-par-lit injections of oligoclase-microcline granite are common, and there the gneiss may represent intruded and transformed amphibolites. Locally, metasomatism may have been an efficient agent in the transformation of the gneiss.

Metamorphism of argillaceous or calcareous rocks may also produce plagioclase-hornblende gneisses, but in the present area there is little indication that the gneiss is a derivative of such rocks.

Hornblende Granite - Porphyritic Hornblende Granite

Porphyritic and even-grained hornblende granites are widespread in the area but are particularly concentrated in the central part. Many lenses too small to be shown on the accompanying map also occur. The hornblende granites from the various localities share many common characteristics but differ markedly in some features. Their differences and their discontinuous distribution suggest diverse origins.

Petrography - The hornblende granite is generally whitish to pink, dark gray weathering, and medium to coarse grained. The porphyritic variety is the more abundant, occurring everywhere except in the granite southeast of Angliers, and constitutes approximately 60% of all the hornblende granite exposed. Granite with a normal hypidiomorphic-granular texture may adjoin the porphyritic type or may be excluded entirely, as near Opasatica lake. The rock is usually massive but, locally, a gneissic structure is defined by parallel mafic components or by the segregation of ferromagnesian minerals into layers or bands. Gneissic granite is dominant southeast of Angliers.

The hornblende granite is composed principally of hornblende, plagioclase, microcline and quartz. Secondary minerals are chlorite, epidote and biotite. Accessory apatite, sphene, zircon, magnetite, and monazite are present here and there. Hornblende is present in all the thin-sections, as euhedral grains with prismatic edges or as elongated crystals. It may be corroded and altered to greenish brown biotite and pale yellow to colorless epidote, and it contains numerous poikilitic inclusions of biotite, sphene and apatite. The absorption formula of the hornblende most commonly observed is: X = light bluish green, Y = dark yellowish green, Z = dark green. Twinning parallel to 100 was observed in several thin-sections. Southeast of Angliers and south of Solitaire bay, the hornblende has the following absorption formula: X = deep blue-green, Y = pale yellowish green, Z = dark green. The optic angle 2V is approximately 70°, and the extinction angle $Z \wedge c$ is 20°. This hornblende appears to be an alteration product of pyroxene, remnants of which are visible amongst the hornblende. The chemical composition and the optical properties of hornblende from the porphyritic granite in the central part of the area are those of common hornblende.

Plagioclase feldspar is the most abundant mineral except in the highly porphyritic portions where microcline may be dominant. The composition of the plagioclase is commonly about An_{20}, but varies locally between An_{15-26}, with minor exceptions such as near Rémigny area where An_{5-7} was found. Much of the plagioclase appears to be more calcic at the center than at the margin, and a clear sodic rim is common at the contact of plagioclase and microcline. The average size of the grains is 2 mm., but some are 10 mm. In many thin-sections, the plagioclase tends to form large rectangular crystals, much bigger than the other components and usually subparallel. The plagioclase is altered to a mixture of sericite or paragonite and epidote in varying degrees and fashions. Generally the alteration products are concentrated at the core of the grains or along the borders, but in many instances they are evenly distributed throughout the plagioclase. Here and there, sericite occurs along definite concentric zones, imitating oscillatory zoning, or it occurs along specific twin lamellae. Oscillatory zoning as such was not observed but is presumed to be represented by the zoned alteration. Chess-board structures were seen in a thin-section of gneissic hornblende granite from southeast of Angliers.

Although no true zoning, in which calcic and sodic zones alternate, was seen, the concentric zones of alteration reflect variations in stability of the primary components and hence variations in composition. This zoning was seen only in those parts of the granite that contain large, elongated plagioclase crystals, and even in individual thin-sections some grains may display it and others may not.

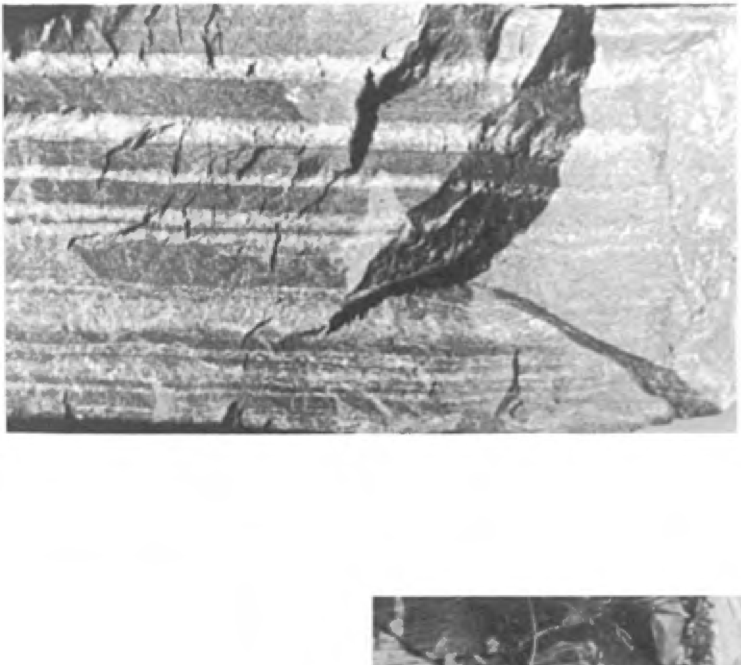
Microcline, the only potassic feldspar of the granite, is an important component of the rock, but has an erratic distribution that does not appear to follow a traceable pattern. In places, microcline makes up 35% of the rock, whereas it may constitute only 2% elsewhere. It is most abundant in the porphyritic variety. (In Table 10, samples 8 and 11 are from porphyritic granites and yet do not reveal much microcline; the reason is megacrysts were avoided in the preparation of the thin-sections in order to obtain representative samples of the groundmass.) The microcline occurs as interstitial grains or as replacement patches in plagioclase as well as in megacrysts. It is twinned, cross-hatched, and, rarely, perthitic, with string-, bead-, and patch-shaped fractions of plagioclase. Most of the perthites result from replacement of plagioclase by microcline. Microcline is essentially unaltered in comparison with the plagioclase and this, coupled with other features, suggests that it is the latest mineral to have formed in the rock. The refractive indices of microcline from the vicinity of Brodeur lake are: $N_x = 1.518 \pm 0.002$, $N_z = 1.525 \pm 0.002$.

Quartz is present as interstitial grains or as veinlets, blebs and vermicular intergrowths in the plagioclase. Much of it, especially if in coarse grains, contains inclusions of plagioclase and apatite. It is generally abundant, but may be absent in the mafic-rich facies of the rock. Pale green to dark brownish green biotite, resulting from the transformation of hornblende, is common in small amounts; rarely, primary olive-green biotite may constitute as much as 20% of the rock. Shredded remnants of pyroxene were observed in a few thin-sections from south of Solitaire bay and northeast of Angliers.

Modal analyses (Table 10) demonstrate the variability of the mineralogical composition of the granites, even within a restricted area. The five chemical analyses of hornblende granite in Table 11 were

A- Tuff and agglomerate layers over pillowed andesite. Island on Baby lake.

PLATE I

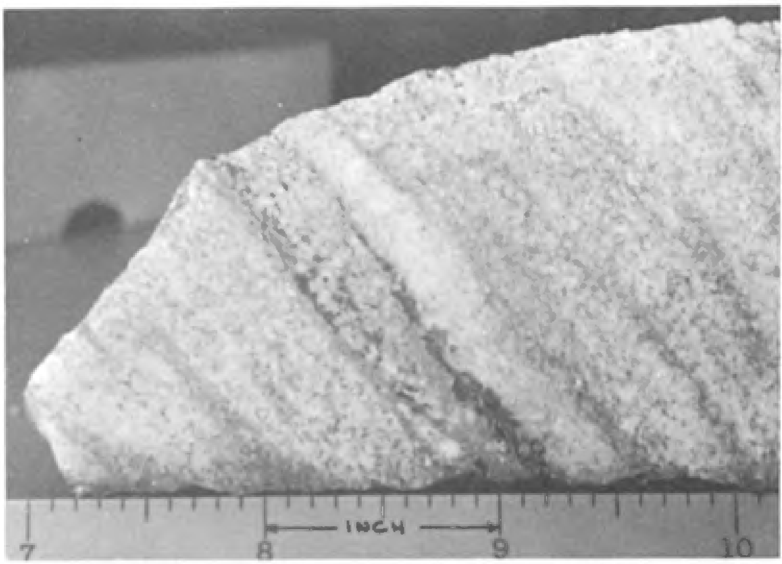


B- Iron-formation, northern type. Magnetite makes up approximately 30% of the rock.

C- Contorted, faulted and slightly brecciated iron-formation, northern type.

A- Fractured and partly assimilated inclusions of amphibolite in hornblende syenite, northeast of Brodeur lake.

PLATE II

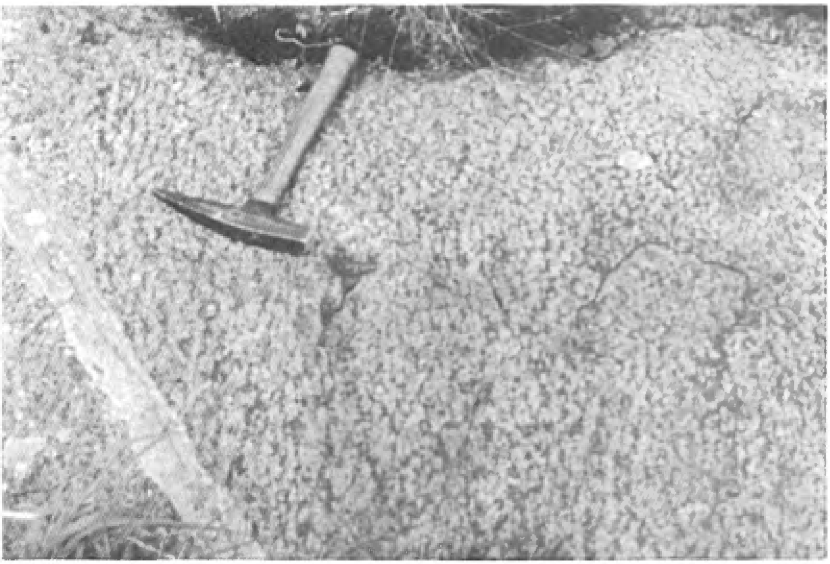


B- Quartz-feldspar gneiss.

C- Drag-folds in biotite schist. The dark layer is rich in amphibole.

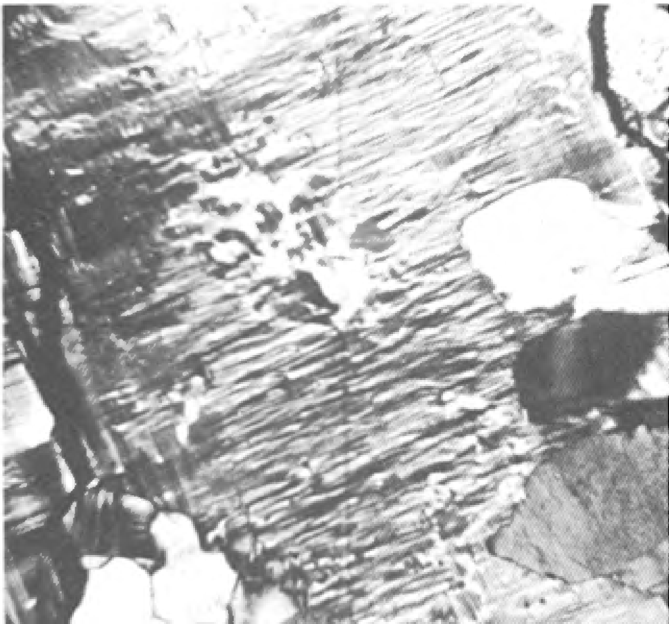
A- Boudinage. Angular blocks of amphibolite fractured by shear planes.

PLATE III



B- Nodular pyroxene syenite. The density of the nodular texture is very high here. West shore of Barrière lake.

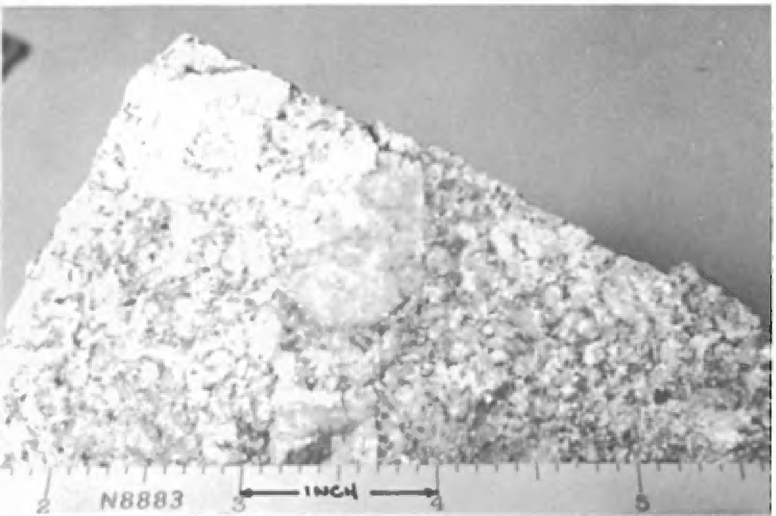
C- Patch and film perthite in a microcline megacryst in hornblende-pyroxene syenite. (Crossed nicols x80).



A- Large angular inclusions of volcanic rocks in hornblende syenite. Klock (Blanchard) bay.

PLATE IV

B- Hornblende and plagioclase inclusions in microcline megacryst. Note the microcline patches and the light rim of the plagioclase. (Crossed nicols x80)



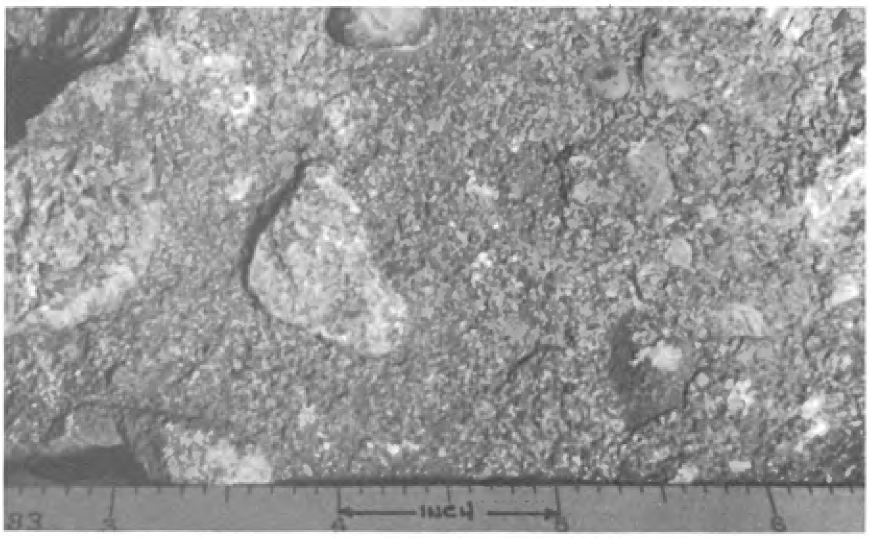
C- Microcline megacrysts in hornblende granite. South of Solitaire bay.

PLATE V

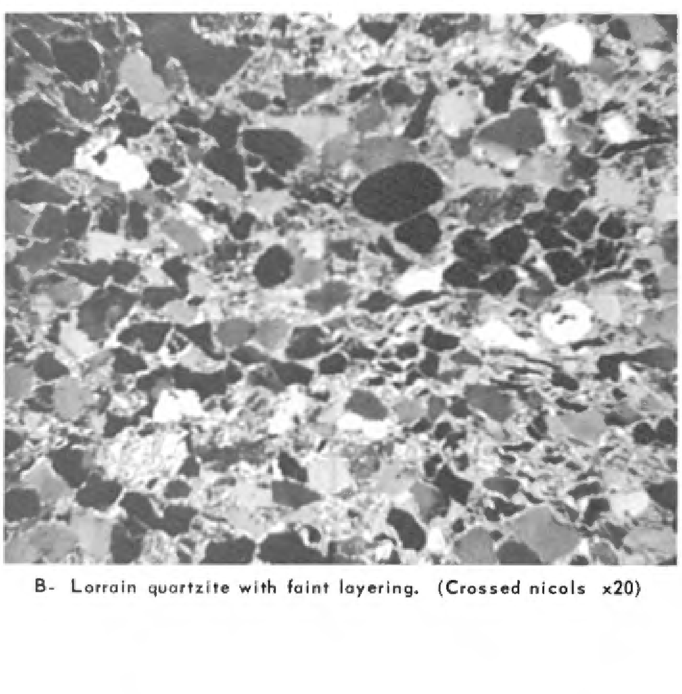
A- Hornblende granite cut by dikes of pegmatite and oligoclase-microcline granite. (Brodeur Lake area)

B- Pegmatite nearly parallel to the foliation of biotite schist. Quartz pod in the lower part of the photograph.

PLATE VI

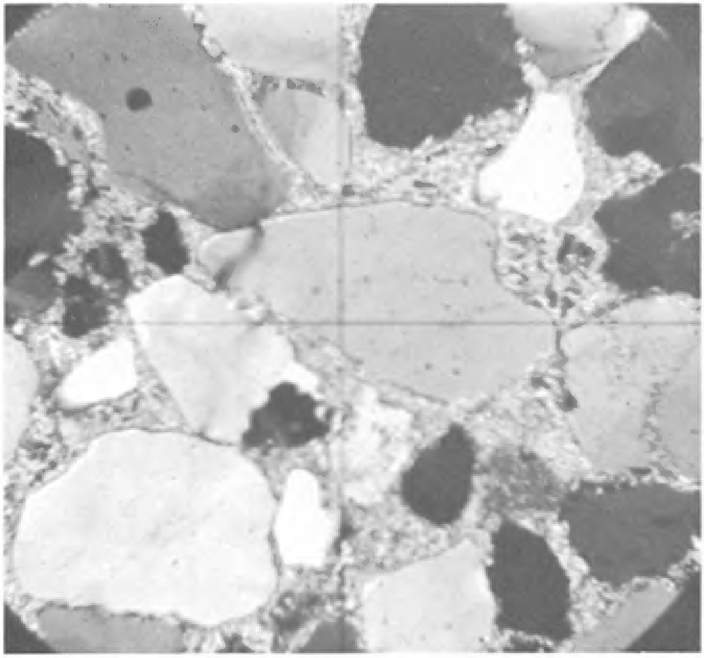


A- Cobalt conglomerate. Assorted size and shape of pebbles are typical.

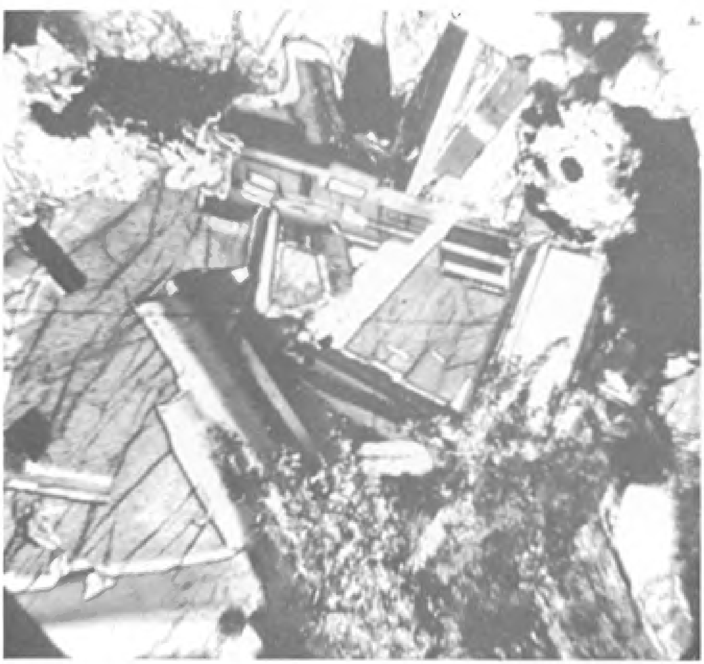


B- Lorrain quartzite with faint layering. (Crossed nicols x20)

PLATE VII



A- Lorrain quartzite. Large amount of sericite in the groundmass. (Crossed nicols x80)



B- Diabase. Plagioclase laths in pyroxene. (Crossed nicols x80)

PLATE VIII

A- Boulders of Lorrain quartzite at the base of the Liskeard Formation. Témiscamingue lake.

B- Blocks of volcanic rocks enveloped by quartz-feldspar gneiss. Orientation of blocks is parallel to gneissic structure, but structural features within blocks have a different orientation. (Prévu Lake – southeast of Angliers)

Table 10

Modal Analyses of Hornblende Granite

	1	2	3	4	5	6	7	8	9	10	11	12	13
Quartz	20.26	11.72	5.82	8.00	14.66	3.31	9.54	14.77	17.41	10.72	tr.	21.88	7.39
Plagioclase	41.50	44.96	46.26	57.46	51.73	50.36	47.69	57.69	47.71	49.36	41.01	55.83	43.70
Microcline	18.14	17.66	33.42	2.92	17.35	15.61	3.95	1.31	17.92	16.78	17.65	11.74	18.47
Hornblende	14.07	10.26	12.00	17.39	10.53	17.99	15.86	12.59	12.12	10.96	28.99	6.96	24.56
Pyroxene	-	-	1.10	-	-	-	-	-	-	-	-	-	-
Biotite	-	-	-	8.23	4.55	12.44	18.29	13.21	3.48	11.01	-	-	5.35
Magnetite	-	-	tr.	tr.	-	-	tr.	-	-	tr.	tr.	tr.	-
Epidote	2.80	6.33	tr.	3.85	tr.	tr.	3.82	tr.	tr.	tr.	1.00	tr.	tr.
Chlorite	2.76	8.80	tr.	tr.	tr.	tr.	tr.	-	tr.	tr.	9.80	2.84	-
Apatite + sphene	tr.	tr.	tr.	tr.	tr.	tr.	tr.	tr.	tr.	tr.	1.30	tr.	tr.
Plagioclase	An_7	An_5	An_7	An_{26}	An_{17}	An_{23}	An_{22}	An_{18}	An_{17}	An_{10}	An_{15}	An_{22}	An_{15}

Samples 8 and 11 are porphyritic.--- Samples 1 to 8 are from the central part of the area. Sample 9 is from north of Témiscamingue lake. Sample 10 is from north of Quinze river. Sample 11 is from near Brodeur lake. Sample 12 is from southeast of Angliers. Sample 13 is from south of Fraser lake.

computed from five modal analyses, and illustrate the variations in K_2O and Na_2O and the relative constancy of the sum of these two components.

Microcline Megacrysts (Porphyroblasts). Idioblastic microcline, 1/4-1 inch long, forms euhedral rectangular grains and, exceptionally (as south of Solitaire bay), roughly hexagonal grains. The porphyroblasts contain inclusions of quartz, plagioclase, hornblende, biotite, apatite and, in places, epidote (Plate IV-B). The included plagioclase is generally smaller than that of the groundmass and invariably has sodic borders. The inclusions appear to preserve the texture of the groundmass, as if the replacing microcline had enveloped them. Some of the microcline is perthitic, with strings and patches of plagioclase. The porphyritic granite is cut by dikes of oligoclase-microcline granite and pegmatite; megacrysts infringe here and there on the dikes and, in some cases, are almost completely enclosed in them.

Table 11

Chemical Analyses of Hornblende Granite

	1*	3*	5*	9*	12*
SiO_2	67.19	64.20	65.36	65.78	68.13
Al_2O_3	14.00	16.41	15.96	15.99	16.02
Fe_2O_3	1.22	0.91	0.76	0.85	0.49
FeO	2.41	1.71	2.61	2.07	1.50
MgO	2.80	2.07	1.82	2.10	1.74
CaO	3.19	2.74	3.14	3.50	3.36
Na_2O	4.53	5.11	5.05	4.82	5.13
K_2O	2.95	5.41	3.27	3.32	1.93
H_2O	0.88	0.44	0.43	0.40	0.60
Total	99.17	99.00	98.40	98.83	98.90

* Corresponds to the number of the modal analysis (Table 10) from which it is derived.

The granite south of Solitaire bay contains quartz and hornblende in equal amounts (15%) and roughly 30% each of microcline and plagioclase (An_{15}), both displaying replacing relationships, with remnants of pyroxene and hornblende. Epidote and biotite are secondary minerals, and sphene, apatite and zircon are accessory. The hexagonal microcline megacrysts (Plate IV-C) enclose small euhedral grains of hornblende, sphene, apatite, plagioclase, epidote and anhedral quartz, disposed in zones parallel to the borders of the microcline. Megascopic features of the megacrysts are their hexagonal shape (a peculiarity in this area of the hornblende granite), their large numbers, the concentric distribution of inclusions, and alternating dark and light layers. A thin-section through part of one megacryst, and therefore not necessarily representative, revealed the following sequence:-1- The contact zone between megacryst and groundmass is a fine-grained, granular mixture of quartz, plagioclase, microcline and hornblende. There are myrmekitic intergrowths and sodic rims on the plagioclase. This zone is thin and is in sharp contrast with the coarser groundmass, where large elongated crystals of oligoclase and coarse interstitial quartz and fine anhedral interstitial microcline occur. 2- The marginal area of the microcline contains small elongated inclusions of quartz and hornblende disposed parallel to the edge of the megacryst but away from it. Small islands of plagioclase occur inside this line of quartz and hornblende, towards the core, and give the microcline the appearance of a patch perthite; they increase in size and number toward the center. These inclusions are not optically continuous. Surprisingly, there are rounded inclusions of microcline in the microcline megacrysts; these are discernible because of their different optical orientation. 3- A thin zone similar to 1- but consisting mostly of granular microcline with minor amounts of quartz, plagioclase and hornblende. 4- A single grain of microcline with islands of plagioclase as in 2-, but without quartz. Here the microcline is not in optical continuity with the microcline of 2- and 3-, thus giving the impression that 2- is a growth ring around 4-.

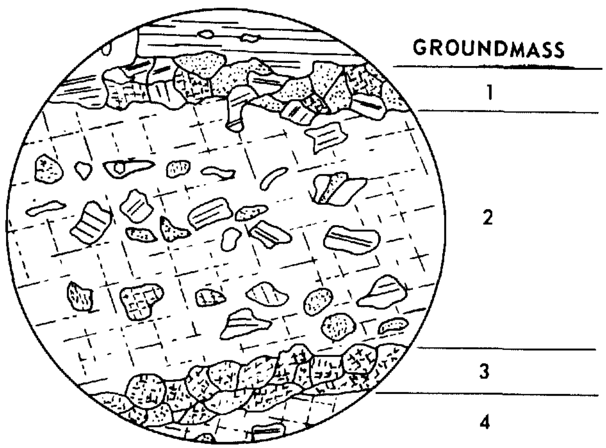


Figure 2

SECTION THROUGH A MEGACRYST OF MICROCLINE (X16). THE SKETCH SHOWS ONLY A SMALL PORTION OF THE PORPHYROBLAST. THE ZONES ARE OUTLINED.

From these observations of the microcline porphyroblasts the following can be concluded.- The inclusions, although zonally arranged, are not optically arranged relative to the megacryst and therefore predate the microcline. The inclusions (especially those of plagioclase, hornblende and epidote) are smaller than equivalent minerals in the groundmass; this may indicate either corrosion or the inhibiting influence of microcline on the growth of these minerals once they were included. The microcline is later than the other components of the rock and is at least contemporaneous with, if not younger than, the oligoclase-microcline granite and the pegmatitic material which intrudes the hornblende granite. The optically different core of the porphyroblasts may record changes in the rate of growth and even periods of inactivity of the metasomatic processes.

Origin of the Porphyroblasts- Porphyroblasts are common in granitic rocks. The consensus of opinion as regards their formation favors metasomatic or solid diffusion processes. Perrin and Roubault (1949) elaborated a theory of solid diffusion which explains readily various puzzling features of the megacrysts, such as inclusions, lack of deformation about and around them, and their large size. In the present case, however, it would not account for the interstitial nature and the replacing relationships of the microcline. Schermerhorn (1956), discussing the microclinization of the granites of Trancoso, described porphyroblastic developments of microcline and ascribed their origin to the metasomatic action of solutions acting in a fluid environment. A similar mode of origin is favored here because it best explains the interstitial nature of the microcline and the corrosion features of the plagioclase such as myrmekites and isolated quartz blebs. Drescher-Kaden (1948) suggests that such corrosion features are proof of intergranular diffusion and we believe that they may also be proof of the action of solutions. We cannot, however, discard the possibility of the non-coeval formation of the interstitial microcline and of the megacrysts. The probability that primary microcline existed in the rock is suggested by "inclusions" of microcline in the megacrysts. The erratic orientation and random distribution of the inclusions create the impression that they have been enveloped in the growing porphyroblast.

The hexagonal porphyroblasts of the Solitaire Bay occurrence and their zonally distributed inclusions are a special case which may be explained either by a slow rate of growth or by rapid growth in very mobile solutions. The border zone is composed of granular quartz, microcline, plagioclase and hornblende, which indicate that there is a breakdown of the groundmass before it is enveloped. This breakdown may concentrate along the borders some components which are disposed zonally once they are engulfed in the growing porphyroblast. A slow rate of growth will allow the components to attain equilibrium with the diffusing elements and the concentration of those portions that are not in equilibrium. A rapid rate of growth would not tend to dispose the inclusions zonally unless it was in a very mobile environment. The primary nature of the inclusions and the shape of the megacrysts are in agreement with this last hypothesis and support it.

The porphyroblasts in general are believed to be the result of metasomatism or metamorphic differentiation.

Age Relations and Correlation of the Hornblende Granite.- The hornblende granite contains elongated inclusions and, in places, large lenses of Pontiac Group amphibolite and biotite schist. Near Brodeur lake the granite is mixed and associated with hornblende syenite into which it appears to grade. Southeast of Quinze lake, the granite contains inclusions of volcanics and has a wide contact zone with andesite to the west. These observations indicate that the hornblende granite is younger than the volcanics to the south and the Pontiac Group to the north, but is contemporaneous with the hornblende syenite near Brodeur lake.

In the central part of the area, abundant dikes and veins of oligoclase-microcline granite and pegmatite cut the hornblende granite, but, in places,the two rocks seem to grade into each other. Thus, the hornblende granite here is older than, or an earlier phase of, the oligoclase-microcline granite. The hornblende granite near Témiscamingue lake is younger than the volcanics which it intrudes, but is not in contact with any other rocks. However, pre-Huronian granites similar to the hornblende granite have been described by Henderson (1936) along the east shore of Témiscamingue lake, just south of the present area.

Gray Granite Gneiss

Gray granite gneiss, intimately mixed with oligoclase-microcline granite and Pontiac Group quartz-feldspar-biotite schist, outcrops toward the northwest corner of the area along and near Opasatica lake. The largest mass, north of Solitaire bay, trends north and dips gently to the east. Lenses near the western shore of Opasatica lake outline an antiform structure trending northwest.

Lenticular inclusions of biotite schist and quartz-feldspar-hornblende schist are common and many are gradational with the gneiss. Oligoclase-microcline granite cuts the gneiss in places but gradually passes into it elsewhere and lit-par-lit veins of granitic material are characteristic.

The granite gneiss is medium grained, pale to dark gray on fresh and weathered surfaces, with pinkish lenticular zones here and there. Dark, mafic-rich layers, 1/32-1/16 inch thick, are interspersed with dominantly quartzose of feldspathic layers 1/4-1/2 inch thick. Contacts from layer to layer usually appear to be gradational. The gneissic structure is defined megascopically by compositional layering, and microscopically by the subparallel alignment of mafic minerals and the elongation of quartz grains.

The gneiss is composed principally of plagioclase and quartz. The accessory minerals are microcline, biotite, muscovite, epidote, chlorite, sphene, apatite, garnet, and iron oxide. Oligoclase (An_{22}) in coarse, subangular grains makes up to 75% of the rock. It is relatively fresh, sericitization being present mostly along grain boundaries. Twinning is rare and indistinct, the twinned grains being cloudy and the lamellae faint. Flattened lenses of quartz occur along definite layers in thin but long grains that show undulatory or strain extinction. Small blebs of quartz are common in plagioclase and microcline as secondary features.

Microcline is rare and usually fine and interstitial. It displays replacement relationships with the plagioclase, accompanied by sodic rimming of plagioclase and myrmekitic structures. The relations are not definite but the microcline appears to replace plagioclase. Olive-green to brownish green biotite is minor but typical. It commonly has a "diseased" appearance and is transformed to colorless or pale yellow epidote and chlorite. Tattered crystals of muscovite usually occur with the biotite and epidote. Small pale reddish garnets are relatively rare.

Table 12

Modal Analyses of Gray Granite Gneiss

	I	2	3	4
Quartz	22.40	24.29	27.77	30.00
Plagioclase	72.58	70.48	64.54	65.00
Microcline	tr.	3.19	2.92	-
Biotite	2.69	1.00	3.60	4.00
Chlorite	tr.	tr.	-	-
Muscovite	1.43	tr.	-	tr.
Epidote	tr.	tr.	tr.	tr.
Sphene + Apatite	tr.	tr.	tr.	tr.
Iron Oxide	tr.	tr.	-	-
Plagioclase	An_{22}	An_{16}	An_{16}	An_{21}

1 and 2 are from north of Solitaire bay.

3- quartz-feldspar gneiss from the north end of Gaboury lake; Pontiac Group.

4- gray granite gneiss, from the Kipawa Lake area (Robert, 1963, p. 102).

The gray granite gneiss is related mineralogically to the oligoclase-microcline granite and to the biotite schist, and it probably represents a mixture of the two rocks. It is very similar in composition and appearance to the quartz-feldspar gneiss of the Pontiac Group (sample 3, Table 12), which may also represent a granitized portion of the biotite schist. Robert (1963) described a similar rock (Table 12, sample 4) and concluded that it was an anatexite. The chemical analyses of gray granite gneiss (Table 13) have many similarities with those of the oligoclase-microcline granite, excluding the K_2O content, and afford additional evidence regarding the origin of the rock.

Table 13

Chemical Analyses of Gray Granite Gneiss

	1	2
SiO_2	72.31	70.00
Al_2O_3	16.27	17.97
Fe_2O_3	0.02	0.07
FeO	0.28	0.76
MgO	0.03	0.08
CaO	2.12	3.19
Na_2O	7.05	6.64
K_2O	0.62	0.51
H_2O	0.02	0.11
Total	98.72	99.33

Obtained from the modal analyses of Table 12. Chemical analyses 1 and 2 correspond respectively to modal analyses 2 and 1.

The mineralogy of the granite gneiss is typical of the staurolite-quartz subfacies of the almandine-amphibolite facies of regional metamorphism which includes rocks that "commonly grade into migmatites veined with granitic materials,..." (Fyfe et al., 1958, p. 228).

To summarize, we believe that the gray granite gneiss, because of its mineralogical composition, chemical composition and field associations, represents members of the Pontiac Group partly assimilated by, and intermixed with, the oligoclase-microcline granite. It has not been subjected to the intense potassic metasomatism that affected most of the granitic rocks of the area.

Biotite Granite

An arcuate band of biotite granite, 7 miles long and up to 2 miles wide, extends from Quinze lake to southeast of Brodeur lake, with a general northeast to east trend. Similar rocks on the west shore of Quinze lake and south and southeast of the main zone are too small to be mapped separately. The biotite granite is associated to the north and southwest with hornblende syenite, and to the south with gneissic oligoclase-microcline granite into which it grades. Conversely, small lenses of oligoclase-microcline granite occur in the biotite granite. The latter is cut by relatively few pegmatite and diabase dikes.

The biotite granite is light to medium gray, dark gray weathering, medium to coarse grained, and partly gneissic. Plagioclase is in stout euhedral or subangular grains so much bigger in places than the other components that the rock could be classed as porphyritic. Quartz is in grains smaller than plagioclase but generally larger than mafic minerals. In the gneissic portions of the rock, quartz tends to be concentrated along layers. Gneissosity, where present, is outlined by the parallelism of ferromagnesian minerals and their tendency to be segregated into layers, by the subparallel arrangement of the elongated plagioclase grains, and by the concentration of quartz in layers. In thin-sections, gneissic structure may not be evident and the rock may have the hypidiomorphic-granular texture typical of many granites.

The biotite granite is composed (Table 14) essentially of plagioclase and quartz, with minor biotite, chlorite and epidote. Accessory minerals are hornblende, apatite, sphene, microcline, iron oxide, allanite and zircon. Plagioclase (average An_{22}) constitutes approximately 60% of the rock. It is altered to sericite or paragonite and epidote, usually from the core or along the grain boundaries, but in some cases the alteration is distributed evenly throughout the grains. Epidote is commonly in clusters or agglomerations in the plagioclase. The plagioclase commonly is zoned as defined by alternating, concentric, dark and light layers and by the zonal distribution of the alteration products in some crystals. The boundaries between the zones are gradational. Twinning, where present, is usually superimposed on the zoning. One-third to one-half of the plagioclase grains are twinned, although many are cloudy with twinning hardly discernible. Chess-board structures are rare. Small crystals of plagioclase also occur as inclusions in the coarse grains of plagioclase.

Microcline is minor and forms replacement patches in plagioclase or small interstitial grains. It is accompanied by myrmekitic structures and sodic rimming of the plagioclase where the two minerals adjoin each other. Whether the microcline is replaced by plagioclase or represents incipient microclinization of the rock is not apparent. In sample 5 of Table 14 microcline is relatively abundant. This sample comes from a lens of biotite granite in oligoclase-microcline granite, southeast of the main occurrence and is not representative of the biotite granite as a whole. However, it demonstrates the increase of microcline where oligoclase-microcline granite is more common.

Table 14

Modal Analyses of Biotite Granite

	1	2	3	4	5
Quartz	28.42	26.87	26.70	32.79	25.80
Plagioclase	60.24	58.51	63.54	59.48	60.53
Microcline	tr.	tr.	tr.	1.00	7.14
Biotite + Chlorite*	5.63	6.35	8.39	2.57	5.60
Hornblende	1.36	tr.	tr.	tr.	-
Epidote	2.81	6.76	tr.	3.69	1.00
Iron Oxide	tr.	tr.	tr.	tr.	-
Apatite + Sphene	tr.	tr.	tr.	tr.	tr.
Plagioclase	An_{22}	An_{20}	An_{22}	An_{17}	An_{25}

Samples 1 and 2 are from near Brodeur lake.
Sample 3, from 2 miles northeast of Moffet, along the east-west road.
Sample 4, from the southeast shore of Quinze lake.
Sample 5, from the southeast corner of the area, outside of the main area of biotite granite.

* Chlorite makes up very little of the biotite-chlorite association, except in sample 2 where it is dominant.

The biotite granite contains about 27% quartz in fine to medium, interstitial grains. Where quartz is concentrated along layers, as thin long lenses of optically continuous material, it may form grains three times longer than the plagioclase grains. Blebs and vermicules of quartz in plagioclase constitute a minute part of the rock. The quartz commonly has moderate to high undulance but is not granulated.

A little hornblende is present in most thin-sections. It is usually pale to dark green, and has a large optic angle and an extinction angle ($Z \wedge c$) of 22°. It contains poikilitic inclusions of quartz and biotite, and alters to yellow epidote and green biotite. The biotite, although in small amounts, characterizes the granite. It is pale yellowish green to dark brownish green, commonly has a "diseased" appearance, and alters to chlorite and epidote. The epidote is colorless to deep yellow, may be twinned, and much of it carries small, vermicular intergrowths of quartz or feldspar. Clinozoisite is rare. Epidote, hornblende, apatite, sphene, biotite and iron oxide tend to occur in clusters.

The origin of the rock is obscured by much conflicting evidence and is therefore problematical. The zoning of the plagioclase, the mineralogical composition, the porphyritic phases, and the association of the rock with oligoclase-microcline granite are compatible with a magmatic source. The gneissic structure, the undulatory extinction of quartz, the faint twinning and the chess-board pattern of some plagioclase are indicative of deformation. Thus, we may have a granite deformed in the late stages of its emplacement. The relative abundance of epidote as a replacement of hornblende and biotite, as well as of the feldspar, may denote an episode of calcium metasomatism.

On the basis of composition, the biotite granite may also represent a quartz-feldspar gneiss or schist invaded and partly absorbed by oligoclase-microcline granite, with consequent development of plagioclase porphyroblasts, which is typical of the marginal facies of granitic intrusions. This mode of origin is further suggested by the presence of quartz-feldspar gneiss west of the main occurrence of biotite granite. Thus, the granite would represent quartz-feldspar gneiss partly modified and assimilated by the oligoclase-microcline granite.

The mineralogical composition of the rock is characteristic of that of quartzo-feldspathic assemblages of the staurolite-quartz subfacies of the almandine-amphibolite facies of regional metamorphism (Fyfe, Turner and Verhoogen, 1958).

Oligoclase-microcline Granite

This is the most widespread intrusive "type" in the area. It includes diverse rocks of generally acidic composition that could be classed individually as monzonite, quartz monzonite, granodiorite, alkali granite, etc. Thus, the term "granite", as used here, denotes the acidic composition with an excess of silica, and the texture of the rock, but does not convey the usual concept of a dominantly potassic or sodic-potassic rock. Actually the rock is, in parts, a granite in the restricted sense, but it is more commonly granodioritic. Locally and rarely the rock passes gradually to a syenite or a diorite. The potassic feldspar content varies widely and is subordinate to the plagioclase content almost throughout.

The granite can be broadly subdivided into two groups: one microcline-rich and the other oligoclase-rich. However, the passage from one group to another is so imperceptible in the field that it is impossible to map them separately. The oligoclase-rich type appears to be most abundant on the basis of the thin-sections examined, but it seems to pass within short distances to the other type and to be so mingled with it that no traceable pattern was recognized in the distribution of oligoclase and microcline.

The oligoclase-microcline granite underlies more than half the area but constitutes more than two-thirds of the rock, because this granitic material is injected into, or is otherwise mixed with, other rock types in bodies too small to be mapped separately at the present scale. It is associated with lenses of biotite schist, amphibolite, quartz-feldspar gneiss, gray granite gneiss, hornblende granite and plagioclase-hornblende gneiss. Minor, porphyroblastic varieties are distributed erratically. The oligoclase-microcline granite is everywhere accompanied by numerous dikes and irregular masses of pegmatite and aplite. It does not appear to have a strong influence on the topography, except locally by control of the drainage pattern.

Petrography The granite is white or pale gray to pink, and may be fine to coarse grained (the grain size being extremely variable even within a thin-section) but usually is medium grained. It is commonly massive, uniform and homogeneous, with a notable exception in the southeast corner where it is gneissose. Gneissose parts also occur elsewhere, as near contacts with quartz-feldspar-biotite schist, but they constitute no more than 10% of the rock. The gneissic structure is outlined by the sub-parallel alignment of mafic components, the elongation of plagioclase grains, and the compositional layering; it may or may not be evident in thin-sections. The texture varies from allotriomorphic-granular to hypidiomorphic-granular, and is sugary where aplitic. The rock is rarely equigranular, the plagioclase grains being usually larger than the other components, and there are porphyroblastic varieties with megacrysts of microcline up to 1/4 inch long. Most components show little alteration except in rare instances where corrosion is strong.

The rock is composed mainly of the following minerals (Table 15): quartz, microcline, plagioclase, biotite, muscovite, chlorite and epidote. Accessory hornblende, pyroxene, apatite, sphene, zircon, pyrite, magnetite, ilmenite, allanite and monazite are present in some thin-sections.

Quartz: Quartz, constituting 2-35% of the rock, occurs as interstitial grains and as a secondary mineral in corrosion structures, or as large, elongated grains concentrated into layers, especially in the gneissic parts. Large grains may contain rounded inclusions of plagioclase and biotite and may partly envelop coarse grains of plagioclase. Undulatory extinction is common in the quartz in many thin-sections, especially those from gneissic granite. Some highly deformed grains show lines or rows of tiny inclusions (Boehm lamellae). Secondary quartz is formed as a result of corrosion in myrmekitic intergrowths in plagioclase at the contact of potassic feldspar and also as isolated blebs disposed along the borders of plagioclase and microcline grains.

Microcline: Microcline generally constitutes about 20% of the rock, but has a range of 1-40% and may be concentrated in layers. The content varies not only from area to area but also within a single outcrop, and is subordinate to the plagioclase throughout. It occurs as fine interstitial grains, as large porphyroblasts enclosing smaller grains of plagioclase, quartz, microcline, biotite and muscovite, or as rectangular or irregular patches within the plagioclase. In the gneissic parts, it occurs in the groundmass with the quartz and displays little granulation. Exceptionally, it forms large anhedral grains, smaller than the porphyroblasts and about the same size as quartz and plagioclase. Where it occurs as fine interstitial grains it may surround or envelop large grains of quartz and plagioclase and still preserve optical continuity; this represents the initial stages in the development of a porphyroblast, or the permeation of a relatively solid rock. The microcline is fresh, undeformed, and typically cross-hatched.

The porphyroblasts of microcline are rectangular, 1/8-1/4 inch long, and contain inclusions of other minerals. In several instances, rows of round quartz blebs lie along their borders; these suggest corrosion and may be products of the replacement of plagioclase by microcline.

Perthitic microcline occurs in numerous thin-sections as string, bead and patch perthites. String perthites are rare and patch perthites abundant. The variations in the plagioclase content are so wide that some grains are actually antiperthitic. The development of the perthite is the result of the replacement of plagioclase by microcline, such as is suggested by variations in the plagioclase content, by the shapes of the patches, and by the fact that all stages of the replacement can be seen from incipient (with few patches of microcline in plagioclase) to complete (with string perthite).

Plagioclase: This, the principal constituent, makes up 30-90% of the rock, or an average of about 45%. It occurs as large anhedral to subhedral grains in the massive granite and as large subrounded or elongated grains with serrated edges in the gneissic granite. The plagioclase is generally coarser than the other components, excepting the microcline porphyroblasts, and in the gneissic granite it lies in a granulated groundmass of quartz, plagioclase and microcline. Some of the large grains of plagioclase are composite, that is, they are made up of two or more segments of different optical orientation. The composition ranges between An_4 and An_{26}, but it is generally An_{16-17}. These variations do not appear to represent trends and may be owing to the diverse rocks associated with, and assimilated by, the granite.

The plagioclase is commonly altered, usually slightly but, in places, moderately to intensely. The commonest alteration products are sericite, paragonite, and, in the highly altered phases, epidote, zoisite and calcite. In general, the alteration products are at the core or along the grain boundaries; rarely they are in concentric zones. In places, the alteration is uniform and the products form a homogeneous mat throughout the grains; elsewhere, they are along certain twin lamellae, or have their long side parallel to the direction of the twin planes. Evidence of corrosion is found at the contacts of plagioclase and potassic feldspar as quartz blebs, vermicular intergrowth of quartz, and clear sodic rims along the plagioclase grains. In highly corroded specimens these features are present even if there is no interstitial microcline or if the plagioclase is not in contact with potassic feldspar. No relations could be established between the degree and type of alteration (core, rim, zone) and the deformation of the rock.

Zoning of the plagioclase is rare and is outlined by the concentric distribution of sericite and paragonite. In places, it is defined by the alteration of light and dark layers with diffuse boundaries. Twinning is usually superimposed on the zoning.

Twinning of the plagioclase according to the albite and albite-carlsbad law is common but is not characteristic of the rock. Where gneissic, it is either absent or very faint and indistinct, and where massive some grains only are clearly twinned. In some sections, only the finer plagioclase grains are twinned, whereas in others only the larger grains are twinned. Chess-board patterns owing to readjustment of the lamellae to strain are seen in deformed granites, and are usually accompanied by undulance and bending of the crystals.

Biotite: Pale yellowish brown to dark brownish green or dark brown biotite averages 4% of the rock, but it ranges from zero to 22%. It occurs mostly in the center and in the southeast corner of the area and is rare in the north. Rounded quartz inclusions in the biotite were noted here and there. Biotite alters to chlorite and some rutile. The refractive indices of biotite from northeast of Rémigny are: $N_y = N_z = 1.634 \pm 0.002$. Secondary green biotite from the alteration of hornblende is present in small amounts here and there. In the southeast corner of the area, biotite, epidote, magnetite and apatite tend to form small clusters in the rock.

Muscovite: Colorless muscovite constitutes up to 10% of the rock but is generally not abundant. It occurs mostly in the northern granites where it may be the sole mica. In many instances, small secondary (?) flakes are dispersed within plagioclase crystals.

Epidote: Epidote occurs in most thin-sections in very small quantities as colorless to pale yellow and deep yellow, anhedral, commonly twinned grains. Small hair-like or rounded intergrowths of quartz or clear feldspar were seen in a few grains at the contact of epidote and quartz.

Accessory minerals: Light green, dark green, and dark bluish green hornblende occurs in several places, usually near amphibolite and hornblende granite. It is shredded and readily alters to epidote and biotite which it encloses poikilitically. Pyroxene, usually a sodic augite, is present in thin-sections of granite adjoining the hornblende-pyroxene syenite and also from granite unrelated to pyroxene-bearing rocks. It is rare and may be so altered that only remnants are seen. Zircon is widespread in the granite and, in most thin-sections, is in small crystals enclosed in biotite and surrounded by pleochroic haloes. Reddish brown to greenish brown allanite (orthite) occurs as a metamict core in epidote minerals and as small isolated grains. Light yellow monazite is rare.

Modal Analyses

The 30 modal analyses (Table 15) of oligoclase-microcline granite illustrate the large variations in the mineralogical composition of the rock. Most components (and not only a few such as was commonly the case in the other granitic rocks of the area) vary widely in amount. Some samples (11; 14) represent transitional rock types and are not granites in the proper sense. We have not included modal analyses from other areas because the compositional range of the rock makes comparisons meaningless. In Table 15, the samples are grouped on a geographical basis in order to illustrate the compositional variations not only from location to location but also within a location. This demonstrates that the distribution of minerals is erratic, except for muscovite which is mostly in samples from the north. Thus, the distribution of the minerals depends on the invaded, assimilated, or remelted rocks rather than on a dominant process such as metasomatism, metamorphic differentiation, or magmatic crystallization.

A classification of the granitic rocks on the basis of the modal analyses, according to the system proposed by Jung and Brousse (1959), yields diverse rock groups. Alkaline and subalkaline granites are dominant,and monzonitic granites and granodiorites are common.

Chemical Analyses. The chemical analyses of Table 16 were calculated from the modal analyses of Table 15, except for the last three which are chemical analyses obtained from the literature. In contrast to the modal analyses, the chemical analyses do not display great variations. The SiO_2 content outlines two main groups of figures around 69% and 73%. Persistent variations predictably occur in the Na_2O and K_2O content, but the sum of these two oxides is nearly constant. The K_2O and Na_2O variations can be

Table 15

Modal Analyses of Oligoclase-microcline Granite

No. of samples	Quartz	Microcline	Plagioclase	Hornblende	Biotite	Pyroxene	Epidote	Muscovite	Chlorite	Sphene + Apatite	Iron ores	Allanite	Plagioclase
1	15.79	21.40	58.61	-	3.48	-	tr.	tr.	-	tr.	tr.	tr.	An_{15}
2	30.47	31.58	34.18	-	1.85	-	tr.	-	tr.	tr.	tr.	tr.	An_{17}
3	24.48	19.30	53.53	-	1.99	-	tr.	-	-	tr.	tr.	-	An_{17}
4	29.63	3.45	59.56	1.40	-	-	4.15	-	tr.	tr.	tr.	-	An_{4}
5	25.07	tr.	70.24	-	1.24	-	2.39	-	-	tr.	tr.	-	An_{15}
6	30.01	11.82	53.29	-	1.59	-	-	tr.	3.29	-	-	-	An_{7}
7	16.69	27.08	47.74	-	7.45	-	tr.	-	bio.	tr.	tr.	-	An_{26}
8	32.29	11.49	45.77	-	-	-	-	10.45	-	-	-	-	An_{10}
9	34.45	21.16	42.32	-	tr.	-	tr.	1.18	tr.	-	-	-	An_{21}
10	28.00	27.20	42.20	-	2.00	-	tr.	tr.	tr.	-	-	-	An_{16}
11	2.35	-	88.07	3.92	-	tr.	1.37	-	-	tr.	tr.	-	An_{15}
12	24.19	18.95	48.57	-	tr.	-	1.94	tr.	4.79	tr.	tr.	-	An_{17}
13	18.85	20.24	56.01	-	3.05	-	tr.	-	1.57	tr.	-	-	An_{16}
14	5.06	23.88	69.66	tr.	-	tr.	tr.	-	-	tr.	tr.	-	An_{5}
15	28.45	29.21	41.53	-	-	-	tr.	tr.	tr.	-	tr.	-	An_{14}
16	23.92	tr.	51.57	tr.	22.16	-	1.57	-	tr.	tr.	-	tr.	An_{25}
17	26.10	15.06	52.86	-	tr.	-	tr.	3.36	1.56	tr.	tr.	tr.	An_{16}
18	26.94	18.92	44.54	-	-	-	2.74	-	6.60	tr.	tr.	-	An_{19}
19	25.58	33.47	39.30	-	-	-	-	1.60	-	tr.	-	-	An_{17}
20	22.85	31.21	43.74	-	-	-	tr.	tr.	1.33	tr.	tr.	tr.	An_{17}
21	20.39	23.75	51.59	-	-	-	1.35	2.65	tr.	tr.	-	-	An_{6}
22	23.16	29.78	43.65	-	-	-	1.00	2.37	tr.	tr.	tr.	-	An_{6}
23	19.95	31.09	45.88	-	tr.	-	tr.	tr.	tr.	tr.	tr.	-	An_{11}
24	30.10	24.45	41.91	-	3.09	-	tr.	tr.	-	tr.	-	-	An_{16}
25	27.67	15.63	50.37	-	4.95	-	tr.	tr.	tr.	tr.	tr.	-	An_{18}
26	12.41	39.78	39.30	-	-	-	tr.	8.23	musc.	tr.	-	-	An_{15}
27	28.59	29.02	38.86	-	tr.	-	-	3.39	tr.	-	-	-	An_{10}
28	29.27	25.05	41.01	-	-	-	-	3.07	1.60	-	-	-	An_{14}
29	21.15	17.90	57.26	-	-	-	tr.	1.48	1.94	tr.	-	-	An_{17}
30	24.46	17.55	50.79	-	4.68	-	1.29	-	tr.	tr.	-	tr.	An_{5}

Samples No. 1-2-3-4, from near Moffet (Gaboury and Quinze lakes).
" 5, from the southeast corner of the area.
" 6-7-8, from the northeast corner, Basserode and Caron lakes.
" 9 to 17 (incl.), from the north-central half of the area.
" 18 to 24, from the west-central part. (Nédelec, Guérin).
" 25 to 29, from the northwestern angle (Opasatica lake, Rollet)
" 30, from near Quinze river.

directly related to the potassic metasomatism. Analysis 28 from a granite near Rollet, and analysis 29 from a granite near Mourier lake, in the adjacent map-area to the east, are similar and indicate a relation between the granites of the two areas. It is also to be noted that these analyses are identical to some of the calculated analyses. Analysis 30, from the LaMotte-LaCorne batholith, illustrates the similarities in the composition of this granite and of the granites of the present area.

Porphyroblastic Granite. Porphyroblastic oligoclase-microcline granite is not so common as the porphyroblastic hornblende granite, but is not rare. The rock does not contain inclusions, does not appear to be related to the hornblende granite, and is not a border phase. In other words, the distribution of the microcline porphyroblasts cannot be related to any particular feature.

The porphyroblasts are generally rectangular and not much bigger than some of the larger plagioclase grains. They contain numerous small inclusions of plagioclase, quartz, biotite, muscovite and epidote disposed randomly or along the edges. Some of the plagioclase inclusions are optically continuous and may be isolated parts of a previously larger grain. The porphyroblasts have no influence on the texture and structure of the host rock, that is, they do not disrupt the arrangement of the minerals about them.

The development of the porphyroblasts is probably one phase of the wholesale microclinization of large segments of the oligoclase-microcline granite. The origin of the porphyroblasts was discussed in the section on hornblende granite, and the conclusions were that they are the result of metasomatism or metamorphic differentiation. Thus, their formation may be owing to the local concentration of potash brought about by migrating solutions. Harme (1958) writes that microcline porphyroblasts are independent of the host rock and this explains why we find them in hornblende-pyroxene syenite, hornblende granite, and oligoclase-microcline granite.

Myrmekites. Myrmekitic intergrowths of quartz in plagioclase at the contact of potassic feldspars are common in the oligoclase-microcline granite, although they are not as widespread as in previously described rock types. In rare instances, round blebs of quartz are disposed along the boundaries of some plagioclase grains that are not in contact with potassic feldspar.

Microclinization. In almost every thin-section of oligoclase-microcline granite, microcline replaces the plagioclase, all stages of replacement being present from incipient to where only fragments of plagioclase remain, as in a perthite. Albitic rims on plagioclase usually accompany microclinization; they are regarded by some geologists as a product of direct

Table 16

Chemical Analyses of Oligoclase-microcline Granite

No of samples	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	Total	M.A.*
1	68.83	17.42	0.09	1.00	0.10	1.77	5.88	3.84	0.06	98.99	1
2	74.06	14.17	0.15	0.72	0.26	1.38	3.36	5.37	0.17	99.64	2
3	72.24	15.76	0.05	0.57	0.06	1.72	5.32	3.36	0.03	99.11	3
4	73.47	13.97	0.54	0.33	0.41	1.81	6.63	0.56	0.24	97.96	4
5	72.33	16.88	0.27	0.03	0.01	2.77	6.99	0.30	0.13	99.71	5
6	74.95	14.44	0.07	0.65	0.69	0.64	5.91	2.14	0.49	99.98	6
7	74.54	16.00	-	-	-	0.92	4.84	3.19	0.50	99.99	8
8	75.75	14.23	0.02	0.19	0.02	1.80	3.96	3.69	0.07	99.73	9
9	74.34	14.27	0.05	0.55	0.06	0.85	4.51	4.67	0.03	99.33	10
10	64.00	20.65	0.40	0.55	0.65	3.53	8.76	0.66	0.18	99.38	11
11	69.00	15.86	0.90	1.22	1.01	2.20	4.72	3.07	0.64	98.62	12
12	69.56	17.13	0.11	1.18	0.42	1.92	5.49	3.62	0.25	99.68	13
13	67.75	18.54	0.05	0.08	0.11	0.88	7.87	3.93	-	99.21	14
14	74.32	14.39	-	-	-	1.18	4.25	4.79	-	98.93	15
15	71.50	16.11	0.56	0.55	0.33	1.69	5.22	2.87	0.35	99.18	17
16	73.31	15.58	-	-	-	1.36	3.89	5.72	0.08	99.94	19
17	71.96	16.01	0.13	0.28	0.28	1.67	4.37	5.13	0.19	100.02	20
18	71.93	16.40	0.15	0.02	0.01	1.00	5.73	4.21	0.17	99.62	21
19	73.09	15.65	0.11	0.01	-	0.81	4.87	5.18	0.14	99.86	22
20	71.07	16.11	0.13	0.01	-	1.25	4.90	5.21	0.07	98.75	23
21	74.32	14.25	0.08	0.88	0.09	1.27	4.22	4.32	0.05	99.48	24
22	71.58	15.22	0.12	1.35	0.15	2.02	4.74	3.04	0.08	98.30	25
23	67.23	19.25	-	-	-	1.19	3.97	7.58	0.40	99.62	26
24	74.62	14.91	-	-	-	0.79	4.16	5.20	0.16	99.84	27
25	73.97	15.13	0.03	0.32	0.34	1.16	4.18	4.50	0.35	99.98	28
26	70.69	17.11	0.04	0.39	0.41	1.96	5.63	3.12	0.31	99.66	29
27	72.15	14.75	0.27	1.34	0.15	0.87	5.66	3.32	0.11	98.62	30
28**	73.54	14.48	0.06	1.42	0.25	0.82	4.24	4.29	0.70	99.80	
29***	73.60	14.57	0.14	1.16	0.53	0.92	3.37	4.88	0.60	99.77	
30****	73.64	14.48	0.03	1.52	0.08	0.96	4.59	4.52	0.32	100.12	

M.A.* - The numbers correspond to the numbers of the modal analyses of Table 15, from which the chemical analyses were obtained.

28** - Analysis of muscovite leucogranodiorite, from the south shore of Solitaire river, near the road. Analysed by W.H. Herdsman. Faessler, C., (1962), p. 58, no. 302.

29*** Analysis of muscovite leucogranodiorite, from the outlet of Mourier lake (east of the map-area). Analysed by W.H. Herdsman. Faessler, C., (1962), p. 58, no. 303.

30**** Analysis of muscovite granodiorite, from the LaMotte-LaCorne batholith. Analysed by W.H. Herdsman, Feassler, C., (1962), p. 60, no. 317.

crystallization during the later stages of magmatic solidification (Rogers, 1961). Discrete microcline blebs in microcline porphyroblasts show that some of this mineral is primary, but the amount appears to be very low.

The replacement of plagioclase by microcline is further supported by the interstitial nature and the late appearance of the microcline, the development of porphyroblasts, and by the occurrences of similar features in other rock types.

Freeman (1957) pointed to the formation of granite from granodiorite by the replacement of plagioclase by microcline and considered granulation as very important in bringing about microclinization of the rock. In the present area, little granulation was observed in the north, whereas it is a dominant feature of the southeastern granites, and, although in both places microclinization is widespread, it is more so in the north. However, almost all the granite shows evidence of deformation, although usually very faintly.

It is notable that the large amount of microcline in some granites in the north is accompanied by much muscovite which may thus also be related to the potassic metasomatism. Another side effect of the microclinization may be the formation of epidote (Ch'Ih, 1950).

Migmatization. Migmatite occurs in the west central, northwest and northeast parts of the area where biotite schist and gray granite gneiss are injected by oligoclase-microcline granite. Near contacts of the granitic masses with the schist and gneiss there is complex interlayering of the rock types. Lit-par-lit injections of granite, granitic dikes and sills, and ptygmatic veins accompanied by myrmekitization and microclinization are typical features of the migmatites.

Migmatites are most common near large lenses of quartz-feldspar-biotite schist or granite gneiss and are rarely associated with the small, isolated lenses common in the central part of the area. Thus, it seems that the migmatites are either the forerunners of the granitic masses or that they represent the early phases of differential anatexis and injection associated with the emplacement of the granite. The latter view is held by several geologists.

Structure.

Gneissic Structure - Banding: The granitic rocks of the southeastern part of the area display a well-defined gneissic structure trending north to northeast. Elsewhere, gneissic structures are present, especially near the contacts with other rock types, but they are not persistent and are only minor features of the rock. Here and there, faint banding is outlined by the segregation of minerals into layers. Flow banding parallel to the contacts of the granite with other rock types is common.

Lineation: Lineation defined by the parallel orientation of platy and elongated minerals is common in the northern granites near biotite schist lenses and is rare in the central part of the area. The lineation is generally parallel to structural trends of the surrounding rocks. Where porphyroblasts are abundant, they may be parallel and so define a lineation. Also, lineation may be shown by elongated inclusions of foreign material.

Pinch and swell: Many granitic sills in biotite schist pinch and swell at regular intervals. These features are as much part of the schist as of the granite and may represent incipient boudinage.

Joints: Cross, longitudinal, and flat joints are part of a major joint system. Flat joints are abundant and many are occupied by aplites and pegmatites.

Faults: No evidence of major faults was noticed in the oligoclase-microcline granite. Minor faults are common, especially in the southeastern granites. Small-scale cataclastic structures are present in several thin-sections. Crushing, granulation, and microfaults are associated with wavy extinction, chess-board patterns in the plagioclase, Boehm lamellae in quartz, myrmekites, and bent or otherwise deformed crystals.

Folds: Folds in the granite are not generally conspicuous and are restricted to the lenses and sills associated with quartz-feldspar-biotite schist. Many granitic veins 1/4-6 inches wide in the migmatized zones of the quartz-feldspar-biotite schist are folded tightly but are not fractured. They originate from larger granitic dikes or sills and extend across migmatitic layers and even oligoclase-microcline granite.

Stratigraphic Relations.- The oligoclase-microcline granite intrudes, or is injected into, all the rock types previously described, excepting the volcanic rocks and these definitely antedate it. The granite is most commonly in contact with the quartz-feldspar-biotite schist of the Pontiac Group; this contact is sharp in some places and gradational in others. It merges into the gray granite gneiss and the quartz-feldspar gneiss, these rocks appearing to be transitional phases of the oligoclase-microcline granite. It may grade into, or be in abrupt contact with, the hornblende granite into which it sends numerous dikes. Inclusions of all of these rocks are present in the granite, the most abundant being streaks or schlieren of biotite schist and of amphibolite. Many inclusions appear to be unrelated to any rock type exposed in the area, but this is probably the result of assimilation or partial digestion. The porphyroblastic granites cannot be said to be border phases because no such relationship was observed. Their distribution is seemingly erratic, and independent of the intruded rocks.

The granite is intersected by pegmatitic material, a few lamprophyre dikes, and several diabase dikes. It is overlain by the Cobalt conglomerate in the northwest corner of the area.

Age and Correlation.- No absolute age determinations are available for the oligoclase-microcline granite within the map-area. However, two determinations from granitic rocks in the adjacent area to the east have been published (Lowdon, 1960, p. 32-33): potassium-argon age determinations of a quartz-monzonite from Béraud township gave 2,600 million years (G.S.C. 59-76) but, as the specimen is highly chloritized, the dating probably is incorrect. A biotite granodiorite from Béraud township gave 2,285 million years (G.S.C. 59-78) and this is probably the date of emplacement of the granite. Snelling (1962, p. 14) writes: "The results do suggest, though only faintly, that metamorphism of the Pontiac schists and granitization in the Ottawa Mountain granite belt occurred a little later than the deformation and metamorphism that affected the rocks of the Abitibi Group ... The batholith (Preissac-LaCorne) was intruded after deformation and metamorphism... More important is the definite indication provided by these two determinations that the metamorphism of the Pontiac Group and the formation of the Ottawa Mountain granite belt occurred or perhaps one should say was initiated, more than 2,000 million years ago..."

The oligoclase-microcline granite of the present area is the western prolongation of acidic rocks described by Freeman (1957) in the adjacent area to the east, and the combined mass is a major one. Some phases of the Preissac-LaCorne batholith to the northeast show many similarities to the oligoclase-microcline granite, and Gussow (1937) established a relation on the basis of similar compositions. However, because of slight differences in age, different mode of emplacement and association, the two granites are not considered to be correlatives. Numerous small masses of granitic rocks in areas to the north are much like the oligoclase-microcline granite and may be correlatives, although this cannot be established because no basis other than similar compositions is available now. Robert (1963), Auger (1952), Denis (1938) and Henderson (1936) mapped and described granitic rocks which they sometimes referred to as "Pre-Huronian granites". These are of varied composition but have some similar features; also, some are on the south and southeast prolongations of the oligoclase-microcline granite of the present area. Thus, all may have mutual relations. Osborne (1956) wrote that the granitic intrusives of the Keewatin-Grenville transition zone may be related on the basis of chemical composition to the Timiskaming intrusives.

Emplacement and Origin.- This subject is complex and obscure because several features can be interpreted in different to opposite ways according to the point of view of the analyst. The bulk of the oligoclase-microcline granite, in the central part of the area, is massive and fairly homogeneous. There, the granite contains few large inclusions and is rarely in contact with large masses of other rock types. In the southeast corner the granite also holds few inclusions but is dominantly gneissic. Elsewhere in the area the granite grades into or is in contact with other rocks.

The large mass in the center lies against, on the north and the south, wide areas of biotite schist and quartz-feldspar gneiss with which it has gradational or digitated contacts. These areas are comparably folded into wide, open, northeast-trending antiforms and synforms to which the granite conforms. The shape of the granite mass is that of a wide stratoid lens and its relation to the schist and gneiss is that of a phacolith. However, this interpretation may be too broad in view of the great width of the granite mass and the locally discordant relations. Elsewhere, the granite is concordant with the quartz-feldspar-biotite schist. The structural features of the granite are usually similar to those of the invaded rocks and the granite must have been emplaced while the rock was being deformed. The development of porphyroblasts and other signs of potassic metasomatism added to the concordant structural features imply a synkinematic emplacement. The relations with the hornblende granite do not give much information on the nature of emplacement; actually the hornblende granite should be regarded as a phase of the oligoclase-microcline granite.

The features described above are those of mesozone to catazone batholiths such as classified by Buddington (1959). Mesozone batholiths are in part discordant and in part concordant, whereas catazone batholiths are predominantly concordant. The relationships of the oligoclase-microcline granite to the surrounding rocks are of a predominantly concordant nature and this enables us to classify the rock as a catazone granite.

A summary of the various features of the granite that relate to its origin follows:-

Fields Relations:

(1) The area underlain by the granite covers approximately 1,000 square miles.
(2) There is widespread evidence of deformation (shape of the granitic masses, slight granulation in the southeast, foliation).
(3) Much pegmatite is associated with the granite.
(4) A few lamprophyre dikes cut the granite.

(5) The contacts between granite and country rocks are generally gradational. This is not meant to indicate that there is a complete transition marked by gradual changes in composition from one rock to the other but that the contact zone is wide and includes a mixture of the two rock types. Gradual changes in composition do occur but are not characteristic features.

(6) Dikes and sills of granitic material are common in country rocks bordering the granite. The dikes have sharp contacts but no chilled borders.

(7) Migmatization and ptygmatic folding are common in the contact zone.

(8) Inclusions of country rocks are common. They are brecciated and dislocated in places, and appear to preserve their original composition and attitude elsewhere. They are not abundant in the center of the mass.

(9) The structural features of the country rocks extend into the granite in places, apparently preserving their trends and general attitude (gneissic structure, parallelism of elongated inclusions.)

(10) Segregations of minerals such as quartz, biotite and muscovite along parallel layers are suggestive of layering or of bedding. Such features are common in the border zones and rare toward the center of the mass.

(11) The granite is in a region that was subjected to regional metamorphism, and the mineralogical composition of the granite is compatible with the metamorphic grade of the surrounding schists and gneisses. Regional metamorphism extends throughout the granite.

(12) There are no aureoles of thermal metamorphism.

(13) The granite is not of uniform texture and mineralogical composition. Variations are large even within a few feet. Massive granite is more prominent than gneissic.

Mineralogical Data:

(1) The composition of the plagioclase is not constant through the area; the variations do not appear to follow a traceable pattern and no compositional zones are apparent.

(2) A few irregularly distributed plagioclase grains are zoned.

(3) Core and rim distribution of alteration products in plagioclase is abundant; uniform sericitization is rare.

(4) Twinning of plagioclase is faint and indistinct in many cases.

(5) The proportions of the feldspars vary over a wide range.

(6) Porphyroblasts are present.

(7) Perthitic structures are common with abundant bead and patch types and few string types.

(8) Myrmekites and corrosion structures are plentiful.

Chemical Data:

(1) The chemical composition of the rock is constant in comparison with the mineralogical composition.
(2) The compositions of the granite and of the biotite schist are similar.
(3) The presence of two feldspars in the granite is suggestive of subsolvus granites.

Many of the above features suggest that the granite is the result of widespread granitization, but there are minor contradictions and some features are typical of magmatic granites.

The sum of the various lines of evidence suggest that the oligoclase-microcline granite is of magmatic (derived from a melt) origin towards its center and of metamorphic origin (granitized) towards its borders. It is clear that much of the granitic material behaved as a magma. However, strong evidence of granitization is given by gradational contacts, migmatites and associated ptygmatic folds, the extreme variability in texture and in mineralogical composition of the rock, the variability in composition of plagioclase as well as the small percentage and irregular distribution of zoned plagioclase, the relative constancy of chemical composition, and the similarity in composition between the granite and the Pontiac biotite schist.

In general, the oligoclase-microcline granite may be considered as a magmatic rock in its behavior and as a metamorphic rock in its origin, and may be said to result from "assimilative granitization", a term used by Lacy (1960).

The major cause of confusion in explaining the origin was ably summarized by Clark and Stearn (1960, p. 262): "Although in the upper part of the crust granite appears to have been intruded as a liquid, if we could dissect a mountain chain at various levels we would probably see all stages in the transition from sedimentary rock, through sedimentary and igneous phases intimately mixed (migmatites), to gneisses, and finally to granite." Read's opinion (1957) that the granite problem is non-existent because each granite should be regarded as a unit to be discussed by itself is demonstrated here.

Pegmatite - Aplite

The oligoclase-microcline granite is intersected by, or grades into, large amounts of pegmatite and aplite. In places, the pegmatite makes up more than 60% of the granitic material, but usually it constitutes no more than 5%. The pegmatite is closely associated with aplite and the two are intimately banded here and there. The pegmatite and aplite outcrop mostly in the northern granitic rocks and east of

Beaumesnil lake and west of Gérin-Lajoie lake, where they form large homogeneous masses up to 2 square miles in extent. South of Brodeur lake, very little pegmatite and aplite are associated with the gneissic oligoclase-microcline granite. The pegmatite usually is in dikes or sills but also forms irregular masses, clots and lenses. It is associated mainly with oligoclase-microcline granite, commonly with quartz-feldspar-biotite schist, and rarely with hornblende granite. Where intimately mixed with oligoclase-microcline granite it constitutes a coarse-grained pegmatitic rock. Aplite occurs almost exclusively as dikes in the granite and is not so abundant as the pegmatite. It contains the same minerals as the pegmatite but in more regular distribution. A few inclusions of amphibolite and quartz-feldspar-biotite schist were seen in both pegmatite and aplite.

Petrography. The pegmatite is generally massive. Slight foliation appears at contacts with the biotite schist and banding is defined locally by concentrations of minerals (micas, garnets). The grain size varies from medium to very coarse, some grains being 8 inches long. The rock may be equidimensional but generally consists of fine interstitial quartz and large crystals of feldspar and mica. The aplite is fine grained and has a sugary texture.

The pegmatites can be classified as mineralogically simple or complex. The simple type is composed essentially of microcline, quartz and muscovite. The complex type is composed of varying proportions of plagioclase, quartz, microcline, muscovite, and biotite, with accessory garnet, magnetite, apatite, beryl, molybdenite and chlorite.

Microcline is commonly dominant (up to 50%) in the simple pegmatite. However, it may be absent or may be roughly equal in amount to plagioclase. The microcline is usually perthitic, and string, film and vein perthites are common. It is usually white to pink, rarely green, and occurs as subhedral crystals up to 8 inches long, as fine grains, and as patches in the plagioclase. Its refractive indices are: $Nx = 1.520 \pm 0.002$, $Ny = 1.524 \pm 0.002$, $Nz = 1.527 \pm 0.002$.

Plagioclase (An_{4-6}) occurs mostly in the complex pegmatites where it may constitute 60% of the rock. It is generally absent from the large pegmatite masses of the central part of the area. Albite forms large crystals (although smaller than microcline) on which the twinning is readily apparent even in hand specimens, and also fine material interstitial to coarse plagioclase and quartz.

Colorless or milky quartz makes up to 30% of the pegmatite and occurs as small grains interstitial to albite or microcline, as blebs or elongated intergrowths in large crystals of feldspar, and as large "blocks" in the center of many dikes. It also forms euhedral crystals extending radially from the walls of vugs.

Muscovite occurs in the microcline-rich pegmatites, in amounts generally smaller than 5% but up to 20%. It forms small platelets irregularly distributed in the rock or "books" up to 6 inches across and 2 inches thick. It is generally fresh, but may be stained with a purplish oxidation product. North of Roger creek and along the northeast shore of Roger lake, dendritic intergrowths of quartz and muscovite were seen. They form fan-shaped feathery aggregates with muscovite seemingly growing out from a stem at acute angles. Where several such intergrowths are side by side they create a chevron pattern. Freeman (1957) describes similar intergrowths as "plumose" and believes that they represent "remade" inclusions of country-rock.

Biotite is widespread in the pegmatite but is generally rare; in places, it makes up to 10% of the rock. It commonly accompanies the muscovite, to which it is subordinate, and also forms small plates or large "books".

The accessory minerals are not common and occur in few places. Deep red garnet is locally abundant in the northeast corner of the area, as euhedral or deformed crystals 1/16-1/2 inch in diameter. It occurs with quartz, plagioclase and magnetite, and much of it is altered to chlorite. Magnetite is widespread as octahedrons or anhedral grains associated with biotite and muscovite. Apatite is found in most pegmatites as tiny prismatic crystals. Beryl was observed at only one locality as 1/4-inch, pale green, prismatic crystals. Molybdenite is widespread.

Zoning. Zoning defined by textural or mineralogical variations is characteristic of many pegmatite dikes, especially the narrow ones. Textural zoning is relatively rare, and, in this respect, most pegmatites are homogeneous. Core zoning (defined by changes in mineralogical composition across the dikes) is common. Usually a quartz-rich core is followed outward by microcline-rich bands on each side up to the walls.

Graphic Pegmatite. Graphic pegmatite or granite occurs in several irregular masses. Two types of quartz-microcline intergrowths are observed:- one is a fine-grained, cuneiform, homogeneous intergrowth with a regular distribution of the components; the other consists of rods of quartz irregularly dispersed in the microcline. The quartz generally forms sub-parallel, elongated prisms which pass through the microcline, and the quartz to feldspar proportion is about one to four.

Emplacement. The emplacement of the pegmatite and aplite was controlled in many instances by the structure of the host rock. In the quartz-feldspar-biotite schist, the pegmatite is usually emplaced concordantly as sills along foliation planes (Plate V-B), but also as dikes along joints. In the oligoclase-microcline granite, the pegmatite is along joints,

7

especially if flat-lying. In many other instances, however, there was no apparent control over the emplacement, this being especially true of the irregular masses and blebs in the oligoclase-microcline granite.

Age and Origin. The pegmatites and aplites are related in space and time to the oligoclase-microcline granite and represent a late stage in the evolution of the granite. Thus, their origin is related to that of the granite and, like it, some are magmatic and some are metamorphic.

The magmatic pegmatites were forcefully emplaced, have graphic textures and relatively constant mineralogical compositions, and possibly include those which contain perthitic microcline. Metamorphic pegmatites have textural variations, do not have chilled borders or sharp contacts, and are zoned and layered. The two types are related and probably were formed by different processes at different places or stages in the evolution of the rock.

Lamprophyres - Pyroxenite - Serpentinite

Lamprophyres

Lamprophyre dikes are scattered throughout the area but are most abundant in the volcanic rocks in the southwestern corner. As classed here, rocks of different composition and association are grouped together. The lamprophyre dikes, as a rule, are only 2-8 inches wide. The rock usually weathers green to brown and may crumble. It is porphyritic, the ferromagnesian minerals forming phenocrysts in a fine-grained, aplitic-textured, mafic and felsic groundmass.

The rock-forming minerals of the lamprophyres are varied, but pyroxene, hornblende, biotite and plagioclase are the most common. Quartz and microcline may be present or absent. Common accessory minerals are apatite, sphene and magnetite. The rock is altered to varying degrees, and hornblende, chlorite and epidote are common secondary minerals. The pyroxene (diopside or augite) occurs in the groundmass as disseminated grains or in aggregates; much of it is altered to hornblende, which appears along the borders of, or as patches in, the pyroxene. Hornblende also forms part of the matrix, and phenocrysts are abundant in some varieties. A blue-green hornblende in coarse, bladed crystals is fairly common. The hornblende is normally fresh but may be altered to biotite or chlorite. Biotite occurs as phenocrysts in some rocks and only in the groundmass in others. Plagioclase (averaging An_{20}), present in the groundmass as interstitial grains, is usually altered to sericite. Quartz is not common and is secondary in many instances. In one thin-section, apatite, generally accessory, made up to 5% of the rock.

The dikes may best be referred to as biotite, pyroxene or hornblende lamprophyres. They are associated with the various granites and with the volcanic rocks in the southwest. Hence they are not all of the same age. It is difficult to say whether they are derived from a parent magma or not; some probably are, but many could be the equivalent of a siliceous rock modified by assimilation of basic material, and some may represent xenoliths of country rock.

Pyroxenite. A few outcrops of pyroxene-bearing rock northwest and southwest of Rollet represent an indeterminate number of basic dikes. The most representative dike is northwest of Rollet, near the road to Opasatica lake, a mile south of the northern boundary of the area.

The pyroxenite is medium grained, porphyritic in part, and brownish weathering. Where porphyritic, thin-sections show phenocrysts of light green diopsidic augite, partly altered to hornblende, in a groundmass of fibrous tremolite-actinolite, highly altered plagioclase, chlorite, and iron oxide. Whether even-grained or porphyritic the mineralogy is similar. Hence the rock is classed as pyroxenite throughout although texturally the porphyritic variety is a lamprophyre (camptonite).

The pyroxenite dikes are confined to an area of oligoclase-microcline granite and biotite schist. They may be part of a complex of ultrabasic intrusions.

Serpentinite. A small, irregular mass of serpentinite outcrops near the east shore of Opasatica lake, 3 miles west of Rollet. The rock is massive, greenish black where fresh, and light greenish gray, smooth weathering.

As seen in thin-section, the serpentinite consists of anhedral crystals of antigorite forming a fibrolamellar aggregate, and massive, almost structureless serpophite. Chrysotile occurs as cross-fiber veinlets in the serpentine mass. Muscovite, chlorite, and iron oxide are accessory minerals.

The alteration has been so complete that there is no indication of the original mineralogical composition of the rock nor of the primary texture.

The relations between the serpentinite and the adjacent granites and biotite schist are unknown. No contacts were observed, the shape of the outcrop is irregular, and no indications of the mode of emplacement were obtained. Twenty feet south of the serpentinite, is a band of very contorted chlorite schist mixed with lenses of amphibolite.

Huronian

Cobalt Group

Conglomerate and argillite of the Cobalt Group overlie the oligoclase-microcline granite and the Pontiac Group biotite schist in the northwest corner of the area.

The conglomerate is exposed 1/4 mile east of Laberge river in a single outcrop one mile long, 1/4 mile wide, and approximately 35 feet high. It is massive and made up of unsorted small and large, angular, subangular and rounded fragments in a greenish matrix of variable grain size (Plate VI-A). Pebbles stand out prominently on the weathered surface. The average diameter of the fragments is 3 inches, the maximum observed being 2 feet. They consist of granite, andesite, rhyolite, basalt and graywacke. Fragments make up 90% of the rock near the contact with the basement and approximately 70% 10 feet above it. Fragments of oligoclase-microcline granite are the most abundant, amounting to 40% of the rock. The matrix is generally fine to medium grained and consists of angular quartz and feldspar embedded in a fine groundmass of chlorite and sericite.

The contact between conglomerate and oligoclase-microcline granite, such as is exposed at the northeast end of the outcrop, appears to be erosional. At the contact, the conglomerate consists almost entirely of angular blocks up to 2 feet in diameter of granite embedded in very little matrix. Upward, the blocks are smaller, subangular to rounded, and less abundant, this change taking place within a few feet.

This conglomerate extends north and northeast in adjoining areas where the evidence in general points to a glacial origin (Wilson, 1962).

A single, isolated outcrop of argillite with an area of 10 by 10 feet crops out a few hundred feet west of the conglomerate, close to the northern boundary of the area. The rock is very fine grained, greenish, and rough weathering. It resembles slate but lacks definite cleavage and is composed of quartz, feldspar and chlorite. In adjacent areas (Wilson, 1913), the argillite apparently passes gradually to conglomerate with the appearance of rock fragments.

Lorrain Formation - Quartzite with Small Lenses of Arkose

Lorrain quartzite and arkose form a long north-trending ridge rising 250 feet above lake level, in the southwest corner of the area, near the east shore of Témiscamingue lake. The quartzite is generally yellowish green, fine to coarse grained to pebbly, and rough weathering. It is in thick, horizontal master beds that may carry several alternating coarse and fine layers within one foot. In places, there are numerous rounded pebbles of quartz up to 3/4 inch in diameter. Crossbedding is common in the arkosic parts but was not seen in the quartzite.

In thin-section (Plates VI-B; VII-A), the quartzite consists of 60-70% of subangular to subrounded quartz grains embedded so thoroughly in fine-grained sericite that they are usually not in contact with one another. The bedding direction, not always evident in hand specimens, is outlined in thin-sections by the subparallel alignment of elongated fragments. Plagioclase and microcline are rare except in the common arkosic lenses.

Although the contact between the Lorrain and the basement rocks was not observed, it can be suggested that the beds exposed are not far above the basement because, in all thin-sections, feldspar grains are present in varying amounts. This is significant in view of Henderson's statement (1936, p. 21) that "Apart from the basal beds a remarkable feature of the quartzite is the total absence of feldspar grains in all the thin-sections examined by the writer." This relationship was also noticed by Valiquette (1962, p. 78) in Fabre township.

Diabase - Gabbro

At least 30 dikes of diabase or gabbro are present in the map-area. Their orientation ranges from northwest to east, but most trend N.15°E. The walls are usually vertical or nearly so, and joints, generally perpendicular or parallel to the trend of the dikes, are also vertical. The diabase forms low ridges in many instances, usually exceeding the level of the surrounding rocks by no more than 20 feet.

The dikes range from one inch to 800 feet wide, 30 feet being common. The observed length ranges from a few feet to 8 miles. Continuity, although not apparent in the field in all cases, may be apparent on aerial photographs or on maps.

The diabase, as a rule, is fresh, massive, and dark green. The grain size is usually medium but is fine to microcrystalline in smaller dikes and along the margins of larger intrusions. Ophitic to subophitic texture is common, lath-shaped or acicular crystals of plagioclase being embedded in large grains of pyroxene. The larger dikes, such as those on the east shore of Basserode lake and southwest of Angliers, are very coarse grained inward. Very fine-grained chill zones up to a foot wide occur at contacts; they are dark and cryptocrystalline, and may contain fragments of the intruded rock.

Two types of diabase are recognized on the basis of mineralogical composition. The more common type consists mainly of a calcic plagioclase and a pale brown pyroxene (augite or titaniferous augite). The other type contains olivine in addition to plagioclase and pyroxene as the main constituents. Otherwise the two types are similar in composition, texture, and appearance. In both types, biotite, magnetite, ilmenite and apatite are accessory minerals. Secondary minerals are hornblende, chlorite, epidote and zoisite.

The plagioclase is twinned and varies in composition from a calcic andesine (An_{46}) to labradorite (An_{62}). Much of it is slightly altered to sericite. Pyroxene occurs as large grains enclosing plagioclase laths (Plate VII-B) or as interstitial grains; some is altered to a green amphibole or to chlorite. Olivine is in rounded crystals embedded in augite and plagioclase. It commonly shows incipient alteration to serpentine, corroded borders, rimming by red-brown iddingsite, and breakdown to dark green chlorophaeite. Quartz is rare and usually found as micrographic intergrowths with feldspar. Magnetite and ilmenite occur as dust or scattered grains on the borders of, or in, other minerals. Apatite, usually associated with hornblende and magnetite, occurs near grain boundaries. Hornblende is present in small amounts as a deuteric or secondary mineral.

Some of the diabase (four dikes) differs slightly in composition and texture from that given above. The variant is porphyritic and is generally more altered. The phenocrysts (1/4-3/4 inch) are irregularly shaped and poorly defined, and make up to 30% of the rock. They are composed of sericite and kaolin,— probably representing phenocrysts originally consisting of feldspar. The groundmass is like that of the normal diabase and is also ophitic.

The diabases were not seen to intersect one another nor to cut the Huronian. In general, the rock is similar to the post-Huronian diabase of the Cobalt area and may be of the same age. Cooke, James and Mawdsley (1931) report that porphyritic diabase such as described above has been observed only in pre-Huronian rocks; thus some, if not all, of the diabase may be pre-Huronian.

The trend of most of the dikes (N.15°E.) is that of one dominant joint set, and also of many linear elements which may be related to faults. The distribution of the dikes thus appears to be related to the large-scale structural pattern of the area.

Basic rocks related to the diabase

One outcrop of a rock which may be related to the diabase was seen at the intersection of the railroad and of the road to Ville-Marie at Angliers. This rock is dark, dense, porphyritic, and very altered. The phenocrysts constitute up to 60% of the rock and are composed of

Table 17

Modal Analyses of Diabase

	1	2	3	4	5	6
Plagioclase	51.36	45.55	56.11	57.68	48.93	50.00
Pyroxene	21.24	49.48	38.34	14.55	43.26	28.00
Olivine	8.63	-	-	17.45	-	-
Hornblende	tr.	-	tr.	-	-	14.00
Biotite	2.66	tr.	-	0.44	0.68	1.00
Epidote	-	tr.	-	-	-	2.00
Chlorite	tr.	tr.	-	-	1.25	
Quartz	-	tr.	tr.	-	-	5.00
Magnetite+ Ilmenite	15.61	4.90	5.50	9.61	5.88	tr.
Plagioclase	An_{45}	An_{40}	An_{54}	An_{55}	An_{50}	

Sample 6 is taken from Freeman (1957) and is given here for purposes of comparison. Sample 2 is from the groundmass of a porphyritic diabase.

saussuritized plagioclase. They are rounded, 1/4-1 inch in diameter, and give the rock a splotchy aspect. The groundmass consists of coarse blue-green hornblende, fine granular quartz, and twinned plagioclase (An_{24}). Blastophitic texture is apparent in hand specimens. The rock intrudes the adjacent hornblende schist conformably, but no contacts or chill zones were seen. Its texture and composition suggests the porphyritic diabase described above.

Wilson (1910, p. 15) described an identical rock from a locality 1 1/2 miles to the west: "A peculiar variation in the green-stone was observed on the north shore of Rivière des Quinze, at the foot of the Cypress rapids. Large, augen-like aggregates of feldspars, showing a rough parallelism in their elongation, occur enclosed in a fine-grained, ophitic groundmass." Cypress rapids are, or were, between the two dams on Quinze river and this exposure is now submerged.

Near, and on two small islands in, Quinze lake, 1 1/2 miles east of the Angliers porphyry, three ourcrops of a similar-appearing rock were examined. This rock, however, differs appreciably in composition from that at Angliers, the slightly gneissic groundmass being almost devoid of plagioclase and quartz and composed mostly of hornblende. On the other hand, the phenocrysts here are similar in shape, composition, and degree of alteration to those in the Angliers porphyry. Also, this rock occurs as a sill in hornblende schist, and on one island it is cut by hornblende granite and brecciated at the contact. This rock seems to be contemporaneous with the schist and may represent a lens of porphyritic amphibolite. If this porphyry is related to the Angliers porphyry then both are older than the granite and are unrelated to the diabase.

Ordovician - Liskeard Formation

Along the northeast shore of Témiscamingue lake and on the east and south sides of Chief island, sedimentary rocks of Ordovician age occur in scattered outcrops. An outcrop about 20 feet wide almost continuously fringes the shore of the lake for one mile. One isolated occurrence was found 600 feet inland along a vertical cliff of Huronian quartzite.

The succession begins with conglomerate, resting on Lorrain quartzite, and grades upward into coarse sandstone followed by finer calcareous sandstone and finally by sandy limestone. The conglomerate consists of phenoclasts of the underlying quartzite in a matrix of angular to subangular grains of quartz and some limy material. Boulders of quartzite range in diameter from a few inches to 5 feet and are very abundant at the base of the contact zone. The sandstone is composed of subangular grains of quartz derived from the Lorrain quartzite, with a little limy cement. The sandy limestone is yellowish green, rough weathering, and composed mostly of limy material with some quartz.

All exposures of the sedimentary rocks dip gently to the west; this probably reflects the slope of the surface on which the sediments were deposited.

The sandy limestone carries fossils but few were seen and no collections were made. Hume (1925), who named the Liskeard Formation, correlated it and particularly the basal part (that of the present area) with the Trenton. However, Caley and Liberty (in Stockwell, 1957, p. 237) write: "...due.. to the recognition of a recurrence of certain Trenton species in the Richmond, the Liskeard is now considered to be Richmond in age and not Trenton". Ollerenshaw and MacQueen (1960) also favored the Trenton but stated that "a transitional age between Trentonian and Richmondian is not impossible".

Pleistocene and Recent

Evidences of Pleistocene glaciation and of glacial lake Barlow-Ojibway are widespread and conspicuous in the map-area. Glacial drift and lake clays cover large tracts in the southeast, the center and the southwest. Deposits of glacial origin are partly covered by the lacustrine clays, especially in areas of low elevation. Glacial features include eskers, kames, moraines, boulder trains, striations, roches moutonnées, and erratics up to 20 feet across.

Four eskers have been recognized: two in the east and two in the southwest. All are narrow, tortuous ridges on top of which are kettle holes and small rounded lakes. They are flanked by swamps and lakes in several places. The two eskers in the east trend approximately N.30°E. The eskers in the southwest trend N.15°E. and north, respectively, the latter being 14 miles long and up to 4,000 feet wide. Generally the width of the eskers is about 300 feet and their height about 50 feet.

In cross-section the eskers are rounded and the crests almost flat, making it difficult to distinguish them in the field. They are more easily recognized on aerial photographs. The eskers are composed mostly of coarse gravel, are flanked by aprons of sand, and are well bedded and crossbedded. All are copious sources of road metal.

Glacial striations, roches moutonnées, and boulder trains indicate a general north to south movement of the ice sheets. The striations generally trend S.10°E. in the south of the area and S.10°W. in the north.

The former existence of glacial lake Barlow-Ojibway in the area is indicated by widespread varved clays consisting of alternating dark and light layers which are 1/8-1/2 inch thick and cover some of the glacial drift. The clay is common along the shores of the bigger lakes, generally below an elevation of approximately 1,000 feet above sealevel.

An east-trending ridge approximately 75 feet high, 1/2-1 mile wide, and 32 miles long extends from the western limit of the area through Rémigny lake to the north end of of Roger lake. Near Caire lake it widens and becomes almost circular in outline. In the center it is composed mostly of gravel and boulders up to 2 feet in diameter, and it is bordered by thickly bedded sand, especially at the western end and near L'Evêque lake. Where the ridge intersects the large esker in the west there are numerous kettle holes up to 1,000 feet in diameter and 100 feet in depth. This ridge may represent morainal deposits reworked by the waters of Barlow-Ojibway lake to form interconnected islands with extensive beaches.

STRUCTURAL GEOLOGY

Folds

Major folds are outlined on the map by the trends of the foliated rocks wherever structural continuity is preserved. The biotite schist, quartz-feldspar gneiss, and gray granite gneiss are the principal rock units which establish the conformation of the folds and wherever they are lacking, as in the center of the area, the structural pattern is obscure. The foliation of these rocks is considered to be generally parallel to the primary structure of the original sedimentary rocks. This relationship is indicated by the parallelism of biotite schist and graywacke near Quinze river. The terms "synform" and "antiform" are used because the stratigraphical succession is unknown, no marker horizons being available, and only the broad outlines of the structural pattern are evident.

Five major folds are recognized. In the northeast near Roger lake, an antiform with a N.15°E.-trending axis is defined by the foliation of the schist lenses in the oligoclase-microcline granite. The biotite schist defines a large, open, asymmetrical fold plunging about 60° north-northeast. To the south and 8 to 16 miles distant a north-trending synform axis is indicated. The biotite schist dips about 60° on either side of the axis and outlines a large open fold plunging north at a steep angle, judging from drag-folds. A northwest- to north-trending antiform, 6 to 8 miles to the west and northwest, is suggested by the foliation in quartz-feldspar gneiss. The position of this fold axis is poorly established because the evidence is incomplete and not very clear. Near Opasatica lake, lenses of biotite schist and gray granite gneiss in oligoclase-microcline granite outline a synform and an antiform, both axes having a general northwest trend. The plunge of the folds, as indicated by lineations and drag-folds, is approximately 60° to the southeast or south. The schist and gneiss usually have gentle dips and the folds are open.

Not indicated on the map is a poorly defined synform suggested by the trends of biotite schist near Fréchette lake at the northern limit of the area. The axis apparently trends N.15°E. and plunges north-northeast. The volcanic rocks toward the southwest corner of the area are isoclinally folded along N.60°E.-trending axes, with southerly dipping planes.

The number of episodes of deformation represented by the folds is unknown although there is some scattered evidence of overprinting of structures. The fold axes are generally sigmoid, and this is considered typical of obliquely intersecting structures (Carey, 1962). Also, the intrafolial folds observed in the biotite schist are suggestive of transposition of S-surfaces. However, deformation of lineations or bending of mica flakes is rare.

The only actual example of intersecting structures seen is near the east shore of Prévu lake, southeast of Angliers. There, north- to northeast-trending quartz-feldspar gneiss intersects east-trending andesites; blocks up to 5 feet of the latter are enveloped in the gneiss (Plate VIII-B). The larger blocks preserve their original trend (defined by pillows), whereas the smaller fragments are rotated along the foliation direction of the quartz-feldspar gneiss, thereby indicating that the north to northeast deformation was later than the easterly trend of the volcanics.

Shear Zones and Faults

Shear zones and minor faults, with a horizontal separation of no more than 2 feet, are common except in the granitic rocks. Most of these structures trend approximately east-northeast but some trend northwest or north.

Two major faults were seen in the volcanic rocks of the southwestern corner of the area. One trends almost east and is characterized by a deep valley extending from north of Baby lake to Long lake. The fault zone is approximately 50 feet wide and is marked by talc-chlorite schist. The attitude of the fault was not determined. The second, and less evident, fault trends N.60°E. along Quinze river and extends southwest to Profond lake. On each shore of the narrower parts of the river chlorite-schist zones dip 70° to the south or vertically. The contact between volcanic rocks and biotite schist is 500 feet to 1,600 feet north of this zone and may also be a fault, such as is suggested by the presence of chlorite schist in the contact zone.

On an island at the northern end of Barrière lake, a brecciated zone accompanied by talc-chlorite schist, and the offsetting of rock types between the two sides of the lake, indicate a north-northeast-trending fault. The attitude of the fault is unknown.

At the northern end of a small island in Quinze lake, just south of Quatre-Milles bay, a fault is suggested by a fractured zone filled with carbonates and chlorite schist. The rock is gneissic hornblende granite mixed with plagioclase-hornblende gneiss and carrying intercalated lenses of biotite schist. The fault parallels the foliation, trends north-northeast, and dips 50° west.

The remarkably straight course of many rivers and lakes constitutes a pattern of subparallel linears (Figure 3) which may have been determined by faults, by joints, or by glaciation. The linears in the area are not accompanied by shearing, silicification, or brecciation. However, to the north (Wilson, 1918; Podolsky, 1950) there is more definite evidence that some linears, a few of which extend into the present area, are related to faults. Also as the lineaments are parallel to the dominant directions of joints in the area, many probably are related to joints. Glaciation may account for some of the linears but it is more likely that it had an accentuating effect only.

Joints

Joints in the map-area commonly strike N.30°E., east, or S.68°E. Other less common directions are N.5°E., N.40°E., S.55°E., and S.21°E. All joints dip steeply except for many that are horizontal, or

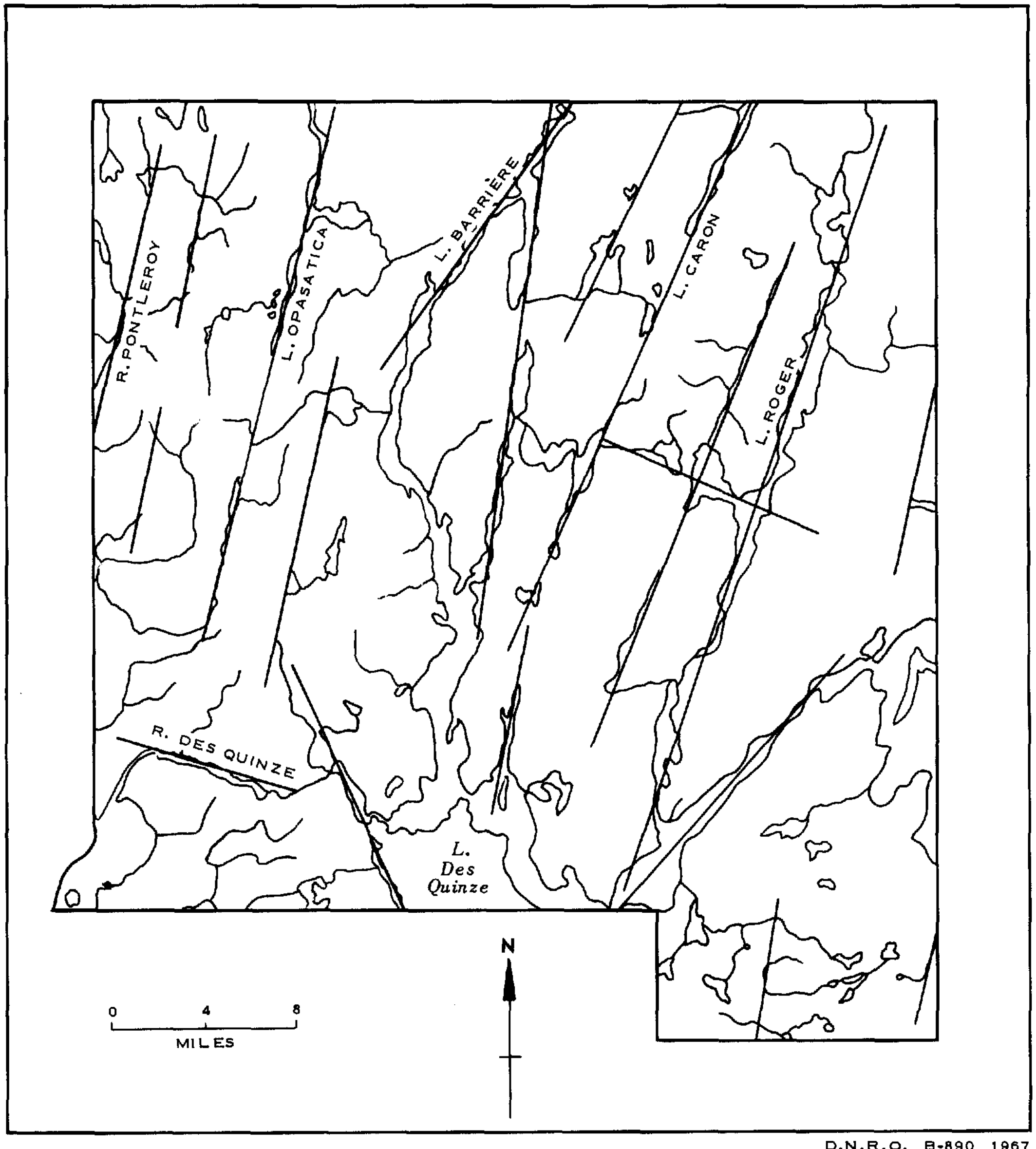


Figure 3

DOMINANT LINEARS OF THE QUINZE LAKE - BARRIÈRE LAKE AREA

nearly so, in large bodies of pegmatite. In gneisses and schists, one set is usually perpendicular to the foliation. Many joints are filled by quartz veins or stringers.

Contour diagrams of the joint poles for the quadrants of the area reveal that four joint sets are common to the entire map-area and that the S.55°E. set, distinctive in the southwest, is related to the volcanics.

The S.21°E. and S.68°E. joint-sets of the northeast and southeast quadrangles are shear joints. The N.30°E. set common to the whole area appears to be a master joint related to the major linears. The stereographic projection of the contour pattern suggests that it could be a longitudinal joint and that the maximum stress direction would be roughly parallel to the S.68°E. joint direction.

Relations of the Structure of the Area to Regional Structure.-

The volcanic assemblage in the southwest trends N.60°E. and is isoclinally folded. In the adjoining area to the south, Henderson (1936, pp. 14-15) concluded that the volcanics are on "the southern limb of a major fold that has been cut off on the north by granite." Southeast of the present area, the volcanic rocks form a broad anticline plunging to the southeast. Henderson distinguished two sets of drag-folds related to this structure, one set plunging at angles rarely exceeding 30° and the second set plunging steeply to vertically. He considered the gently plunging folds to be "true secondary folds formed by differential movement between beds or flows during the initial longitudinal folding of the rocks along an east-west axis", and the steeply plunging folds to have formed later as a result of the "thrusting action of the invading granite." In other words, the steep folds accompany the deformation which is dominant north and south of the volcanic zone. This relationship indicates that the north-south and east-west deformations are not contemporaneous.

In the Kipawa Lake area, south of the volcanic zone, Robert (1963) believes that the northeast, north, and northwest structural trends in paragneisses blend with the east-west deformation of the quartz-feldspar-biotite schist and volcanics to the north. Robert mentions the gradual passage from "Timiskaming-type" metasedimentaries to biotite schist and states that the north trends may be contemporaneous with or younger than the east trends. Osborne and Morin (1962, p. 128) had come to the same conclusion: "The northeast-trending structure is obviously younger than both the north- and east-trending folds. The north-trending structures are either the same age or younger than the east-trending folds in the metavolcanic rocks. Of the two hypotheses we prefer the former because we believe that the less altered rocks on top of the greenstones are conformable with more altered sedimentary rocks to the south and these, except close to the greenstone, show no imprint of the old east-trending folding." This contemporaneity is difficult to explain, and Osborne and Morin (1962, p. 128) write: "Such disharmonic folding as this has been described and though its mechanics are not well understood it is probably the result of proximity of a section of the crust dominated by thick greenstone units to one composed of bedded rocks including shales."

In the map-area, just north of the volcanic zone along Quinze river, the north-trending Pontiac Group overlies the volcanics. The conditions at this locality are very similar to those to the south discussed by Osborne and Morin and by Robert. Therefore, similar relationships may exist, but the evidence mentioned earlier (Henderson, 1936) indicates that the east-west and north-south folds are not contemporaneous. The intersection of east-west structures by the north to northeast trends of the quartz-feldspar gneiss near Prévu lake suggests the superimposition of the north to northeast deformation over the east-trending volcanics.

The younger northeast trends alluded to by Osborne and Morin (1962), as quoted above, were not seen in the present map-area, and are rare in the Kipawa Lake area (Robert, 1963).

The north trends of the Pontiac Group of the present area give way to the east trends of the Keewatin volcanics to the north in the Rouyn-Beauchastel Area (Wilson, 1962). There is no sharp break between the two trends. Wilson (p. 19) agrees that the east trend of the Pontiac Group in the northern area "supports the hypothesis of Gunning and Ambrose (1939, p. 37) that the rocks of the Pontiac (Kewagama) group are part of the south limb of a major syncline." However, north-trending structures have been observed in Rouyn township by Podolsky (1950), who writes that the Pontiac strata "form compressed, Z-shaped buckles whose axes appear to plunge steeply north. There is no indication from the fabric diagrams of non-affine movements along cleavage planes to produce such buckles, thus it is concluded that they represent tilted, original pre-Timiskaming folds." (p. 89)

Freeman (1957c) suggested that the adjacent area to the east was part of a large anticlinorium trending northeast. He also wrote that in the northern part, and to the north, of his area, the rocks are part of the southern limb of a broad syncline trending east, with moderate dips to the north. Here again, the juxtaposition of two structures, with different orientations, is observed and no definite break between the two is apparent. Overprinting of structures is not mentioned either by Freeman or by Wilson.

In the map-area, the dominant structural trends are north with local variations to the east and to the west. The northwest orientation of the folds in the northwest corner of the area is interpreted as such a local variation. Indeed this part of the area is underlain by the same synkinematic granite that is associated with the north-trending structures. The granitic rocks were emplaced concordantly during the episode of north-south deformation. Prior to this emplacement there may have been other deformations, but because of the intensive metamorphism and large-scale granitization, no traces of earlier deformation now remain.

Osborne and Morin (1962), who divided the Grenville into two tectonic-metamorphic units, included the present map-area in their Grenville B subprovince, and wrote (p. 119): "The tectonic pattern of the Grenville B subprovince is distinctive in its irregularity and is a result of the superimposition of new structural trends on older ones. The newer structures trend generally northeast but are exceedingly irregular, giving the impression of anastomosing zones passing around blocks of somewhat greater resistance than adjacent blocks. Both north- and east-trending older structures can be recognized but, in a considerable part of the Grenville B subprovince, though the effects of the two foldings can be recognized, the direction of the older has not been ascertained." These specifications closely conform to the structural pattern of the present area, except that no truly northeast-trending structures exist. The north- and east-trending structures are present, and the former appears to be superimposed over the latter. The east trends are preserved in the volcanic rocks because of their thickness and consequently greater resistance to large-scale deformation.

METAMORPHISM - NATURE OF THE "GRENVILLE FRONT"

Metamorphism

The degree of metamorphism of the rocks in the map-area is relatively uniform and most assemblages belong to the staurolite-quartz subfacies of the almandine-amphibolite facies of progressive regional metamorphism, as defined by Fyfe, Turner and Verhoogen (1958). The volcanic sequence in the southwest corner of the area may straddle the boundary between the upper greenschist facies and the lower almandine-amphibolite facies, but this departure from the normal can be related either to retrogressive metamorphism accompanying granitic intrusions or to the greater resistance to metamorphism of a thick volcanic sequence owing to a high water content. Thus, except for these volcanics, no metamorphic zoning is recognized in the area.

However, if we compare the metamorphic grades of adjacent areas with that of the present area, a pattern can be outlined. In the Kipawa Lake area to the south, Robert (1963a) recognizes an increase in grade of metamorphism from north to south and suggests that the paragneisses underlying this region belong to the kyanite-muscovite subfacies of the almandine-amphibolite facies. He writes that the biotite schist, which he believes to be a correlative of the Pontiac schist, is less metamorphosed than the gneisses to the south but more metamorphosed than the "Keewatin-type" metavolcanics and "Timiskaming-type" metasedimentaries described by Denis (1938), Retty (1931), Auger (1952), and Henderson (1936) to the north. On the basis of mineralogical composition, he assigns the metavolcanics and metasedimentaries north of the Kipawa Lake area to the staurolite-quartz subfacies. From the descriptions given by Denis (1938), Auger (1952) and Henderson (1936) of the volcanics and sedimentaries, the metamorphic grade appears to be as defined by Robert (1963a) with a few exceptions where it is lower, that is, where the rocks belong to the greenschist facies.

An isograd, the boundary between the staurolite-quartz subfacies and the kyanite-muscovite subfacies, thus runs easterly south of the present area. The trend of the isograd cannot be defined accurately, but it may well be parallel to the northeast-trending Grenville A - Grenville B boundary of Osborne and Morin (1962). However, this direction may be modified somewhat by the east-trending volcanic sequence along which another isograd, the boundary between the greenschist facies and the almandine-amphibolite facies, may pass.

Freeman (1957) states that in the Béraud-Mazérac area, to the east of the present area, narrow layers of amphibolite belong to the albite-epidote-amphibolite facies and that the Pontiac biotite schist belongs to the biotite-chlorite subfacies of the greenschist facies. This would indicate that there is a north-trending transition from the greenschist to the almandine-amphibolite facies between the two areas. Freeman refers to staurolite, sillimanite and garnet in highly disturbed zones but states that their presence is related more to the original chemical composition of the rock than to the grade of metamorphism and he rejects their value as index minerals. From this, and from his explanation that chlorite may be a result of retrogressive metamorphism, we may conclude that the grade of metamorphism is actually higher than stated and corresponds more or less to the lower limit of the almandine-amphibolite facies. If this is so, there is no transition in grade of metamorphism from one area to the other. This is also indicated by Eakins (1962) who writes that the Kewagama Group (correlated with the Pontiac Group) in the Malartic area belongs to the lower and to the higher portions of the epidote-ampnibolite facies. The Malartic area is northeast of the Béraud-Mazérac area of Freeman, and the grade of metamorphism is similar to that of the present area.

Wilson's (1962) Pontiac schist in the Rouyn-Beauchastel area, north of the present area, is composed of quartz and albite-oligoclase along with brown mica partly altered to chlorite. This mineral assemblage is also that of the staurolite-quartz subfacies, although the presence of albite in places may indicate a transition to the upper greenschist facies. Eakins (1962) mentions that in the Malartic area, albite gives way to oligoclase, and thus a transition in grade of metamorphism such as the one just outlined is defined. Snelling (1962, p. 5) states that the Pontiac Group north and northeast of the map-area has a metamorphic grade somewhat higher than that of the Abitibi Group, and that "The mineral assemblages in members of the Pontiac Group indicate metamorphic conditions of the muscovite-biotite subfacies and the almandine-amphibolite facies." The transition in grade of metamorphism here probably trends east-west, along the volcanic-sedimentary sequence of the Rouyn-Malartic zone.

From these considerations we may conclude that two isograds are present between the Kipawa Lake area to the south and the Rouyn-Beauchastel area to the north, and that the degree of regional metamorphism decreases from south to north. The isograds to the south and to the north are, respectively, the upper and the lower limits of the staurolite-quartz subfacies. The lower isograd is north of the present area, where its position is not well established, and also in the southwest corner along the volcanic assemblage. The higher isograd is south of the area, in the northern part and north of the Kipawa Lake area.

The Grenville Front (See Robert, 1963 and "in press", for a more detailed analysis)

The Grenville front, separating the Superior from the Grenville provinces, is considered to pass through or near the area, but its location is not established with certainty.

Grenville formations are usually regarded as being characterized by northeast-trending structures and a relatively high grade of metamorphism, and as being separated abruptly from the east-trending rocks of the Superior province. In places these conditions prevail, but in the present area the "front" is gradational. Derry (1950) located it just south of the map-area, whereas Robert (1963) located it to the north near latitude 48°. The latter concluded that the front was a metamorphic transition and assigned it to the staurolite isograd of the almandine-amphibolite facies of regional metamorphism.

The biotite schist of the Pontiac Group is generally regarded as part of the Keewatin-Timiskaming sequence of the Superior province. It extends from the northern border of the area almost to the southern border and is in contact in the southwest with the volcanic-sedimentary zone. It reappears south of the area, where it is assigned by Robert (1963) to the Grenville. Thus the biotite schist belongs to both geological provinces.

The Grenville front is not here a faulted complex as it is elsewhere. The dominant north trends agree with the trends in the

Kipawa Lake area, but differ from those of the Keewatin volcanics in the Superior province to the north. On the basis of the tectonic pattern, the area may be considered as belonging to the Grenville since the east trends farther north are typical of the Superior province.

The grade of metamorphism is relatively high in the area, being within the staurolite-quartz subfacies and thus above the staurolite isograd mentioned by Robert as corresponding to the Grenville front. How-ver, the volcanic zone in the southwest is just below this isograd, and the front, if it corresponds to this degree of metamorphism, must describe a sinuous pattern to circumscribe the volcanics.

From these considerations it appears that the rocks of the Keewatin are converted to the gneisses of the Grenville and thus the same rock units are shared by both provinces. In tectonic style, the area belongs to the Grenville. The metamorphic grade in the area is also that of the Grenville farther south. However, it is arbitrary to assign the front to a specific isograd, and the writer prefers to use the general trend of the metamorphic transition instead of a particular isograd in order to avoid contortions in the front.

Osborne and Morin (1962) suggested that the east-west and north-south structures of the Grenville B subprovince are contemporaneous. On this basis, the area and parts of the Superior province to the north belong to the Grenville B subprovince, and consequently it is implied that the Keewatin and the Grenville are both of Archean age, although they may not be contemporaneous. According to Snelling (1962), the rocks near the front were involved in the 1,000-million-year-old orogeny of the Grenville province. Osborne (1962) proposed the term "Millenary" for this orogeny and suggested that it was a thermal event.

To summarize, the Grenville front here is a metamorphic transition situated somewhere between the kyanite-muscovite-quartz subfacies of the almandine-amphibolite facies and the upper greenschist facies. The front is, therefore, gradational and includes the whole map-area. As rocks of similar age and lithology on either side of the front are involved in the Grenville orogeny the front does not correspond to a specific time division.

ECONOMIC GEOLOGY

No economic deposits have been exploited within the area. However, the Rouyn-Noranda deposits to the north, the Belleterre gold mine to the southeast, the Cobalt silver area to the southwest, and the recent development of the Lorraine project to the south have spurred prospecting in the area. The volcanics in the southwest, especially, have been intensely prospected and several mineralized showings are now known.

Molybdenite (2,8,9,10,11*)

Molybdenite was seen in some quantity along the shore of Gérin-Lajoie lake, in ranges VII and VIII of Bauneville township (2); along a range road in Guérin township on lots 50 and 51, Range II (8), and also in lots 39 and 40, Range I (9); west of Nédelec in lot 29, Range VII of Nédelec township (10); and southeast of Rollet on lot 23, Range III of Desandrouins township (11).

The molybdenite is associated with pegmatite dikes and quartz veins cutting oligoclase-microcline granite, quartz-feldspar-biotite schist, or porphyroblastic amphibolite (Nédelec). Diffenbach (1961) determined the following order of mineral deposition for localities 8, 9 and 10: feldspar, molybdenite, pyrite, chalcopyrite, bismuth, bismuthinite and quartz. Yellow powdery molybdite also occurs, and powellite and bornite are reported from diamond drill cores. Diffenbach shows the similarities of these mineralized zones to the Preissac-Lacorne deposits.

Exploration work on the five major showings, consisting mostly of geological mapping, trenches, pits, and shallow diamond drill-holes, failed to outline an orebody and the properties are now inactive.

Iron (7)

The iron-formations near Quinze river have been explored by various mining companies using magnetic surveys, geological mapping, trenching,pitting, diamond drilling, and stripping. The formations are 10 to 140 feet wide (average of 40 feet) and appear to extend intermittently for 7 miles. There are at least two formations, probably three. The one just south of Quinze river is still (1964) being explored. It consists of alternating layers of quartz and magnetite, and contains 37% iron of which 29% is from magnetite.

Copper-Zinc-Gold (4,5,6)

Outcrops containing copper, zinc and gold were examined along the Rollet-Cloutier road on lot 31, Range VII, Desandrouins township (4); on the northeast shore of Barrière lake, on lots 3 and 4 of Range X, Caire township (5); and along the Angliers-Rémigny road on lots 60 and 61, Range VII, Guérin township (6). The mineralization consists of variable amounts of pyrite, pyrrhotite, chalcopyrite, sphalerite, and gold in, respectively, amphibolite, biotite schist and hornblende gneiss. Analyses of grab samples gave:

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* Numbers refer to locations on the map.

Locality 4:	Cu = 0.07%	Locality 5:	Cu = 0.10%	Locality 6:	Cu = 0.35%
	Fe = 9.04%		Fe = 35.65%		Fe = 32.06%
			Zn = 0.04%		Zn = 0.10%
			Au = 0.004 oz./ton		Au = 0.002 oz./ton

The mineralized zones are small except at locality 6, where the width is 20 feet and the maximum observed length is 1,000 feet. Little or no work has been done on these showings.

Lead (1)

In lot 30, Range I, Brodeur township, at the eastern end of the east-west road south of Grassay lake, pyrite, chalcopyrite and galena are disseminated in a small outcrop of quartz-feldspar-biotite schist along a narrow zone approximately 4 feet long. A grab sample assayed Cu = 0.01%, Pb = 0.49% and Ag = 0.180 oz./ton. A trench is the only evidence of prospecting here.

Hematite (13)

Just east of Route 46a, west of Rémigny lake, in lot 15, Range VIII, and lots 10 and 11, Range VII of Rémigny township, hematite is associated with pegmatite dikes, 1/4-1/2 inch wide. The hematite forms veinlets within the dikes and the grains extend perpendicularly from the walls. No work has been done on this showing but it has been examined by prospectors.

Nickel and Copper (12)

South of Solitaire bay on lots 1 to 8 of Range III and IV, Desandrouins township, nickel and copper occur in a mineralized zone 35 feet wide in quartz-feldspar-biotite schist. Pyrite, pyrrhotite, chalcopyrite, and pentlandite are the principal minerals. Assay of a grab sample gave: Fe = 39.55%, Cu = 0.11%, Ni = 0.27%. Near the showing are several narrow pyroxenite dikes. Work is now (1964) in progress on the showing and electromagnetic surveys were made recently, the results of which are not yet available.

Asbestos (14)

Cross-fiber chrysotile veinlets, 1/16-inch wide, are found in a small mass of serpentinite 2 miles northwest of locality 12.

Beryl (3)

A few small crystals of beryl were found east of Caron lake on lots 56-57, Range X of Caire township. One prospector reports crystals up to 6 inches long near here.

Mica

Various mica finds have been reported by prospectors, notably near Arenaine (Bull Rock), Basserode and Roger lakes, but the showings are generally small and the quality of the micas is poor.

Granite

A granite quarry at the east end of lot 31, Range I, Montreuil township, beside the highway, was worked in 1946-47. The oligoclase-microcline granite here is homogeneous and fine grained. Quarrying was discontinued when areas of closely spaced joints were encountered. The granite was used for tombstones and for the exterior facing of the church at Dupuy in Abitibi-West county.

Sand and Gravel

Sand and gravel deposits of good quality are abundant and amply provide for local needs.

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ALPHABETICAL INDEX

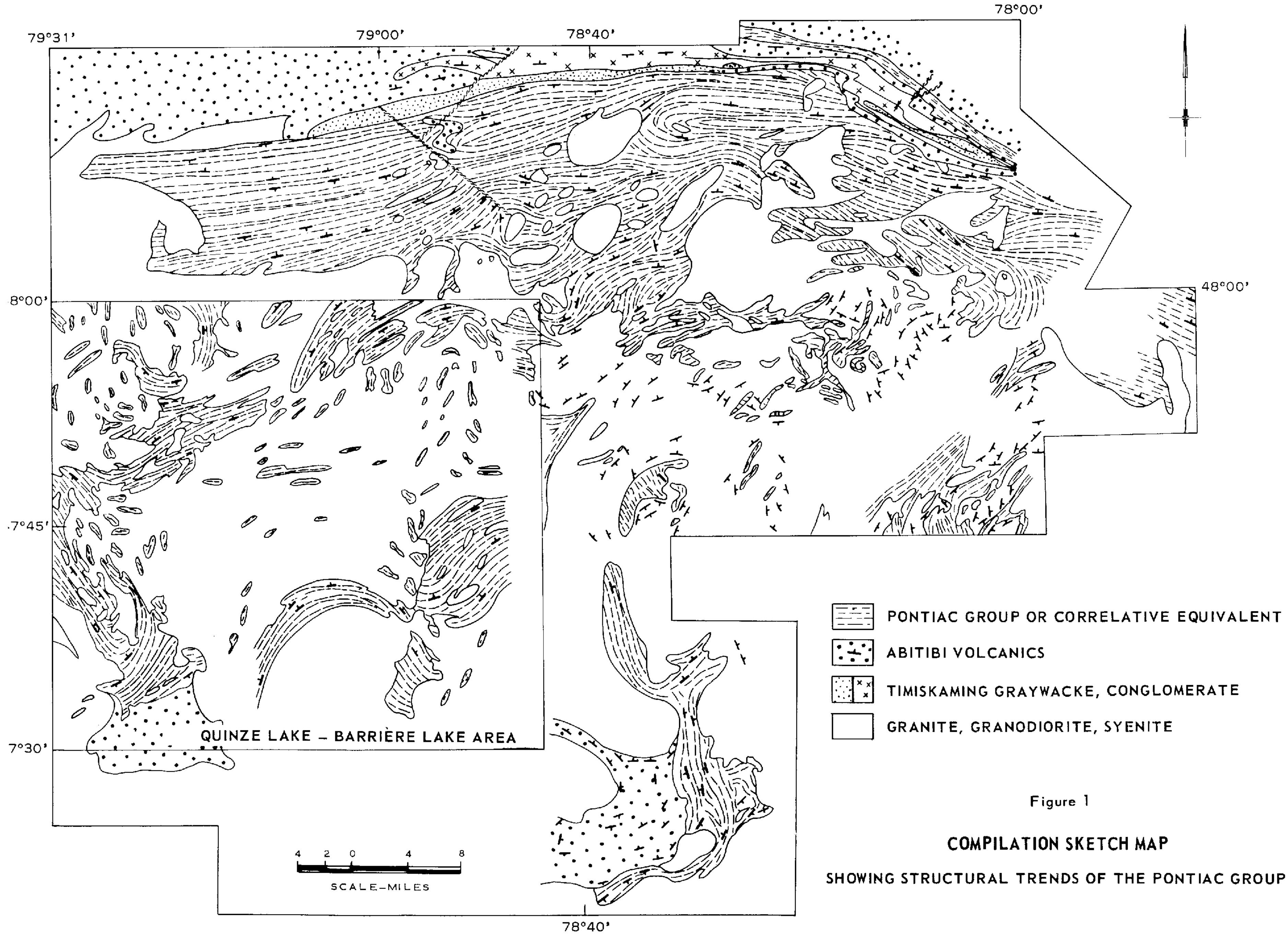

Figure 1

COMPILATION SKETCH MAP

SHOWING STRUCTURAL TRENDS OF THE PONTIAC GROUP

D.N.R.Q. B-890 1967