# RG 129(A)

GRAS LAKE - FELIX LAKE AREA, SAGUENAY COUNTIES

QUEBEC DEPARTMENT OF NATURAL RESOURCES

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GEOLOGICAL EXPLORATION SERVICE

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GEOLOGICAL REPORT 129

# GRAS LAKE - FĒLIX LAKE AREA

Saguenay County

by
P. J. Clarke

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## INTRODUCTION

### General Statement

The iron deposits of the Mount Reed - Mount Wright district have undergone intensive development since 1952. The Geological Surveys Branch (now Geological Exploration Service) of the Quebec Department of Mines (now Department of Natural Resources) has, since 1957, mapped geologically much of the region in order to show the location of the deposits and their relation to the surrounding rocks. This report is based on field work done during the summers of 1960 and 1961 when the writer mapped, respectively, the Gras Lake and Félix Lake areas, each of which was reported on in preliminary fashion at the time (Clarke, 1961, 1962).

The combined area covers a strip of land about 42 miles long and 17 miles wide, the center of which lies approximately 145 miles north of Sept-Iles and 58 miles northeast of the iron-mining center of Gagnon. All the consolidated rocks belong to the Grenville province of the Precambrian shield. They include metamorphosed sedimentary rocks of the Labrador trough, Archean granulitic rocks on which the sediments were deposited, and igneous rocks which intrude both those groups.

The Archean rocks occur at intervals along an east-west band stretching from Hobdad lake eastward almost to Moisie river. Proterozoic (?) gneisses lie on both sides of this zone. Iron-formation and associated marble and quartzite, together forming the Gagnon Group, occur in down-folded portions of the Proterozoic rocks. East of Moisie river gabbro is abundant, and rocks of the Gagnon Group are notably absent.

## Location and Access

The area is bounded, for the most part, by longitudes 66°30'W. and 67°30'W. and latitudes 52°15'N. and 52°30'N. However, the mapping was extended slightly south from Gras lake to include known occurrences of the iron-formation and, between longitudes 66°45'W. and 67°00'W., about 6 miles northward to join the mapped portion of the Carheil Lake area (Murphy, 1965), investigated in 1959. The total area covers about 795 square miles, including all of Bergeron, Leduc and Courchesne townships, almost all of Desjordy and Dugas, and smaller parts of Faber, Gueslis, Esmanville, Paquin, Malapart, Cabanac, Hind, Legal, Guillimin and Boily townships.

The area is easily reached by float-plane from bases near Sept-Iles or Gagnon. The latter town, which lies 50 miles southwest of Gras lake and 68 miles southwest of Félix lake, is accessible by air and Quebec Cartier Mining Company's railway. Oreway, a stop on the Quebec North Shore and Labrador Railway (subsidiary of Iron Ore Company of Canada), 186 miles from Sept-Iles, is 34 miles east-northeast of Félix lake. This lake can be reached from Oreway by a one-portage canoe route through Ashuanipi and Opocopa lakes. The course of a proposed extension of Quebec Cartier's railline northward to Mount Wright, 25 miles north of Bergeron lake, crosses the western part of the area.

Canoe travel is easy in the western part of the area where the Gras Lake - Pékans River, Hope Lake - Bergeron Lake, and Lamêlée Lake - Hobdad Lake - Petite Manicouagan River systems provide good north-south routes. In the eastern half of the area canoe travel is restricted to Carheil, Gentilhomme, Moisie and Félix rivers along which rapids are common (Plate XII).

## Field Work

The Gras Lake area was mapped in the summer of 1960 and the Félix Lake area, in 1961. Pace-and-compass traverses were run throughout the area at intervals of about 1/2 mile, and accessible shorelines were examined. Advance prints of the 1:40,000-scale National Topographic Series topographic maps and R.C.A.F. vertical aerial photographs at scales of 3,300 feet = 1 inch and 3,580 feet = 1 inch were used to control traverses and locate outcrops in the field. Geological data were plotted on 1/2 mile = 1 inch base maps prepared by La Compagnie Photo-Air Laurentides, Quebec.

## Previous Work

The geology of the Gras Lake sheet is included in 1 inch = 4 miles mapping done during 1957 and 1958 by S. Duffell and R.A. Roach (1959). Adjoining areas to the north have been mapped by D.L. Murphy (1959, 1960), and to the northwest and the west by L.S. Phillips (1958,1959). Articles on the region near Mount Wright and Wabush lake to the north have been written by J.E. Gill, H.M. Bannerman and C. Tolman (1937), G. Gastil and D.M. Knowles (1960), and W.F. Fahrig (1960). R.F. Mueller (1960, 1961) and S.H. Kranck (1961) have described mineral assemblages of the silicate iron-formation of this and nearby areas. Unpublished theses by C. Gleeson (1956) and A.G. Spatt (1959) cover parts of the area. Much of the material in this report is included in the author's doctoral thesis (Clarke, 1964). Unpublished geological reports on the holdings of mining companies working in the area were available to the author.


## Acknowledgements

In the summer of 1960 the field party included: senior assistant, C.S. Luff; junior assistants, John G. Cassils, Michel Noiseux, Roger Blais and Fernand D'Aoust; cook, Gilles Nadeau; and canoemen, Sylvestre and Alexandre Pinette. In 1961 R.N. Diffenbach was senior assistant; M. Moreau and D.W. Owen, junior assistants; Sylvestre Pinette, cook; and Alexandre Pinette and Marcel Fontaine, canoemen. Without the able assistance of these men the work could not have been done.

The laboratory investigations were carried out by the writer at the University of Manitoba.

Company reports of assessment work, including diamond-drill logs, and detailed geological and geophysical maps of many of the iron deposits, were available to the author. Without these data much of the detail of the economically important parts of the area would not be known. The author is especially grateful to Mr. L.J. Severson of Quebec Cartier Mining Company for permission to publish previously confidential information.


## Description of the Area

### Physiography

Most of the area lies between 1,500 and 2,500 feet elevation. The only important exception is the Moisie River valley which is cut down to 1,300 feet at the area's southern boundary. The tops of most high hills have an elevation of about 2,400 feet, and may represent the surface of a highly dissected peneplain (Plate XI).

The topography is largely determined by varying degrees of resistance to erosion of the different rock types. Rocks most likely to form hills are granulite, iron-formation, the alumina-rich rocks overlying the iron-formation, and gabbro. Most hills rise about 400 feet above the surrounding gneisses. The greatest relief, 1,000 feet in 1 mile, occurs between Moisie river and the hills just west of the junction of Moisie and Gentilhomme rivers.

The western part of the area is drained by Petite Manicouagan river, the central part by Pékans and Carheil rivers, and the eastern part by Moisie river. Drainage is mainly towards the south but is interrupted by hills in the southern part of the Gras Lake sheet. The land north of these hills is low and swampy, and largely covered by glacial deposits reworked by water seeking a way around the hills.

Moisie and Gentilhomme rivers separate relatively rugged uplands to the west from flatter swampier country to the east, the topographic expression of a change in rock type.

## Glacial Geology

The Pleistocene glaciation left a cover of till and sorted sediments over much of the area. Till is the more abundant and is commonly molded into south-southeasterly-trending ridges.

In the low western part of the area, including Bergeron and part of Gueslis townships, a glacial lake left a flat surface of sand and mixed sand and boulder deposits. Eskers and fluvioglacial deposits lie in channels commonly followed by present rivers (Plate V-B).

## Flora

The area has a light forest cover. The most common trees are black and red spruce, with a butt diameter of 4 to 8 inches. On protected slopes spruce and balsam may reach 100 feet in height. Groves of balsam grow in moist sheltered spots, and hills of gabbro support good stands of white birch. Jack-pine grows on sandy fluvioglacial deposits.

Underbrush is not thick. Caribou moss covers dry sandy soil, whereas wetter areas are carpeted with green moss and some labrador tea. Alders grow on stream courses and wet hillsides. Much of the area has been burnt at one time or another. The most recent large fire burnt over much of the western part of the Gras Lake sheet.

## Fauna

The only fur-bearing animals seen in the area were mink, otter and beaver; the latter are quite abundant. Mice, red squirrels, porcupines and occasionally weasels were seen around camp. Rabbits, ducks, geese and partridge are present but are not plentiful. Caribou are more common near the swampy eastern section of the area than elsewhere, and some wolves were heard and seen in these parts. A bear damaged a cache, but none were seen.

Table No. 1

Table of Formations

| | | |
|---|---|---|
| CENOZOIC | PLEISTOCENE AND RECENT | Sorted fluvioglacial deposits<br>Glacial drift |
| Great Unconformity | | |
| PROTEROZOIC | INTRUSIVE ROCKS | Gabbro and altered gabbro (Shabogamo?) and associated ultrabasic, intermediate and acidic intrusives<br>Quartz monzonite |
| PROTEROZOIC | DISTINCTIVE UPPER METASEDIMENTARY ROCKS | Hornblende-garnet rock<br>Quartz-mica-kyanite schist<br>Rusty-weathering graphitic schist |
| PROTEROZOIC | GAGNON GROUP | Wabush Lake iron-formation { Olivine-pyroxene-carbonate facies; Oxide facies; Silicate-carbonate facies }<br>Wapussakatoo quartzite<br>Duley marble |
| PROTEROZOIC ? ARCHEAN | MAINLY LOWER GNEISSES | Potassic metasomatized gneiss (stratigraphic position uncertain)<br>Less migmatized, homogeneous and banded gneisses (occur both above and below Gagnon Group)<br>Segregated, quartz-feldspar-biotite and hornblende gneisses and migmatite |
| ARCHEAN | | Granulite, altered granulite |

## Climate

The summer of 1960 was a wet one, with heavy rain on 35 of the 81 days for which records were kept. Ice left the lakes about June 12 and snow had not fallen when the party left the field in mid-September, although there was frost as early as August 31. The highest temperature of the summer was 90°F., registered on August 21. The mean minimum and maximum temperatures for the summer months were: for the last 14 days of June (43°F. and 68°F.), July (45°F. and 70°F.), August (44°F. and 66°F.), and for the first 5 days of September (44°F. and 58°F.).

The summer of 1961 was drier than that of 1960. Ice left the lakes about June 10 and the last snowfall was on June 12. The temperature dropped below freezing on the night of August 25.

# GENERAL GEOLOGY

## General Statement

All bedrock of the area is Precambrian in age. It is divided into the following major groups:

1) Archean granulite facies gneiss, retrogressively metamorphosed by the Grenville metamorphism;

2) Probably Proterozoic gneisses and migmatites underlying the Gagnon Group;

3) Marble, quartzite and iron-formation, named the Gagnon Group, and representing the chemical sediments of the southern extension of the Labrador trough;

4) Metasedimentary rocks stratigraphically above the Gagnon Group;

5) Igneous rocks intrusive into the above groups.

The Archean rocks are scattered along an east-west band stretching from Hobdad lake almost to Moisie river, in the southern half of the area. They were once hypersthene-bearing granulites similar to those occurring northeast of Mount Wright, (Duffell and Roach, 1959; Clarke, *) In the présent area, most of the hypersthene has been replaced by fine-grained, reddish brown biotite, garnet and quartz.

Hornblende and biotite gneisses underlie the Gagnon Group and are probably younger than the granulitic rocks. They are the most common rocks in the area. These gneisses are divided, mainly on the basis of texture, into segregated and homogeneous types which are gradational.

In the gneisses with a segregated texture there is a separation of minerals into mafic-rich and felsic-rich portions which may have the form of speckles, lenses or bands. As the biotite is generally tabular rather than flaky and is not oriented in a single plane, the gneiss has poor foliation fissility. Both biotite-rich and hornblende-rich types are common.

In the homogeneous gneisses mafic and felsic minerals are mixed evenly through the rock. Biotite is the common mafic mineral. As it is flaky and is concentrated in parallel planes, fissility is good. Where felsic porphyroblasts or layers have grown, they generally have a mafic selvage separating them from the mixed groundmass.

The homogeneous gneiss generally occurs close to rocks of the Gagnon Group which it underlies, although it is probably only slightly older. Whether the segregated gneiss represents a deeper, more migmatized variety of Proterozoic gneiss, or thoroughly recrystallized Archean granulite, is not certain. However, the author believes that most of it was probably originally Proterozoic paragneiss.

The gneisses east of Moisie river are characterized by a high microcline content. Hornblende, the predominant mafic mineral, occurs as 1 to 3 mm. grains in a matrix of quartz and feldspar. These gneisses have no foliation fissility, but break on joints instead. They appear to be baked or hardened by feldspathization, probably associated with the gabbros that are common in the eastern part of the area.

The Gagnon Group consists of three formations: the Duley marble, the Wapussakatoo quartzite, and the Wabush Lake iron-formation. The marble and quartzite generally underlie the iron-formation. There are two major facies of iron-formation — an oxide facies, composed of quartz with about 30% hematite or magnetite, and a silicate-carbonate facies, composed of iron-rich pyroxene and quartz, with some dolomite and minor magnetite. The oxide facies occurs with quartzite and marble near Don and Hippocampe (Seahorse) lakes, south of Demi-Mille lake, and near Fire lake, all in the western part of the Gras Lake sheet. The silicate-carbonate facies was deposited under more reducing conditions than the oxide facies. It is accompanied mainly by marble. A quite continuous band of marble and silicate-carbonate iron-formation occurs along Pékans river from the northern border to Gras lake where it turns to run westward across the area. A similar, parallel, but less continuous band follows Gentilhomme and Moisie rivers to the southern border of the area where it too turns to the west. Other occurrences are near Lamêlée, Hobdad and Midway lakes, and near the northern end of Carheil river.

The gneisses overlying the Gagnon Group are most abundant in two major north-south synclinal structures followed by Pékans river and Gentilhomme-Moisie rivers, respectively, and south of the southern band of iron-formation. Most of this gneiss resembles the homogeneous gneiss that lies below the Gagnon Group, but it is interlayered with distinctive rock types which are generally garnetiferous. In the Gras Lake sheet the Gagnon Group is overlain by a rusty-weathering, garnet- and graphite-bearing schist. In the Félix Lake sheet the schist is kyanite-rich and may or may not contain graphite. A massive rock composed essentially of hornblende and garnet occurs near the top of the sequence in the Gentilhomme-Moisie syncline, and to a lesser extent in the southern part of the Gras Lake sheet.

Two main types of igneous rocks have intruded the above rocks: quartz monzonite, which forms generally conformable bodies, up to 1/2 mile or so wide, mostly in the lower biotite and hornblende gneisses; and a basic suite composed mainly of gabbro with associated ultrabasic, intermediate and acidic differentiates. Most of the basic rocks occur east of Moisie river, but small plugs cut the gneiss near the south end of Gras lake and south of Gentilhomme lake. Sills of amphibolite, the metamorphosed equivalent of the gabbro, intrude competent rocks of the Gagnon Group in the vicinity of Fire, Hobdad, Lamêlée and Midway lakes. Amphibolite also occurs with the basic plugs near Gras and Gentilhomme lakes.

## Archean Rocks

### Granulite and Altered Granulite

The oldest rock recognized in the region is a compact brown gneiss belonging to the granulite facies. It occurs along an east-west band stretching from Hobdad lake almost to Moisie river, in the southern half of the area. It resists erosion well and commonly forms hills; good exposures are found in the hills southwest of Bergeron lake and west of Leduc lake.

In outcrop, the granulite is light brown with a rusty weathered surface. It is a compact rock with thin felsic bands every few inches but without noticeable mineral orientation. This texture results in poor fissility and rounded outcrops (Plate IA). Injected granitic material makes up about 15% of most exposures, and in places completely encloses blocks of granulite. Garnet may form at the contact of granitic layers. Some outcrops have football-sized lenses of pyroxene (Plate IB).

North of the Grenville front (Duffell and Roach, 1959; Clarke, *) the granulite consists of quartz, plagioclase and microcline feldspars, hypersthene and biotite, with hornblende and augite in the basic varieties. In the present area Grenville metamorphism has converted much of the hypersthene (and feldspar) to fine-grained biotite, quartz and garnet. Two feldspars are present, tan to light gray plagioclase, and microcline. Large feldspar grains show warped cleavage faces. Quartz has a gray or blue cast.

The appearance of the rock in thin-section is best described as disordered. Rearrangement is not complete and, besides the fine minerals replacing hypersthene, there are many inclusions of quartz and biotite in feldspar and garnet. The fine-grained aggregates of biotite and quartz are generally rimmed with garnet. In some samples remnants of strongly pleochroic hypersthene remain at the centers of these aggregates (Plate VIA). The reactions controlling this alteration involve a gain of water and a decrease in anorthite content in rocks passing from the granulite facies to the amphibolite facies. They are as follows:

| Granulite Facies | | Amphibolite Facies |
|---|---|---|
| 1) $KAlSi_3O_8 + 3(MgFe)SiO_3 + H_2O$ | $\rightleftharpoons$ | $3SiO_2 + K(MgFe)3AlSi_3O_{10}OH_2$ |
| K-spar + hypersthene + water | $\rightleftharpoons$ | quartz + biotite |
| 2) $CaAl_2Si_2O_8 + 2(MgFe)SiO_3$ | $\rightleftharpoons$ | $Ca(MgFe)Al_2Si_3O_{12} + SiO_2$ |
| anorthite + hypersthene | $\rightleftharpoons$ | garnet + quartz |

Biotite occurs as coarse primary grains and as fine-grained alterations. Both types are pleochroic from light yellow-brown to red-brown. Some biotite is altered to chlorite and rutile, or bleached green near felsic bands. Feldspar in the felsic layers is generally myrmekitic, and signs of deformation are common. Twins may pinch out or abut against a fracture, and bent twins are not rare. Single plagioclase grains contain both albite and pericline twins.

Complete replacement of the hypersthene leaves a rusty-weathering garnet-biotite gneiss with characteristic mafic speckles (Plate VIB). Mineralogically, this gneiss resembles the homogeneous, probably Proterozoic gneisses, and continued alteration could make the distinction impossible. The rocks recognized as granulites failed to reach equilibrium during the Grenville metamorphism. It may be that the characteristic speckled texture of the gneiss — in fact the occurrence of any recognizable granulite — depends on the scarcity of water during the metamorphism of the old gneiss (Yoder, 1955).

Table 2 gives visual estimates or modes of composition of 18 thin-sections. Plagioclase compositions were determined either by the Rittmann method (Emmons, 1943, pp. 115-133) or by refractive index. Mineral composition of a typical granulite from Table 2 is : 40-55% plagioclase (about $An_{28}$), 0-8% microcline, 9-23% quartz, 6-24% biotite, 2-10% garnet, 0-3% hypersthene, some clinopyroxene and hornblende in basic types, and traces of apatite, magnetite, pyrite, zircon and sphene. Because this group includes rocks of both basic and intermediate composition, affected by varying degrees of recrystallization, it has a wider range of mineral composition than most other rock units.

A suite of granulite, altered granulite, and gneiss specimens was analysed chemically to discover whether there was any large difference between the various gneiss types, and what chemical changes accompany the granulite. The analyst was H. Boileau of the Quebec Department of Mines Laboratories. The results, with other pertinent analyses for comparison, are given in Table 3.

Chemical processes accompanying weathering and deposition change the composition of rock material during sedimentation. The more thorough the weathering and sifting during transport the more the sediment will differ in composition from its source rock. Thus, a shale and a graywacke derived from similar material will have significant compositional differences. The main differences are higher $K_2O/Na_2O$, $Fe_2O_3/FeO$, and $MgO/CaO$ ratios, and higher $Al_2O_3$ content in the more weathered and finer-grained sediments (Pettijohn, 1949). Comparison of these values gives a measure of the amount of weathering or shaliness of a sediment, and a clue to the origin of isochemically metamorphosed gneisses.

Figure 1 is a plot of the critical values from analyses in Table 3. The main change accompanying retrograde metamorphism of the granulite is the addition of water, and in its last recognized stage of alteration the granulite still contains less water than the overlying gneiss. The incoming water was probably accompanied by mobile rock material. Sample No. C-31-160-61, the wettest of the recognized granulites, also contains more $K_2O$ than normal. The other chemical data are not conclusive. The granulite and both types of lower gneiss have compositions similar to the average graywacke or subgraywacke. The upper schists analysed for D.L. Murphy have the composition of a shale.

Since there is no chemical difference between the Archean granulite and the segregated gneiss it is possible that the gneiss was derived from the granulite by the addition of water. However, the Proterozoic homogeneous gneiss also has the same composition and is just as likely to be the source of the segregated gneiss.

The Archean granulite is confined to an east-west-trending band close to a parallel synclinal structure. Folds in the surrounding gneiss bend around, and are generally overturned towards, the granulite, but the gneiss itself is no different from gneisses occurring throughout the area. Thus it appears that the granulite follows an anticlinal axis, or a ridge on the floor of the Proterozoic sea, rather than a zone of weaker than average retrograde metamorphism. East of Carheil river adjacent masses of granulite and gneiss dip in opposite directions suggesting an unconformity between the two groups. So although the granulite and gneisses have similar compositions, the author believes that the gneisses are derived from Proterozoic sediments and are not recrystallized granulite.

Table 2

Mineral Compositions of Granulite and Altered Granulite

| Sample | Location | Plagioclase An 25 30 35 40 | % | K-spar | Quartz pr | Quartz sec | Biotite pr | Biotite sec | Hnb | Opyrx | Cpyrx | Garn | Ap | Others |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C-4-26-60 | 52°19'N.;67°06'W. | | 50 | 5 | 10 | | 25 | | | | | 5 | | Zr tr |
| C-25-153b-60 | 52°17 1/2'N.;67°10 1/2'W. | | 23 | | 4 | 12 | 12 | 21 | | 2 | | 27 | tr | Mag tr |
| C-41-260-60 | 52°18'N.;67°23'W. | | 50 | | 10 | | 7 | | 16 | | 4 | 5 | 1 | Epi 6,Py tr |
| L-12-50-60 | 52°23 1/2'N.;67°07 1/2'W. | | 39 | | 6 | 8 | 17 | 8 | | | | 19 | tr | Chl 2,Py 1,Zr tr |
| *L-12-50-60 | 52°23 1/2'N.;67°07 1/2'W. | | 25 | 35 | 35 | | | | | | | | | Epi 3,Zr 1,Chl 1,Mag 1 |
| L-16-63-60 | 52°19'N.;67°00'W. | | 44 | | 34 | | 11 | | | 2 | | 8 | | Mag 1 |
| L-16-64-60 | 52°18'N.;67°00'W. | | 40 | | 10 | | 7 | | 3 | 35 | | | 3 | Sph 3,Zr tr |
| L-37-149-60 | 52°20'N.;67°23'W. | | 41 | 8 | 15 | | 30 | | | | | 2 | tr | Py 2,Zr 1 |
| G-19-54-60 | 52°18'N.;67°10'W. | | 60 | | 10 | | 10 | | 3 | | | 10 | 1 | Epi 5 |
| G-21-57-60 | 52°20'N.;67°18'W. | | 47 | | 13 | | 16 | | 11 | | 3 | 4 | | Py 2,Chl 1,Zr 1,Sph 1,Cal 1 |
| G-29-87-60 | 52°20'N.;67°17'W. | | 45 | | 20 | | 8 | | 1 | | | 2 | 1 | Chl 20,Cal 2,Sph 1,Epi tr,Py tr |
| C-13-57-61 | 52°24'N.;67°58'W. | | 75 | | 10 | | 6 | | tr | | 2 | 7 | 1 | Mag 1 |
| **C-20-101-61 | 52°21 1/2'N.;66°51 3/4'W. | | 50 | 7 | 7 | | 31 | | | 2 | | 3 | tr | Zr tr |
| C-21-106-61 | 52°20 3/4'N.;66°55'W. | | 45 | 35 | 10 | | 5 | | | | | 3 | 2 | Py tr |
| **C-31-160-61 | 52°18 1/4'N.;66°54 1/2'W. | | 45 | 4 | 6 | | 30 | | 6 | 3 | | 7 | tr | All tr,Mag tr |
| C-31-161-61 | 52°18'N.;66°55 1/4'W. | | 60 | | 23 | | 7 | | tr | | 6 | 3 | tr | |
| **D-17-61-61 | 52°21'N.;67°00'W. | | 47 | tr | 33 | | 15 | | | | | 3 | tr | Py tr,Zr tr |
| D-23-80-61 | 52°19'N.;66°51'W. | | 70 | 5 | 10 | | 2 | | 2 | 3 | 4 | 2 | tr | Mag 1 |
| Mean | | 28.3 | 47.5 | 12.4 | 15.9 | | 14.9 | | 2.4 | 2.6 | 1.0 | 6.1 | tr | |
| Mean Deviation | | | 9.1 | 11.9 | 7.3 | | 9.6 | | 3.0 | 3.7 | 1.8 | 4.6 | | |

*Granitic layer

**Analysed sample - Mode 1,500 pts.

Plagioclase by Rittmann ⟼, by Tsuboi —, method

pr = primary, sec = secondary

Hnb = Hornblende, Opyrx = Orthopyroxene, Cyprx = Clinopyroxene, Ap = Apatite, Zr = Zircon, Mag = Magnetite, Epi = Epidote, Py = Pyrite, Chl = Chlorite, Sph = Sphene, Cal = Calcite, All = Allanite

Table 3

Chemical Analyses of Granulites and Gneisses

| Sample No. Rock type | C-25-108-59(3) Fresh Granulite | C-20-101-61 Altered Granulite | C-31-160-61 Altered Granulite | D-17-61-61 Speckled Gneiss (Altered Granulite) | D-11-42-61 Well Segregated Lower Gneiss | C-30-193-60 Homogeneous Lower Gneiss | Fresh Granulite(3) (composite spec.) Duffell and Roach, G.S.C. Lab.749 | Av. of 3 banded Lower Gneiss Murphy(1961), p.57 | Av. of 2 Upper Schists Murphy(1961), p.129 | Av. Diorite by Daly Barth(1959), p.69 | Av. Granodiorite by Daly Barth(1959),p.69 | Av. of 11 Graywacke Pettijohn(1949),p. 250 | Av. of 3 Subgraywacke Pettijohn(1949),p.256 | Av. Shale Clarke, F.W.(1924),p.34 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | 65.85 | 59.60 | 56.75 | 60.80 | 60.63 | 62.70 | 62.8 | 65.10 | 56.69 | 56.77 | 65.01 | 64.2 | 77.8 | 58.10 |
| $Al_2O_3$ | 15.06 | 16.95 | 16.82 | 16.26 | 16.22 | 16.07 | 16.1 | 15.27 | 17.16 | 16.68 | 15.94 | 14.1 | 9.5 | 15.40 |
| $Fe_2O_3$ | 1.07 | 1.05 | 2.38 | 0.57 | 0.99 | 1.05 | 1.0 | - | - | 3.16 | 1.74 | 1.0 | 0.9 | 4.02 |
| FeO | 4.38 | 6.02 | 6.00 | 6.28 | 5.70 | 4.84 | 5.22 | - | - | 4.40 | 2.65 | 4.2 | 2.6 | 2.45 |
| CaO | 3.38 | 3.24 | 2.59 | 3.30 | 3.13 | 2.90 | 3.7 | 3.42 | 1.10 | 6.74 | 4.42 | 3.5 | 1.2 | 3.11 |
| MgO | 2.46 | 4.30 | 4.35 | 3.83 | 3.76 | 3.28 | 3.5 | 3.71 | 3.44 | 4.17 | 1.91 | 2.9 | 1.6 | 2.44 |
| $Na_2O$ | 3.59 | 4.05 | 2.79 | 3.39 | 3.13 | 3.43 | 3.5 | 3.95 | 2.59 | 3.39 | 3.70 | 3.4 | 2.0 | 1.30 |
| $K_2O$ | 2.19 | 2.53 | 5.19 | 2.82 | 3.25 | 2.82 | 1.9 | 1.82 | 3.80 | 2.12 | 2.75 | 2.0 | 1.5 | 3.24 |
| $H_2O+$ | 0.94 | 0.72 | 1.27 | 1.17 | 1.43 | 1.40 | 0.76 | - | - | 1.36 | 1.04 | 2.1 | 1.6 | 3.7(2) |
| $H_2O-$ | 0.05 | 0.03 | 0.11 | 0.06 | 0.09 | 0.08 | - | - | - | | | 0.1 | 0.1 | 0.7(2) |
| $TiO_2$ | 0.52 | 0.74 | 0.87 | 0.65 | 0.70 | 0.65 | 0.6 | - | - | 0.84 | 0.57 | 0.5 | 0.6 | 0.65 |
| $P_2O_5$ | 0.13 | 0.13 | 0.19 | 0.19 | 0.13 | 0.17 | 0.1 | - | - | 0.25 | 0.20 | 0.1 | 0.2 | 0.17 |
| MnO | 0.08 | 0.09 | 0.11 | 0.11 | 0.12 | 0.08 | 0.1 | - | - | 0.13 | 0.07 | 0.1 | 0.2 | - |
| $CO_2$ | 0.05 | 0.09 | 0.04 | 0.07 | 0.25 | 0.08 | - | - | - | - | - | 0.6 | 0.5 | 2.63 |
| S | 0.02 | 0.10 | 0.18 | 0.15 | 0.11 | 0.09 | - | - | - | - | - | - | 0.1 | - |
| $Li_2O$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | - | - | - | - | - | - | - | - |
| $V_2O_3$ | 0.03 | 0.06 | 0.06 | 0.05 | 0.06 | 0.06 | - | - | - | - | - | - | - | - |
| BaO | 0.13 | 0.11 | 0.11 | 0.13 | 0.11 | 0.09 | - | - | - | - | - | - | - | - |
| SrO | 0.12 | 0.09 | 0.07 | 0.07 | 0.08 | 0.08 | - | - | - | - | - | - | - | - |
| $Cr_2O_3$ | 0.02 | 0.03 | 0.04 | 0.03 | 0.03 | 0.03 | - | - | - | - | - | - | - | - |
| ZrO | - | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | - | - | - | - | - | - | - | - |
| TOTAL | 100.07 | 99.96 | 99.96 | 99.96 | 99.95 | 99.93 | 99.3 | 92.27 | 84.78 | 99.99 | 100.00 | 99.8 | 100.4 | 96.51 |
| MgO/CaO | 0.73 | 1.33 | 1.68 | 1.16 | 1.20 | 1.13 | 0.95 | 0.79 | 3.13 | 0.62 | 0.43 | 0.83 | 1.33 | 0.78 |
| $K_2O/Na_2O$ | 0.61 | 0.62 | 1.86 | 0.83 | 1.04 | 0.82 | 0.54 | 0.46 | 1.47 | 0.63 | 0.74 | 0.59 | 0.75 | 2.49 |
| $Fe_2O_3/FeO$ | 0.24 | 0.17 | 0.40 | 0.09 | 0.17 | 0.22 | 0.19 | - | - | 0.72 | 0.66 | 0.24 | 0.35 | 1.64 |
| Excess(1) $Al_2O_3$ | 2.52 | 3.89 | 3.66 | 3.45 | 3.58 | 4.56 | 3.3 | 2.66 | 8.57 | -2.32 | 0.65 | 1.7 | 3.6 | 4.64 |

(1) $Al_2O_3$ in excess of that combined in normative feldspar

(2) Av. shale-Clarke(1924), p.30. %$H_2O$ on p.34 is 5.0%(total $H_2O$?)

(3) Collected north of Grenville front

Clarke, P.J. and Murphy: analyst - H. Boileau

Duffell and Roach: analyst - K. Hoops

GRAPHICAL PLOT OF CHEMICAL ANALYSES OF GRANULITES AND GNEISSES

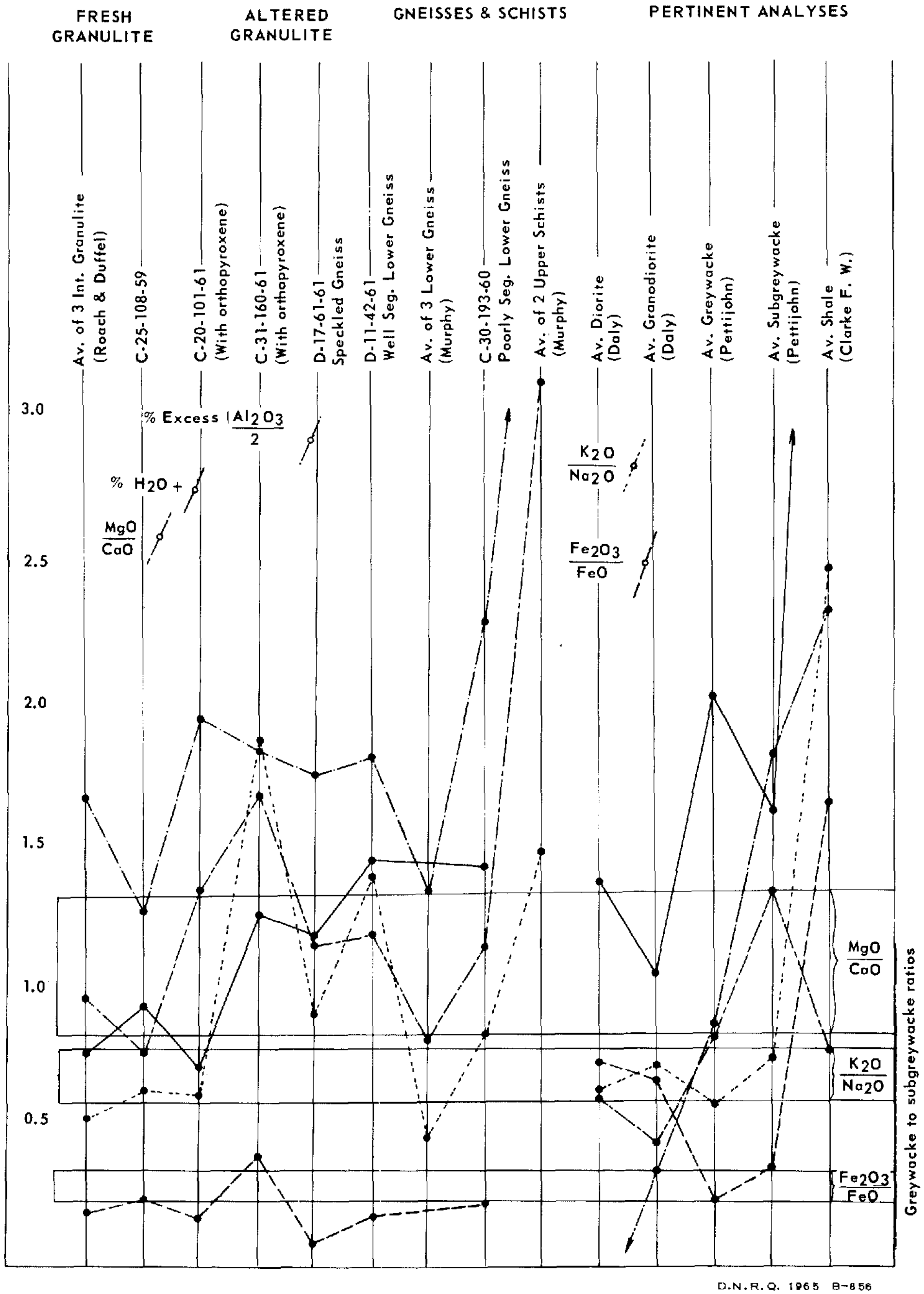



FIGURE 1

## Gneisses and Schists

### General

Several types of gneisses and schists occur in the area. They are found throughout the stratigraphic sequence, both above and below the Gagnon Group, but are described together so as to be most easily compared.

Criteria used to distinguish the various types of gneisses are: degree of separation of mafic and felsic minerals; stratigraphic position relative to the Gagnon Group; and mineralogical composition. The following groups of gneiss and schist are recognized: a) segregated gneisses, which may be either biotite- or hornblende-rich, and which occur below the Gagnon Group; b) homogeneous to banded gneisses, which occur both below and above the Gagnon Group; c) potassic metasomatized gneiss associated with gabbro masses east of Moisie river; the stratigraphic position of this rock is uncertain; and d) three mineralogically distinctive gneisses and schists that overlie the Gagnon Group — a rusty-weathering graphitic schist, a quartz-mica-kyanite schist, and a rock composed essentially of hornblende and garnet.

Like all artificial classifications, this one is sometimes difficult to use, mainly because the degree of segregation of the gneiss is variable and the position of a particular rock relative to the Gagnon Group is not everywhere apparent. However, the classification is believed to reflect real differences, and to be more useful than lumping the gneisses into larger groups.

Mineral composition fields of the various types of gneisses are shown on triangular diagrams in Figure 2 (attached). The first triangle (A) relates to the whole rock; the second (B), to its feldspars; and the third (C), to its mafic minerals. In total rock composition, two of the younger rocks — the mafic rich hornblende-garnet rock, and the feldspar-poor quartz-mica-kyanite schist — stand apart from the others. The other rocks group well, and there is generally more variation within a single rock type than between different types. Of these others, the upper homogeneous gneiss is the most variable in composition and is generally the most femic. The potassic gneiss is the richest in feldspar as a result of its added microcline content.

Almost all the gneisses contain plagioclase between $An_{25}$ and $An_{35}$. The microcline content is more variable and is attributed mainly to the addition of potassium. The most microcline occurs in the lower gneisses and metasomatized potassic gneisses. Other types of gneiss generally contain less than 5% microcline.

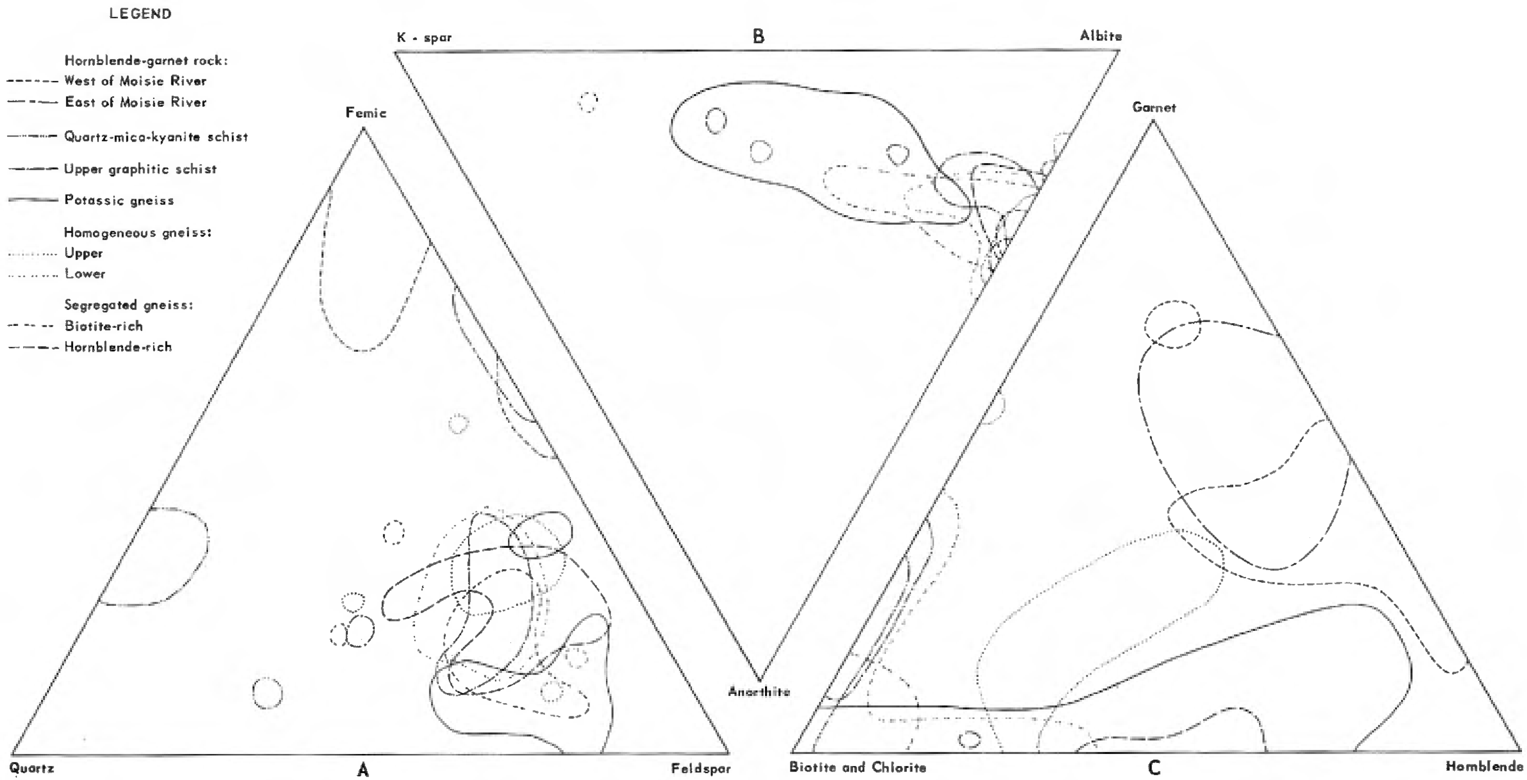



FIGURE 2

MINERAL COMPOSITIONS OF GRAS LAKE-FELIX LAKE GNEISSES AND SCHISTS

D.N.R.Q. 1965 B-656

The gneisses vary most in their content of mafic minerals. The segregated gneisses contain mostly biotite, or equal parts biotite and hornblende, but very little garnet. The lower homogeneous gneiss contains biotite and either garnet or hornblende, but not both together. The upper homogeneous gneiss has about equal hornblende and biotite, and may contain both garnet and hornblende. Some of this gneiss seems gradational with the hornblende-garnet rock. Both biotite and hornblende occur in the potassic gneiss, with garnet found mainly in the hornblende-rich varieties. Some clinopyroxene occurs in this and the hornblende-garnet rock but cannot be shown on the diagram. The upper graphitic and kyanitic schists are both biotite-rich, with some garnet but no hornblende.

As well as differing in the amounts of minerals present, the various gneiss types show differences in the composition of the mineral species themselves. Figure 3 is a plot of the refractive indices of coexisting biotite and hornblende in the granulite, gneisses, and intrusive rocks of the area. In this figure, Ny of biotite is plotted against the greater of the refractive indices measured on cleavage flakes of hornblende (Parker, 1961). A direct relation between the refractive indices of the two minerals is apparent. This is to be expected as the refractive index increases in both minerals with increase in the ratio Fe+Ti+Mn/Mg, and with increase in ferric iron. Biotite and hornblende with the lowest refractive indices are found in the segregated gneiss, intermediate indices in the lower and upper homogeneous gneisses, and the highest indices in the potassic gneiss. This increase is accompanied by a color change from olive-brown, through red, to very dark brown or black. The highest indices are found in very dark colored minerals in the acidic orthogneiss derived from the Shabogamo gabbros. It was probably fluids from the orthogneiss that metasomatized the potassic gneiss.

The composition of the garnet also differs somewhat from rock type to rock type. Figure 4 is a plot of refractive index against cell edge for garnets of the various rock types. Garnets from the same rock type fall within a limited field.

Because of solid solution among a large number of end members in the garnet group, it is not possible, with the present information, to determine composition. However, all the garnets of the group are almandine-rich, and generally the higher the refractive index the greater the almandine content.

The presence of calcium tends to expand the garnet cell, so that the ratio of a garnet's cell edge to its refractive index can be used as a measure of its calcium content (Sturt, 1962). The ratio of cell edge to refractive index ($a_0/n$) of garnets from most of the local rock types is plotted in Figure 5. There is a strong correlation between rock type and garnet composition. The composition of garnet is controlled mainly by the

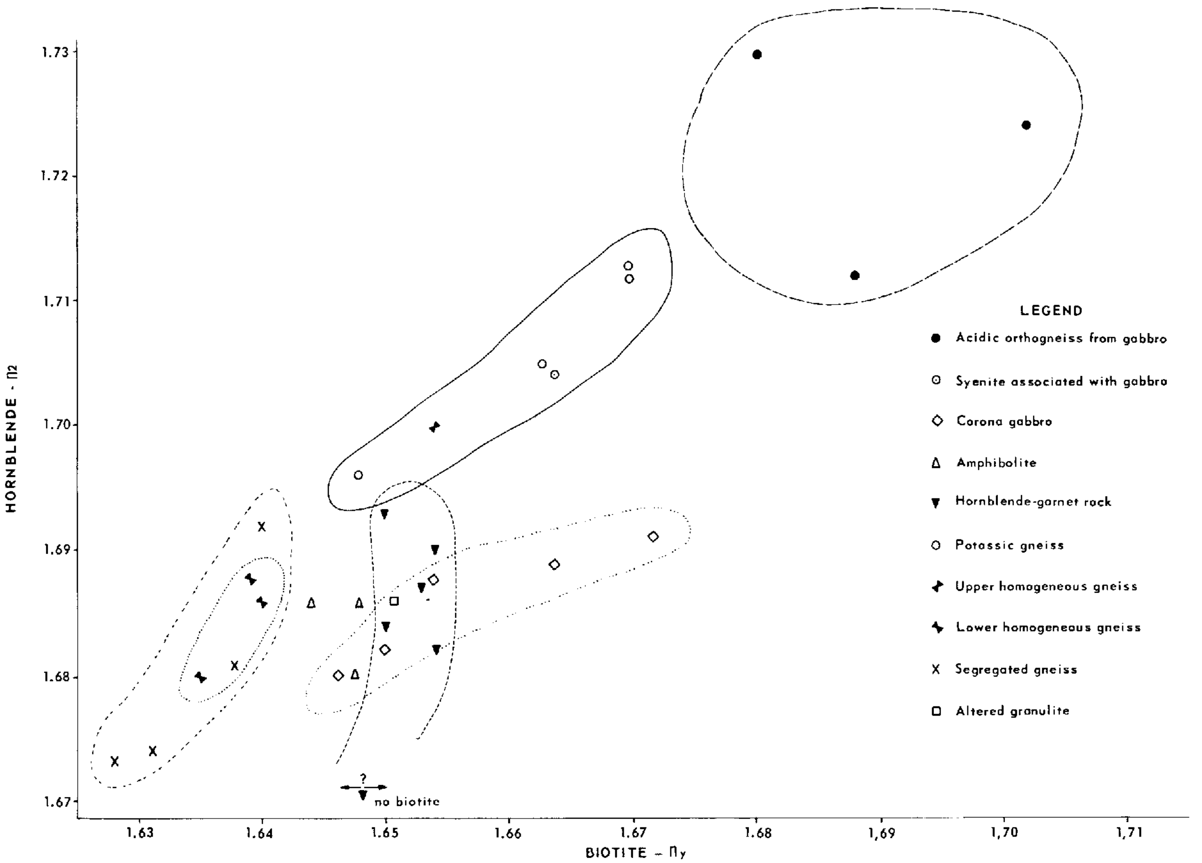



FIGURE 3

VARIATIONS OF REFRACTIVE INDICES OF HORNBLENDE AND BIOTITE WITH ROCK TYPE

.N.R.Q. 1965 B-856

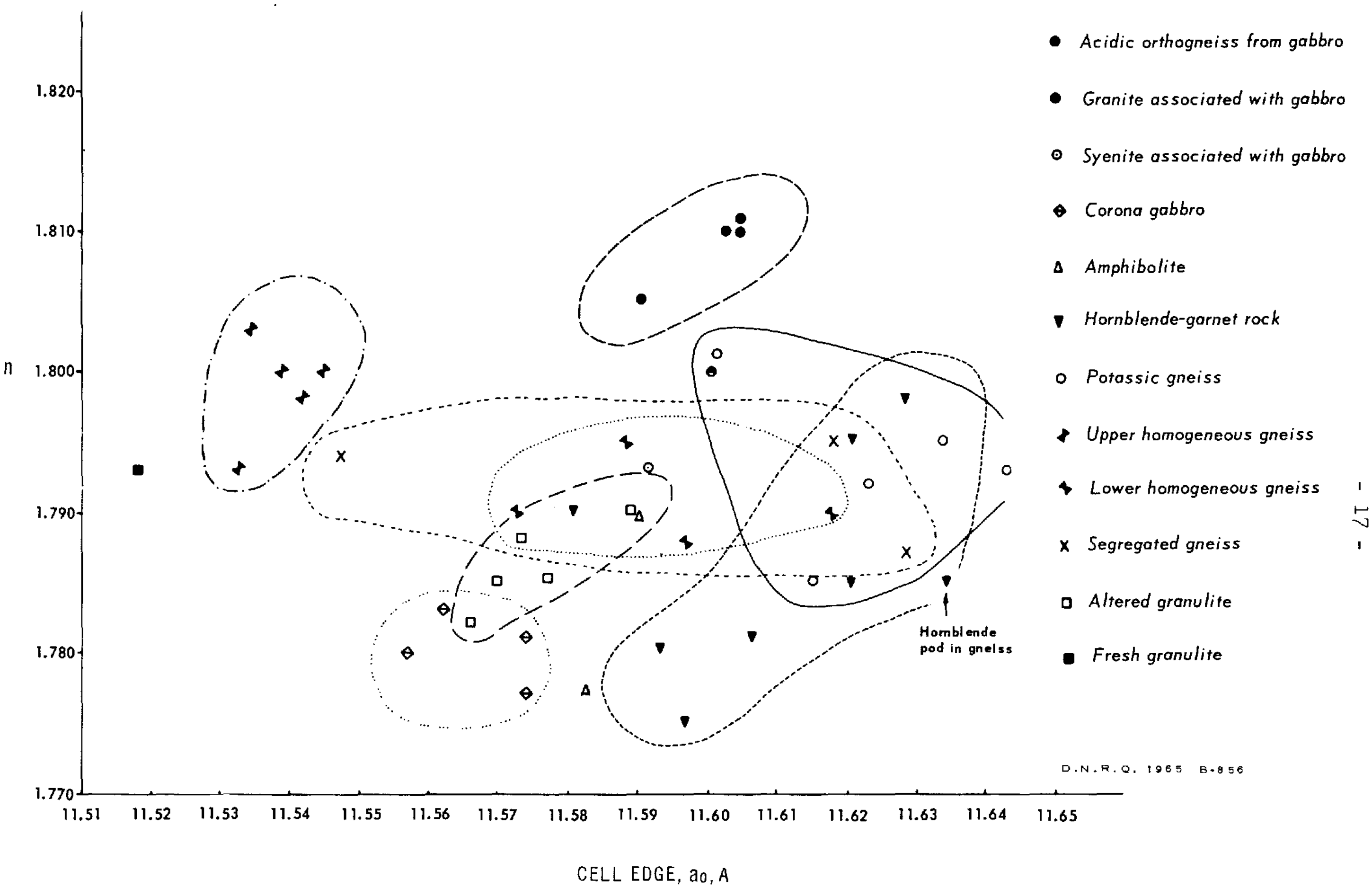



FIGURE 4

VARIATIONS OF CELL EDGE AND REFRACTIVE INDEX OF GARNET WITH ROCK TYPE

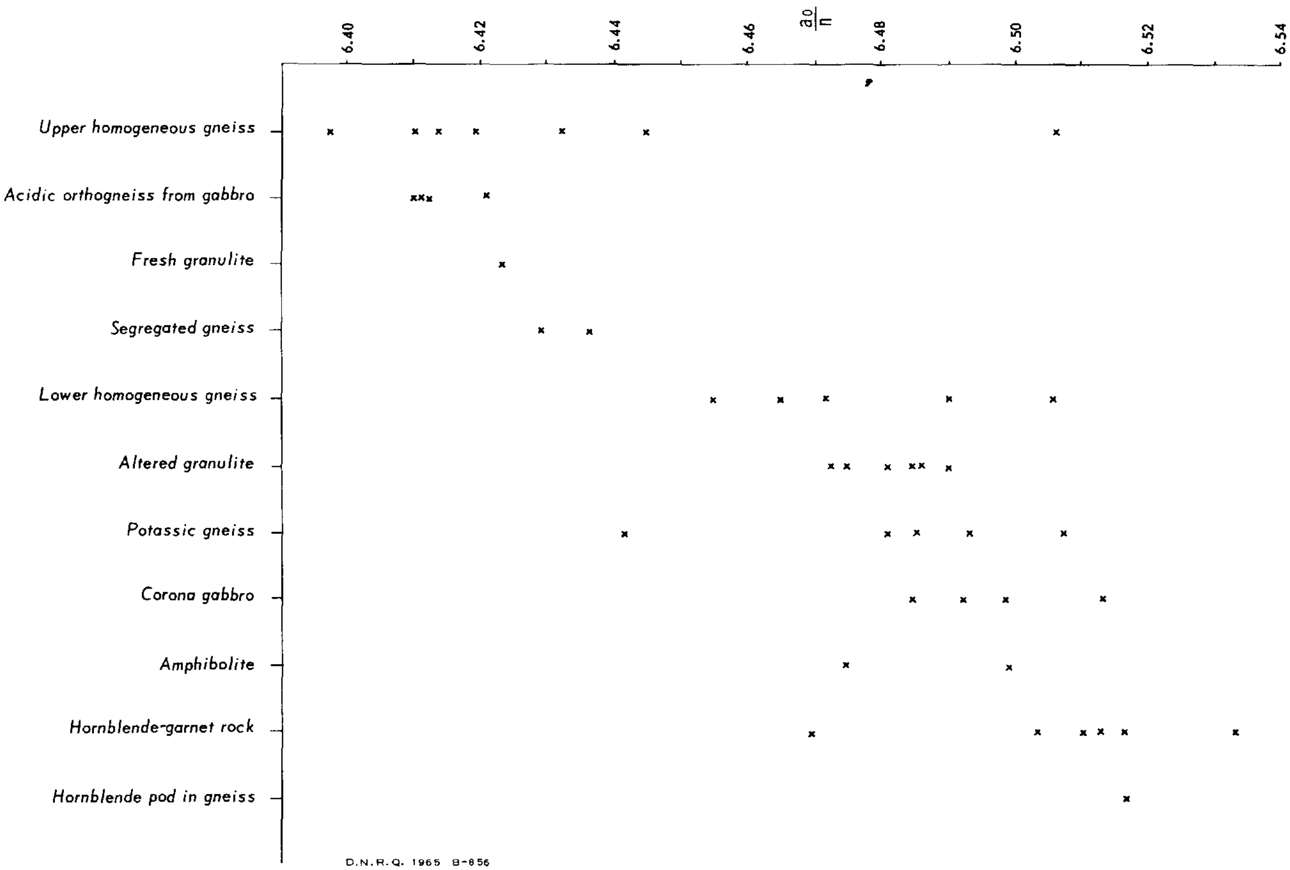



FIGURE 5

VARIATION OF $\frac{a_0}{n}$ OF GARNET WITH ROCK TYPE

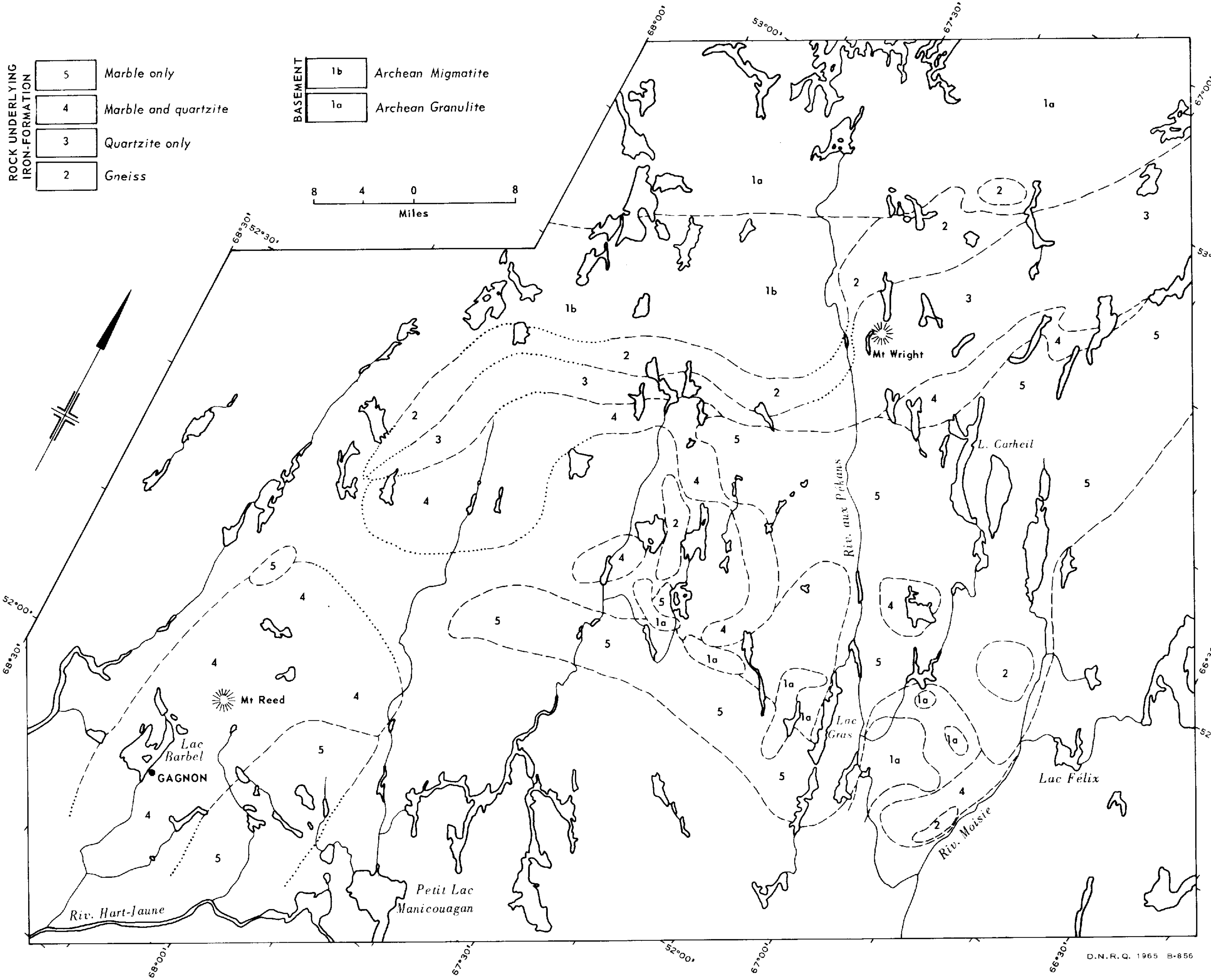



FIGURE 6

SEDIMENTARY FACIES OF ROCKS UNDERLYING THE IRON-FORMATION chemical composition of the rock; thus the more calcic almandines occur in calcium-rich, hornblende-bearing rocks, whereas the more iron-rich ones occur in the ferric-iron-rich acidic orthogneiss. Compositional differences in garnets from rocks of similar composition can be attributed to differences in metamorphic grade. For instance, more calcic garnets occur in the altered granulite and lower homogeneous gneiss than in the more highly metamorphosed fresh granulite and segregated gneiss.

Segregated Gneiss

The most abundant rock type in the area is a coarse-to medium-grained gneiss in which layers or lenses of predominantly felsic minerals alternate with layers of mixed mafic and felsic minerals (Plate IIB). There are both biotite-rich and hornblende-rich varieties of this gneiss. In places the hornblende-rich gneiss occurs as bands about 1/2 mile wide in the biotite-rich type.

In typical specimens, quartz, white plagioclase and in places pink microcline form 1/4- to 1/2-inch felsic bands in alteration with mafic bands. The mafic bands contain shiny black 2 mm. flakes of biotite, which are mixed about 1:2 with quartz and feldspar. In some rocks of this type, mineral segregation takes the form of contorted felsic lenses or mafic speckles instead of bands.

In the biotite gneiss, plagioclase is generally evenly twinned, and may be slightly antiperthitic. Quartz shows undulose extinction, and planes of tiny inclusions cross many grains. Biotite is mostly brown or olive and forms subhedral flakes inclined about $15^{\circ}$ to the foliation. Alteration to chlorite is common. Common accessories are epidote with allanite cores, apatite, zircon and pyrite (Plate VIIA). About half the samples studied show the effects of shear and alteration. In these samples plagioclase is sericitized and partly replaced by microcline. The biotite is ragged and altered to chlorite, and hornblende may be altered to chlorite and sphene. Some sections contain garnet, which may be partly replaced by biotite and feldspar.

Table 4 lists estimates of mineral compositions of 15 thin-sections of biotite-rich and 10 thin-sections of hornblende-rich gneiss. A typical biotite gneiss contains: 40-57% plagioclase (about $An_{28}$), 0-12% microcline, 18-28% quartz, 17-23% biotite, which may be altered to chlorite, up to 2% each of epidote, garnet and hornblende, and traces of muscovite, pyrite, apatite, zircon and sphene.

The hornblende-rich gneiss resembles the biotite-rich type in most respects. All gradations exist between a banded hornblende gneiss and a gneissic granodioritic rock in which the mafic minerals form 2 to 4 mm. specks rather than bands. Most quartz has undulose extinction and forms 0.5 to 1 mm. long lenses made up of several grains. Plagioclase may be partly

## Table 4

### Mineral Compositions of Lower Segregated Gneisses

#### (a) Biotite-rich

| Section | Location | Plag | An 20 30 40 | K-spar | Qtz | Bio | Chl | Hnb | Epi | Garn | Ap | Sph | Others |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C-10-52-60 | 52°27'N.;67°08'W. | 50 | | 5 | 20 | $20^{o}$ | | | tr | | | | Musc 2,Py tr |
| C-20-121-60 | 52°13 1/2'N.;67°05'W. | 36 | | | 44 | | 6 | | | 12 | | | Musc 1,Mag 1 |
| C-28-170-60 | 52°22 1/2'N.;67°18 1/2'W. | 60 | | | 25 | $10^{r}$ | 3 | | tr | 2 | tr | | Py 2,Zr tr |
| C-32-204-60 | 52°26 1/2'N.;67°18 1/2'W. | 50 | | 20 | 15 | $7^{o}$ | | | 2 | | | tr | Alb 5,Zr tr,Tour tr |
| C-37-241-60 | 52°18'N.;67°17'W. | 45 | | 10 | 20 | $18^{o}$ | 8 | | tr | | | | Py tr |
| C-41-261-60 | 52°18'N.;67°23'W. | 53 | | | 25 | $18^{b}$ | | | 1 | | 1 | | Py 1 |
| L-8-34-60 | 52°17'N.;67°05 1/2'W. | 56 | | 13 | 20 | $7^{g}$ | | 1 | 4 | | tr | | Zr tr,Cal 1 |
| L-8-41-60 | 52°26 1/2'N.;67°05'W. | 55 | | | 25 | | 15 | | 2 | | 1 | | Cal 1,Py tr |
| L-28-105-60 | 52°28 1/2'N.;67°26'W. | 50 | | 5 | 15 | 20 | 2 | | 3 | 2 | tr | 2 | |
| L-41-158-60 | 52°23'N.;67°27'W. | 50 | | 5 | 25 | 2 | 15 | | 1 | | | 5 | Musc tr,Py tr |
| G-10-24-60 | 52°29'N.;67°06 1/2'W. | 15 | | 35 | 25 | $15^{b}$ | | | 2 | | 1 | | Musc 2,Zr tr,Cal 3 |
| **D-11-42-61 | 52°26 1/2'N.;66°51'W. | 36 | | | 28 | $34^{o}$ | | | tr | 1 | tr | | Py 1,Musc tr,Zr tr |
| D-42-154-61 | 52°29 1/2'N.;66°41'W. | 53 | | | 23 | $18^{r}$ | | 3 | | 1 | | | Cal tr,Py tr,Zr tr |
| C-13-61-61 | 52°26'N.;67°00'W. | 67 | | | 21 | $10^{r}$ | | | | tr | tr | | Py tr,Cal tr |
| C-30-155-61 | 52°16 1/2'N.;66°50'W. | 52 | | 5 | 13 | | 22 | 3 | tr | 2 | tr | | |
| Mean | | 48.5 | | 6.2 | 22.9 | 11.9 | 4.7 | 0.5 | 1.1 | 1.3 | 0.4 | 0.4 | |
| Mean Deviation | | 8.3 | | 6.8 | 5.5 | 7.1 | 5.6 | 0.7 | 0.9 | 1.6 | 0.3 | 0.7 | |

** Mode, 1500 points

#### (b) Hornblende-rich

| Section | Location | Plag | An 20 30 40 | K-spar | Qtz | Bio | Chl | Hnb | Epi | Garn | Ap | Sph | Others |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C-11-62-60 | 52°28'N.;67°03'W. | 50 | | | 20 | $15^{r}$ | | 15 | tr | | tr | | Zr tr |
| C-18-104-60 | 52°26'N.;67°12 1/2'W. | 65 | | | 12 | $8^{b}$ | | 12 | 1 | | tr | 1 | |
| C-28-171-60 | 52°23 1/2'N.;67°16'W. | 55 | | 4 | 19 | $10^{b}$ | | 8 | 2 | | 1 | 1 | Zr tr |
| C-47-288-60 | 52°28 1/2'N.;67°26 1/2'W. | 55 | | 16 | 7 | $7^{o}$ | | 12 | 2 | tr | tr | 2 | |
| L-28-103-60 | 52°28 1/2'N.;67°23 1/2'W. | 60 | | tr | 14 | $17^{b}$ | | 5 | | tr | 1 | tr | Py 2 |
| L-10-47-60 | 52°25'N.;67°05'W. | 55 | | | 30 | $7^{d}$ | | 5 | | | 1 | 1 | Zr tr |
| D-11-44-61 | 52°26'N.;66°52'W. | 40 | | | 33 | $9^{b}$ | | 13 | | 1 | | | Py 2,Zr tr |
| C-6-21-61 | 52°31 1/2'N.;66°45'W. | 55 | | | 30 | $2^{b}$ | 5 | 5 | tr | | tr | | |
| *C-2-8-61 | 52°30 1/2'N.;66°48'W. | 10 | | | tr | $tr^{b}$ | | 72 | | 11 | | tr | Py tr,Augite 6 |
| **C-21-111-61 | 52°21'N.;66°46'W. | 31 | | 30 | 7 | $16^{dr}$ | | 13 | tr | | 2 | 1 | Mag 1,Zr tr,Py tr |
| Mean (except C-2-8-61) | | 51.8 | | 5.5 | 19.1 | 10.1 | 0.5 | 9.8 | 0.7 | 0.2 | 0.8 | 0.8 | |
| Mean Deviation(except C-2-8-61) | | 7.6 | | 7.8 | 8.1 | 3.8 | 0.9 | 3.6 | 0.6 | 0.3 | 0.5 | 0.5 | |

Plagioclase composition Rittmann method ⟼
Tsuboi method —

Color of biotite: d = dark, r = red, b = brown, o = olive, g = green

* Hnb layer in gneiss
**Section contains K-spar lens

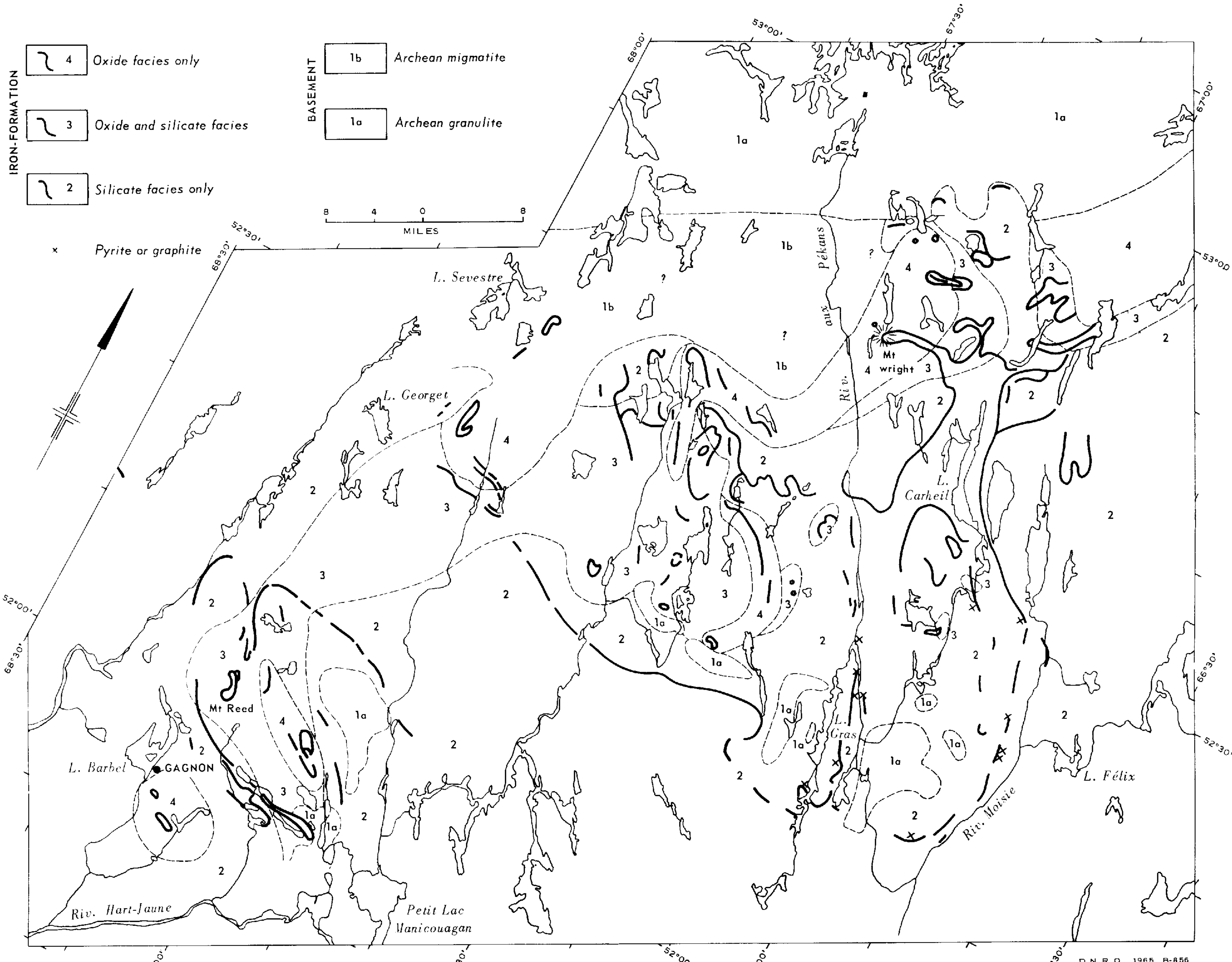



FIGURE 7

SEDIMENTARY FACIES OF IRON FORMATION

altered to sericite or microcline. Microcline has well developed grid twinning. Most of the biotite is brown. Hornblende has an extinction angle of 20 to 24° and the pleochroic formula: X = yellow-green, Y = green, Z = dark green or bluish green. It may be poikilitic and in some sections seems to be partly replaced by biotite and epidote or sphene. Sphene and euhedral epidote generally accompany the mafic minerals. Allanite cores are common in the epidote.

Average mineral composition for the segregated hornblende gneiss is: 44-60% plagioclase ($An_{22-31}$), variable microcline content probably depending on the addition of potassium, 11-27% quartz, 6-14% biotite, 6-14% hornblende, up to 1% each of epidote and sphene, and minor garnet, pyrite and zircon.

Both the biotite- and hornblende-rich types of the segregated gneiss are characterized by organization of the mafic and felsic constituents into separate bands, pods or speckles. Strained quartz, and altered biotite and plagioclase are more common here than in other types of gneiss. Addition of potassium in some places has resulted in the replacement of plagioclase by microcline, garnet by biotite and feldspar, and hornblende by biotite and epidote. Apparently this gneiss formed under conditions of greater mobility and stress than the other Proterozoic rocks. It most likely represents the lowermost Proterozoic, mixed perhaps with some completely recrystallized Archean gneisses.

## Homogeneous Gneisses

The homogeneous gneisses generally occur within a few miles of the Gagnon Group rocks. They occur both above and below, but are best exposed where they underlie the Gagnon Group, as south of Don lake, along Pékans river, and west of Gentilhomme and Moisie rivers.

### Lower Homogeneous Gneiss

In the gneiss below the Gagnon Group, biotite is the principal mafic mineral. It generally occurs as fine flakes distributed evenly through the rock and lying in a single plane, thus giving the rock good fissility (Plate IIA). In places, incipient segregation has formed felsic porphyroblasts or thin felsic bands with biotite selvages. However, the gneiss is not contorted or migmatized like the segregated gneiss.

In thin-section the rock has a clean appearance (Plate VIIB). Its plagioclase is evenly twinned and unaltered. Microcline is rare. Quartz is generally clear but may show a little strain. Biotite is subhedral, brown, and rarely altered to chlorite. Hornblende is variable, but the common type has an extinction angle of 26 to 30° and the pleochroic formula: X = yellow-brown, Y = green, Z = bluish green. It is commonly embayed by felsic minerals.

Garnet is rare. Most sections contain euhedral epidote with cores of allanite. Estimates of mineral compositions of 11 thin-sections of the lower homogeneous gneiss are given in Table 5a. A typical gneiss from this group contains: 49-58% plagioclase($An_{25-31}$), 16-26% quartz, 13-23% biotite, 0-5% hornblende, up to 3% microcline, and traces of pyrite, epidote, apatite and zircon. Garnet and muscovite may occur but are rare.

The more even texture, lack of strain in quartz, and chloritization of biotite, compared with the segregated gneiss, probably result from less stress during crystallization.

Upper Homogeneous Gneiss

The gneiss above the Gagnon Group is similar in texture to the lower gneiss but varies more in composition. It is generally richer in mafic minerals, particularly hornblende and garnet. It also includes gradations into the distinctive types of gneiss described below.

Biotite in thin-section is brown or red-brown and generally lies parallel to the foliation. Hornblende has an extinction angle of 24 to 28%, and in most rocks is pleochroic from yellow-green to blue-green. Both hornblende and garnet are embayed by anhedral felsic minerals. Euhedral epidote with allanite cores grows near the biotite. Mineral compositions of seven thin-sections are given in Table 5b. A typical rock of this group has the composition: 37-59% plagioclase ($An_{23-34}$), 11-34% quartz, 9-21% biotite, 3-11% hornblende, 2-6% garnet, and minor epidote, muscovite, apatite and pyrite. The upper gneisses vary more in composition than the lower, as the mean deviation of every mineral but garnet is greater than that of the same mineral in the lower homogeneous gneiss.

Potassic Gneiss

Microcline-rich gneisses predominate east of Moisie river. They weather pink and are generally finer grained and tougher than the gneisses from other parts of the area. They may or may not show mineral segregation, but in either case tend to break on joints rather than along foliation planes (Plate III). Microcline commonly occurs as lenses or single grayish pink porphyroblasts with warped cleavage faces.

Thin-sections show a matrix of 0.5 to 1.5 mm. equant feldspar grains enclosing oriented crystals of biotite and hornblende, and thin lenses of quartz (Plate VIIIA). Plagioclase is slightly more albitic than in other gneiss types. Twinning of the microcline is more shadowy than well defined. Perthite is not especially common although albite has separated at microcline-plagioclase contacts. A light green pyroxene with $Z \wedge c = 70^{\circ}$ (aegirine-augite) occurs in some samples, and some contain garnet embayed by a mixture of feldspar and biotite.

Table 5

Mineral Compositions of Homogeneous Gneisses

(a) Below Gagnon Group

| Section | Location | Plag | An 20 30 40 | K-spar | Qtz | Bio | Hnb | Garn | Epi | Ap | Zr | Py | Others |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *C-18-103-60 | 52°26'N.;67°09'W. | 60 | | | 20 | $15^{b}$ | 5 | | tr | tr | tr | tr | |
| C-28-169-60 | 52°22 1/2'N.;67°18'W. | 39 | | 8 | 18 | $21^{rb}$ | 1 | 12 | | | tr | tr | Mag tr |
| **C-30-193-60 | 52°25'N.;67°20'W. | 45 | | | 27 | $26^{b}$ | | | tr | tr | tr | tr | |
| C-34-214-60 | 52°26'N.;67°16'W. | 55 | | tr | 12 | $16^{b}$ | 10 | | 3 | tr | tr | tr | |
| C-36-229-60 | 52°27'N.;67°20 1/2'W. | 50 | | 5 | 20 | $15^{o}$ | | | | tr | tr | tr | Musc 5,Cal tr |
| C-2-3-61 | 52°32'N.;66°51'W. | 52 | | | 33 | $14^{d}$ | 2 | tr | 1 | ½ | | | Mag tr |
| *C-4-12-61 | 52°33'N.;66°47'W. | 60 | | | 25 | $10^{b}$ | 5 | | 1 | tr | | | |
| C-15-68-61 | 52°25'N.;67°52'W. | 53 | | | 23 | $23^{o}$ | | | tr | tr | tr | tr | |
| C-30-157-61 | 52°17'N.;66°49'W. | 67 | | 3 | 13 | $14^{b}$ | tr | tr | | tr | | tr | |
| *C-46-237-61 | 52°29'N.;66°45'W. | 53 | | | 17 | $27^{o}$ | | | tr | tr | tr | 1 | |
| D-6-23-61 | 52°30'N.;66°52'W. | 50 | | | 25 | $20^{r}$ | | 4 | | tr | tr | 2 | |
| Mean | | 53.4 | | 1.4 | 21.3 | 18.3 | 2.1 | 1.5 | 0.6 | tr | tr | 0.5 | |
| Mean Deviation | | 4.6 | | 2.0 | 5.0 | 4.7 | 2.4 | 2.3 | 0.5 | | | | |

(b) Above Gagnon Group

| Section | Location | Plag | An 20 30 40 | K-spar | Qtz | Bio | Hnb | Garn | Epi | Ap | Zr | Py | Others |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C-17-97-60 | 52°22'N.;67°01'W. | 55 | | | 10 | $15^{b}$ | 7 | 3 | 2 | 1 | | | Musc 2,Sph 3,Mag 1 |
| C-20-127-60 | 52°15'N.;67°04'W. | 70 | | tr | 20 | $5^{rb}$ | | 5 | tr | | | tr | |
| L-18-69-60 | 52°13 1/2'N.;67°00'W. | 35 | | | 10 | 35 | 15 | | tr | 1 | tr | 2 | |
| G-13-32-60 | 52°24'N.;67°01 1/2'W. | 53 | | | 12 | $18^{d}$ | 11 | 6 | | tr | | | |
| G-14-35-60 | 52°21'N.;67°02'W. | 35 | | | 40 | $7^{rb}$ | 10 | 7 | 1 | tr | | | |
| G-27-77-60 | 52°15'N.;67°13 1/2'W. | 52 | | | 21 | $19^{b}$ | 6 | 3 | tr | tr | | tr | |
| D-5-16-61 | 52°31 1/2'N.;66°55'W. | 35 | | tr | 45 | $10^{r}$ | | 5 | | tr | tr | tr | Musc 1 |
| Mean | | 47.9 | | - | 22.6 | 15.6 | 7.0 | 4.1 | 0.6 | 0.6 | - | 0.4 | |
| Mean Deviation | | 11.0 | | - | 11.6 | 6.5 | 4.3 | 2.0 | 0.5 | 0.3 | - | 0.4 | |

* Banded
** Mode, 1500 points

Plagioclase composition: Rittmann method ⊢—⊣ ; Tsuboi method ——

Color biotite: d = dark, r = red, b = brown, o = olive

Mineral compositions of 12 thin-sections of potassic gneiss are given in Table 6a. A typical gneiss of this type contains: 40-50% plagioclase ($An_{15-25}$), 15-30% microcline, 11-25% quartz, 1-8% biotite, 1-12% hornblende, 0-1% aegirine-augite, about 1% opaque oxide, and traces of apatite, allanite, garnet, zircon and sphene.

The most characteristic features of this gneiss, apart from its high microcline content, are the strong pleochroism and high refractive indices of biotite and hornblende, the tendency for quartz to form long thin lenses parallel to the foliation, and the high content of accessories such as sphene, ilmenite, allanite and zircon. These characteristics seem to have been imposed on gneisses of diverse origins by metasomatism associated with the intrusion of the gabbro that is common east of Moisie river. The same features characterize two samples of segregated gneiss that occur close to basic sills west of Moisie river. Some of the gneisses near Moisie river contain graphite and were probably similar to the rusty-weathering graphitic schist before being metasomatized, but most of the gneiss resembles the lower segregated gneiss more closely than other types. Because of the altered nature of the gneiss any correlation must be tentative.

## Distinctive Upper Metasedimentary Rocks

There are three rock types above the Gagnon Group that can be recognized by their distinctive mineral composition. They are: 1) a rusty-weathering graphitic schist; 2) quartz-mica-kyanite schist; and 3) a rock composed largely of hornblende and garnet.

### Rusty-weathering Graphitic Schist

The graphitic schist is a medium-grained, homogeneous rock distinguished mainly by its rusty weathering and the presence of graphite, pyrite, garnet and in places kyanite, along with the usual quartz, feldspar and biotite. It is most abundant in the western half of the area, particularly in the valley of Pékans river, south of Gras lake, and between Petite Manicouagan river and Hope Lake. A thin band also occurs west of Pegma lake.

Mineral compositions of eight thin-sections of this schist are given in Table 7a. Most samples fall in the range: plagioclase ($An_{23-28}$), 39-52%; microcline, 0-10%; quartz, 15-29%; biotite, 15-22%; garnet, 3-9%; graphite, 1-3%; and minor amounts of muscovite, epidote, apatite and zircon.

In thin-section, biotite is pleochroic from colorless to red-brown, and contains interleaved graphite. Quartz is generally unstrained. Garnet is filled with tiny inclusions of biotite and feldspar. The plagioclase is generally perthitic especially near the edges of felsic clots. This schist was probably deposited as a foul-water silt associated with the oxygen-poor silicate-facies iron-formation.

Table 6

(a) Mineral Compositions of Potassic Gneiss East of Moisie River

| Section | Location | Plag | An (10 20 30) | K-spar | Qtz | Bio | Hnb | Cpx | Epi | Garn | Ap | Opaque | Others | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C-21-109-61 | 52°21 1/4'N.;66°47'W. | 35 | ⊢⊣ | 41 | 14 | $8^d$ | | | tr | tr | 1 | | Chl tr,Musc tr,Py tr | W. of Moisie near basic sill |
| C-24-123-61 | 52°15'N.;66°46'W. | 60 | ⊢⊣ | 19 | 17 | $2^d$ | 1 | | | | | 1 | Sph tr | Granitized paragneiss |
| C-33-173-61 | 52°22'N.;66°38'W. | 55 | | 23 | 21 | $1^d$ | tr | | tr | | tr | tr | Sph tr | Granitized paragneiss |
| C-33-174-61 | 52°21'N.;66°38'W. | 48 | ⊢⊣ | 5 | 30 | $6^d$ | 6 | | 1 | tr | tr | 1 | | K-spar antiperthitic |
| C-35-187-61 | 52°16'N.;66°35'W. | 46 | ⊢⊣ | 13 | 34 | $2^{dr}$ | 2 | | | tr | tr | 1 | Chl 1,Zr tr | |
| C-40-211-61 | 52°26'N.;66°30'W. | 38 | ⊢⊣ | 30 | 26 | $3^d$ | 3 | tr | tr | tr | tr | 2 | Zr tr | |
| C-41-217-61 | 52°26 3/4'N.;66°31'W. | 50 | ⊢⊣ | 23 | 7 | $2^d$ | 13 | 1 | | 4 | tr | 1 | Sph tr,Zr tr | |
| C-43-226-61 | 52°24'N.;66°43'W. | 50 | - | 25 | 15 | tr | 3 | | tr | tr | tr | 1 | Chl 7 | Hnb altered to Chl |
| C-43-229-61 | 52°23'N.;66°44'W. | 33 | ⊢⊣ | 37 | 20 | $1^d$ | 6 | | tr | 1 | tr | 1 | Zr tr | Unsegregated |
| D-26-96-61 | 52°16'N.;66°52'W. | 43 | ⊢⊣ | 14 | 5 | 15 | 16 | 4 | tr | | | | Zr tr | W. of Moisie near basic sill |
| D-31-116-61 | 52°26'N.;66°36 1/2'W. | 43 | ⊢⊣ | 31 | 14 | $3^d$ | 7 | | tr | | tr | 2 | Zr tr,Serp tr | |
| D-31-119-61 | 52°26 1/2'N.;66°36 1/2'W. | 44 | ⊢⊣ | 9 | 12 | $10^d$ | 24 | tr | tr | | tr | | Zr tr | Banded |
| Mean | | 45.4 | | 22.5 | 17.9 | 4.4 | 6.8 | 0.5 | 0.4 | 0.6 | 0.4 | 0.9 | | |
| Mean Deviation | | 6.0 | | 8.8 | 6.9 | 3.3 | 5.5 | 0.7 | 0.2 | 0.6 | 0.2 | 0.4 | | |

(b) Mineral Compositions of Hornblende-garnet Rock East of Moisie River

| Section | Location | Plag | An (10 20 30) | K-spar | Qtz | Bio | Hnb | Cpx | Epi | Garn | Ap | Opaque | Others | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C-40a-216-61 | 53°23'N,66°32 1/2'W. | 27 | ⊢⊣ | | | | 7 | 53 | | 12 | | tr | Sph tr | |
| C-41-219-61 | 52°24'N.;66°33'W. | 56 | ⊢⊣ | | 11 | 10 | 13 | | 2 | tr | tr | | Carb 8,Zr tr | (Scarn rock?) |
| C-42-223-61 | 52°24'N.;66°35'W. | 40 | ⊢⊣ | | | $7^r$ | 8 | 9 | | 25 | 1 | 5 | Scap 3,Py tr | |
| D-39-146-61 | 52°17'N.;66°30'W. | 42 | ⊢⊣ | | | $8^r$ | 29 | 1 | | 18 | 1 | 1 | Sph tr | |
| Mean (except C-41-219-61) | | 36.3 | | - | - | 5.0 | 14.7 | 2.1 | - | 18.3 | 0.6 | 2.0 | | |
| Mean Deviation (except C-41-219-61) | | 6.2 | | - | - | 1.7 | 10.6 | 21.3 | - | 4.4 | 0.5 | 1.8 | | |

## Table 7

### Mineral Compositions of Distinctive Rocks above Gagnon Group

#### (a) Rusty-weathering Graphitic Schist

| Section | Location | Plag | An (20 30 40) | K-spar | Qtz | Bio | Hnb | Garn | Ky | Graph | Musc | Epi | Ap | Zr | Cpx | Others |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C-3-21-60 | 52°20'N.;67°03'W. | 40 | — | 5 | 15 | $25^{r}$ | | 10 | tr | 3 | | | | | | |
| C-37-234-60 | 52°18'N.;67°14 1/2'W. | 32 | — | 23 | 17 | $18^{r}$ | | 3 | | 3 | 2 | tr | | tr | | |
| *C-39-254-60 | 52°16'N.;67°20'W. | 56 | — | 2 | 21 | $13^{r}$ | | 3 | | 2 | | tr | 2 | tr | | |
| L-6-30-60 | 52°30'N.;67°11'W. | 46 | — | | 16 | $23^{r}$ | | 7 | | 4 | 2 | tr | | tr | | |
| G-2-5-60 | 52°21'N.;67°03'W. | 52 | — | | 14 | $21^{r}$ | | 11 | | 1 | | | | tr | | |
| C-16-71-61 | 52°24'N.;66°50 3/4'W. | 37 | — | | 42 | $17^{r}$ | | 2 | | 1 | | | tr | tr | | |
| C-18-84-61 | 52°22 1/2'N.;66°47'W. | 48 | — | 7 | 30 | $10^{r}$ | | 3 | | tr | | tr | tr | tr | | |
| **C-29-152-61 | 52°17 1/2'N.;66°46'W. | 53 | — | | 23 | $17^{r}$ | | 6 | | tr | | | | tr | | |
| Mean | | 45.5 | | 4.6 | 22.3 | 18.0 | | 5.6 | | 1.9 | 0.5 | 0.2 | 0.4 | 0.4 | | |
| Mean Deviation | | 6.9 | | 5.3 | 7.1 | 3.8 | | 2.9 | | 1.1 | 0.8 | 0.3 | 0.5 | 0.1 | | |

#### (b) Quartz-mica-kyanite Schist

| Section | Location | Plag | An (20 30 40) | K-spar | Qtz | Bio | Hnb | Garn | Ky | Graph | Musc | Epi | Ap | Zr | Cpx | Others |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C-20-126-60 | 52°15 1/2'N.;67°04'W. | 25? | | ? | 50 | $8^{r}$ | | | 15 | 3 | | | | | | |
| C-5-13-61 | 52°32'N.;66°51'W. | 5 | | | 50 | $25^{r}$ | | 5 | 8 | 1 | 3 | | 2 | | | |
| C-7-23-61 | 52°30'N.;66°48'W. | | | | 47 | 13 | | 4 | 4 | tr | 31 | | | tr | | |
| C-16-73-61 | 52°24'N.;66°49 1/4'W. | | | | 60 | $20^{r}$ | | 5 | 12 | tr | 2 | | | tr | | |
| Mean | | 7.5 | | 0 | 51.7 | 16.5 | | 3.5 | 9.8 | 1.2 | 9.0 | | 0.5 | 0.2 | | |
| Mean Deviation | | 8.8 | | 0 | 3.8 | 5.7 | | 1.8 | 3.8 | 0.9 | 11.0 | | 0.8 | 0.4 | | |

* K-spar antiperthitic
** East of Moisie river

#### (c) Hornblende-garnet Rock (West of Moisie River)

| Section | Location | Plag | An (20 30 40) | K-spar | Qtz | Bio | Hnb | Garn | Ky | Graph | Musc | Epi | Ap | Zr | Cpx | Others |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| L-17-65-60 | 52°16'N.;67°00 1/2'W. | 35 | — | | | $15^{r}$ | 20 | 20 | | | | tr | 2 | tr | | Sphene 3,Mag 2,Carb tr |
| G-32-99-60 | 52°15 1/2'N.;67°22'W. | 9 | — | | | 6 | 7 | 29 | | | | | | | 47 | Mag 1,Rut 1 |
| C-2-4-61 | 52°31 3/4'N.;66°50'W. | 5 | — | | 7 | 1 | 60 | 15 | | | | | tr | | 13 | Sph tr |
| C-10-36-61 | 52°28'N.;66°51 3/4'W. | 47 | — | | | $1^{r}$ | 34 | 6 | | | | | | | 2 | Trem 7,Mag tr,Carb 5 |
| C-10-37-61 | 52°28'N,66°52'W. | 10 | — | | 17 | | 24 | 31 | | | | | | | 13 | Opaque tr,Rut tr, Opx 1 |
| C-11-42-61 | 52°27 1/2'N.;66°46'W. | | | | | tr | 60 | 20 | | | | | tr | tr | 15 | Opaque 5,Carb 1 |
| D-2-7-61 | 52°32'N.;66°55'W. | 10 | | | 10 | | 60 | 12 | | | | | | | 8 | |
| D-7-27-61 | 52°30 1/2'N.;66°49'W. | | | | 5 | 1 | 21 | 3 | | | | 37 | | | 14 | Py 1,Sph 3,Scap 9,Carb 4 |
| Mean (except D-7-27-61) | | 16.6 | | | 4.8 | 3.3 | 37.9 | 19.0 | | | | | 0.4 | 0.1 | 14.0 | |
| Mean Deviation | | 13.9 | | | 5.5 | 4.0 | 19.0 | 6.9 | | | | | 0.5 | 0.2 | 9.6 | |

Quartz-mica-kyanite Schist

In the eastern part of the area the graphite schist gives place to a quartz-rich mica-kyanite schist. A continuous layer of this schist trends southward from Gentilhomme lake. It is a tough rock which forms rounded outcrops and caps the highest hills in the area. Quartz is the major felsic mineral. Coarse-grained muscovite occurs with the biotite, and pink garnets are present in most samples. Some varieties are graphitic and rusty weathering. Feldspar is notably rare. Deep blue laths of kyanite up to 1 inch long stand in relief on weathered surfaces. The kyanite is concentrated near layers and pods of glassy quartz.

Composition estimates of four thin-sections are given in Table 7b. A typical composition would be: 0-15% plagioclase, 48-55% quartz, 10-22% biotite, 2-20% muscovite, 2-6% garnet, 6-14% kyanite, a trace to 2% graphite, and minor apatite and zircon. A good foliation results from the alignment of mica and kyanite tablets, and elongate lenses of quartz (Plate IXA). The foliation flows around porphyroblasts of garnet or clots of kyanite and quartz. Biotite is red-brown and commonly grows together with muscovite or graphite. Quartz is very clear and unstrained. Garnet is poikilitic.

Before metamorphism this rock was probably an aluminous shale. It is interesting that alumina-rich beds closely overlie the alumina-poor iron-formation. A period of chemical erosion with deposition of iron-formation. A period of chemical erosion with deposition of iron from solution, followed by uplift and transport of the clayey residue, would result in this sequence.

Hornblende-garnet Rock

The mica-kyanite schist is commonly overlain by a massive, black rock composed essentially of 2 to 4 mm. grains of garnet and hornblende, plus some plagioclase and pyroxene. The garnet is evenly distributed through the rock, and is commonly coated with a thin crust of plagioclase. Plagioclase may also be concentrated in thin lenses and bands, giving the rock a weak foliation.

The best exposures are found in the syncline west of Gentilhomme and Moisie rivers where it stands as hills, although it crumbles into coarse sand where exposed to weathering. Although the upper gneisses of the Gras Lake sheet are rich in both hornblende and garnet, little of the true hornblende-garnet rock was found there.

Thin-sections show the biotite to be red or brown. Hornblende is pleochroic from X = yellow-green to Z = deep bluish green or in places brown, and has an extinction angle of 24 to 29°. It is generally anhedral and embayed by feldspar, but may also grow as euhedral grains in pyroxene.

Most of the pyroxene is colorless to light green diopside or augite, with extinction angles ranging from 35 to 65°. In most samples part of the pyroxene is replaced by a colorless or light green amphibole with an extinction angle of about 18° (actinolite), which grades outward into the usual green hornblende. Garnet is pink, commonly poikilitic, and rimmed with plagioclase (Plate IXB). Some of the plagioclase is zoned, with cores of composition $An_{32}$ grading into borders of $An_{23}$.

Mineral compositions of eight thin-sections of hornblende-garnet rock are given in Table 7c. One of these samples is partly altered to epidote, scapolite and carbonate. An average composition of the unaltered sections is: 3-30% plagioclase, 0-10% quartz, 0-7% biotite, 19-57% hornblende, 12-26% garnet, 4-24% clinopyroxene, and minor amounts of opaque oxide, carbonate, apatite, zircon and sphene.

A band of basic gneiss similar to the above rock occurs with the potassic gneisses near the eastern edge of the area. Mineral compositions of four thin-sections are given in Table 6b. Typical specimens of this rock contain: 30-42% plagioclase, 3-7% red biotite, 7-24% hornblende, 0-42% clinopyroxene, 14-23% garnet, a small percentage of opaque oxides, and traces of apatite and sphene. Most samples are rich in pyroxene or amphibole but not in both. The pyroxene is light green, with an extinction angle of 50°, and is partly replaced by green or brown hornblende. Garnet may be replaced by biotite and feldspar, and both garnet and hornblende are poikilitic.

## Gagnon Group

### General

The Gagnon Group consists of three formations: the Duley marble, the Wapussakatoo quartzite, and the Wabush Lake iron-formation. These formations, named by Gastil and Knowles (1960), are mainly chemically precipitated sediments of the Labrador trough which have been metamorphosed by the Grenville orogeny. Rocks of this type occur through a belt extending from north of Wabush lake to Matonipi lake, a distance of about 170 miles. The group takes its name from the iron-mining town of Gagnon, situated near the center of the belt. It appears to lie conformably on the homogeneous biotite gneisses, and to be conformably overlain by other gneisses and schists.

Unit thicknesses are variable and any formation may be missing. Generally the marble and the quartzite underlie the iron-formation. There are two major facies of iron-formation — oxide, and silicate-carbonate facies. A third facies containing olivine and no quartz completes the sequence.

Ore-grade material is generally confined to the oxide facies. The type of sedimentation was controlled largely by the abundance of oxygen at the place of deposition. Where oxygen was plentiful the oxide facies was deposited, accompanied by quartzite, with or without marble. In oxygen-deficient circumstances the silicate-carbonate facies and marble were deposited. The kinds of sedimentary rock accompanying the iron-formation, and the various facies of the iron-formation itself, in the district between Mount Wright and Mount Reed are shown in Figures 6 and 7 (attached), respectively. Similar facies maps covering the area between Carheil and Wabush lakes were published by Gastil and Knowles (1960).

The zone containing the oxide facies iron-formation and quartzite trends NE.-SW., close to the main Archean-Proterozoic contact. During deposition of the Gagnon Group the Proterozoic shoreline apparently lay close to the present Archean-Proterozoic contact. Near shore the iron-formation is underlain by gneisses derived from detrital material. In quieter waters to the southeast, chert and then limestone were laid down. The facies pattern of the iron-formation is similar, with oxide facies in the northwest grading into silicate-carbonate facies to the southeast. Graphite and pyrite indicate reducing conditions in the eastern part of the present area.

In this area the oxide facies of iron-formation occurs near Don and Hippocampe lakes, south of Demi-Mille lake, and near Fire and Midway lakes. Quite continuous layers of silicate-carbonate facies iron-formation and associated marble run along Pékans and Gentilhomme-Moisie rivers, and swing westward near the southern border of the area. Other occurrences are in the synclines near Lamêlée, Hobdad and Midway lakes.

Duley Marble

Marble, the most abundant formation of the Gagnon Group, occurs principally in the valleys of Pékans and Gentilhomme rivers, and in the band trending westward from the south end of Gras lake. It is a coarse-grained, equigranular rock, buff to white on the fresh surface and weathering black or in iron-rich varieties, cocoa-brown (Plate IVA). Because of its massive nature and solubility the marble tends to form blocky outcrops.

Quartz, phlogopite or calcium amphiboles and pyroxenes form up to 60% of the rock, and most exposures contain from 10-30% of these minerals. They occur as discrete grains, or in layers several inches thick, which follow original bedding or later fractures. The long axes of amphiboles and pyroxenes are commonly aligned parallel to the regional foliation. The carbonate portion is mainly dolomite with 0-5% calcite disseminated through it or concentrated beside the silicate minerals.

In the iron-rich varieties of the marble, the calc-silicates are green diopside or actinolite, rather than colorless diopside and tremolite such as occur in the more common varieties.

Visual estimates of the composition of nine thin-sections of marble are given in Table 8a. The first, second, fifth and sixth samples are from silicate-rich bands and do not represent the composition of the marble as a whole. Actually, a thin-section is too small to give an accurate measure of the composition of the coarsely layered marble. Twelve calcites from the Gras Lake - Félix Lake, and Normanville areas were X-rayed, and all found to contain less than 3% $MgCo_3$ in solid solution (Clarke, 1964).

Wapussakatoo Quartzite

Quartzite occurs with the iron-formation near Don, Fire and Midway lakes, and in minor amounts near Carheil and Moisie rivers. It is thinner than the quartzite near Mount Wright and Wabush lake, generally measuring 10 to 50 feet thick. Most occurrences are medium or coarse grained, white or gray in color, and show a coarse layering. It may also be coarsely recrystallized resembling vein quartz, or mica-rich and schistose. Original bedding gives rise to a strong joint set, and faint color bands. The contact with the marble is abrupt and apparently conformable, whereas the contact with the iron-formation is gradational.

In addition to quartz, the quartzite contains minor amounts of hematite, cummingtonite, carbonate, mica, tourmaline, zircon, rutile and, in the eastern part of the area, graphite and pyrite. Table 8b gives estimates of mineral compositions of five thin-sections. Sample C-29-179-60 is gradational with iron-formation, and C-30-153-61 is strongly sheared and altered. In thin-section, the quartzite is made up of a mosaic of 0.5 to 2mm. quartz grains. The grains generally have sutured borders and show undulose extinction in segments set at an angle to the foliation. The minor minerals occur between the quartz grains or included in them. Elongate or foliate minerals such as amphibole, mica, hematite, or graphite, lie parallel to the main foliation.

There is disagreement as to whether the quartzite is the metamorphosed product of a clean quartz sand or of a chert. Any distinguishing sedimentary structures have been destroyed by metamorphism. From a study of their zircons, Gross (1955) concluded that the Mount Wright quartzites are derived from beach sands. Murphy (1961), after studying their carbon content, concluded that they are metamorphosed cherts. Additional evidence of their development from chert is the gradation between quartzite and iron-formation, and the similarity between the quartzite and the quartz bands in the iron-formation.

In the less metamorphosed part of the Labrador trough the iron-formation (Sokoman Formation) is underlain by both chert (Fleming Formation) and quartz sandstone (Wishart Formation). Most likely the same situation existed where the rocks were metamorphosed, and the quartzite originally contained both cherty and sandy parts. However, the author believes that in

Plate I

A- Outcrop of Archean granulite. The rock lacks fissility and has generally migmatized appearance.

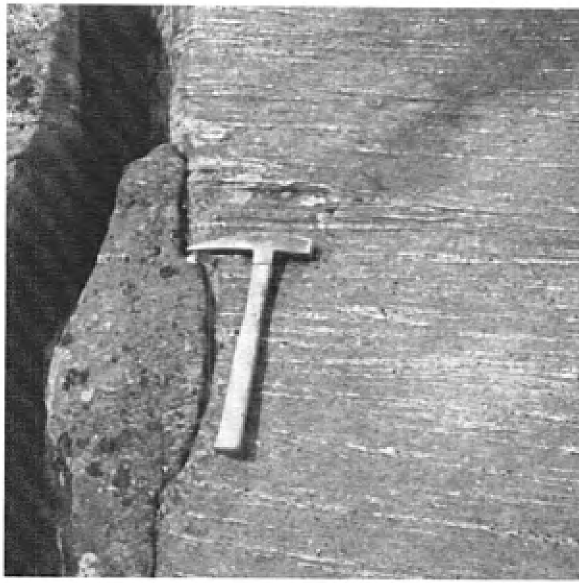
B- Contorted granulite. Note mafic pods and discordant granitic bodies.

Plate II

A- Lower homogeneous gneiss. Note typical good fissility resulting from even foliation. Felsic bands show near the bottom of the photo.

B- Segregated gneiss. Note mafic layers between prominent, closely spaced felsic bands.

Plate III



A- Even foliation in potassic gneiss from near Moisie river. There is poor fissility parallel to the foliation.

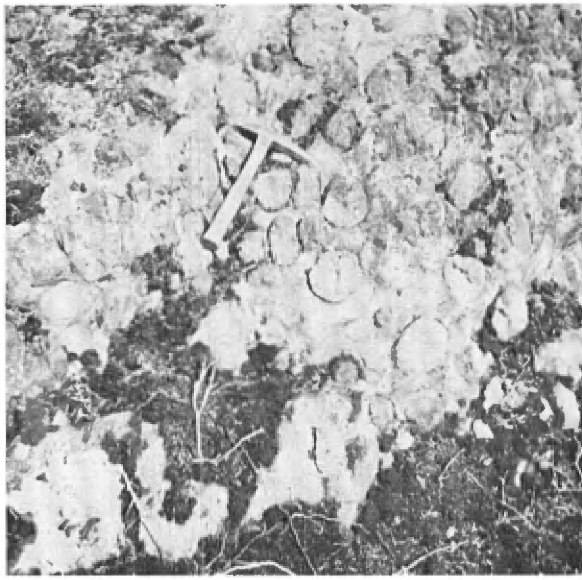
B- Cliff of potassic gneiss. Strong joints and poor fissility result in jagged, blocky outcrops.

Plate IV

A- Black-weathering Duley marble. Relatively pure carbonate beds are interlayered with bands containing quartz and calc-silicates.

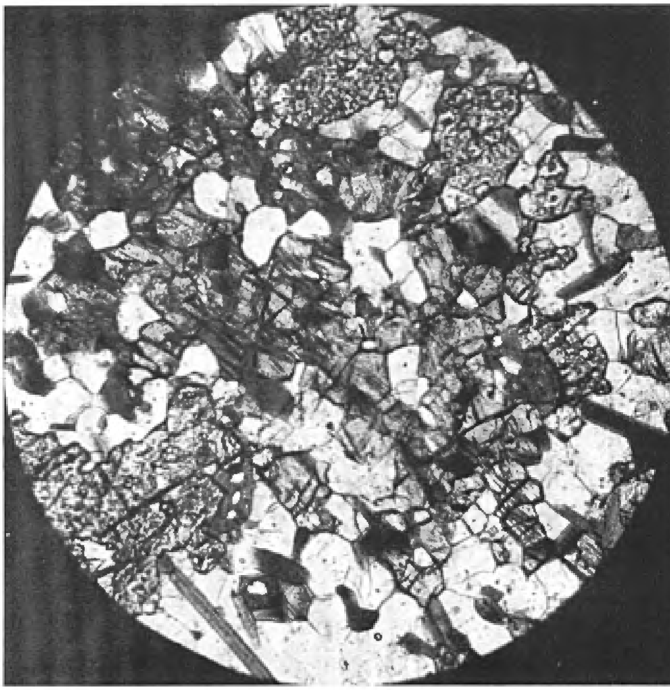
B- Silicate-carbonate facies of Wabush iron-formation. This exposure is composed of quartz and interlayered pyroxene bands.

Plate V

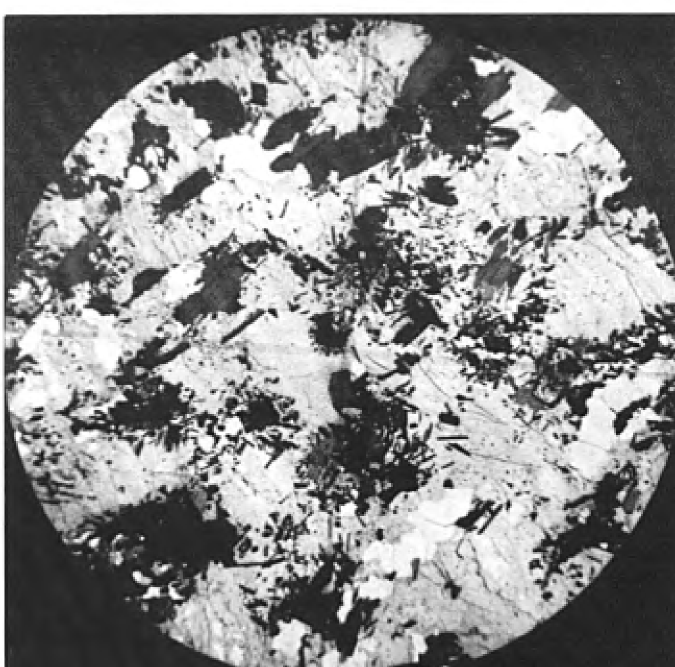


A- Hobdadite, a variety of the silicate-carbonate facies of the Wabush iron-formation. Nodules of hypersthene have grown in a matrix of chlorite and iron carbonate. This outcrop is on the top of Lamêlée hill.

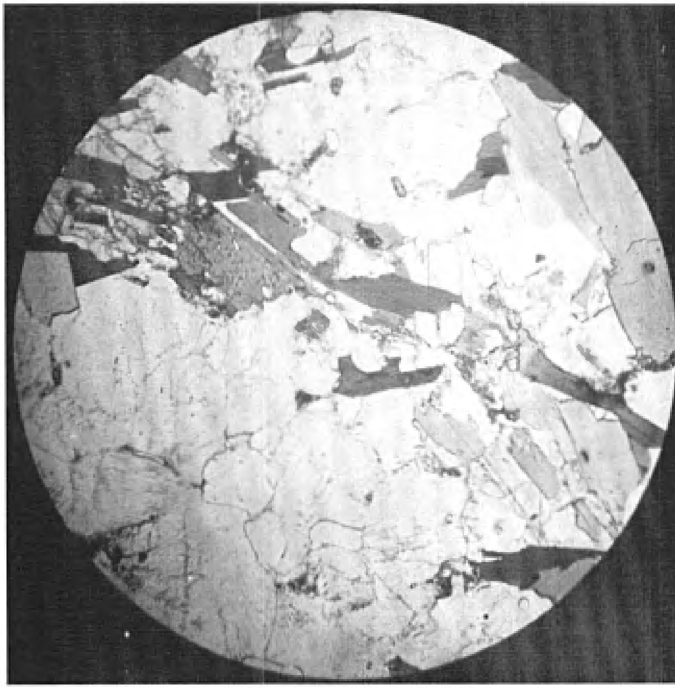
B- Sand-plain along Pékans river near the southern boundary of area.



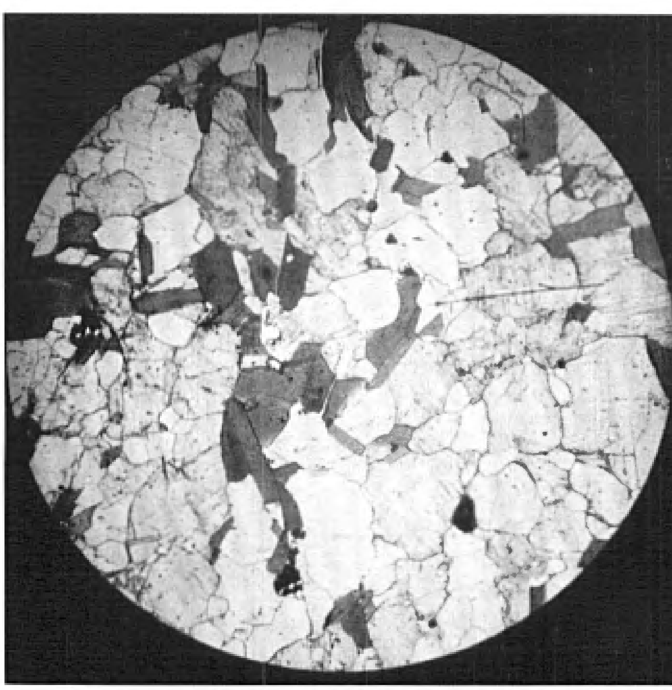
A- Photomicrograph of Archean granulite, showing hypersthene grain partly replaced by fine-grained biotite and surrounded by garnet. Note the mosaic texture of the feldspar. Plane polarized light, dia. 1.5 mm.



B- Photomicrograph of altered granulite, showing several clusters of fine-grained biotite, garnet and feldspar, characteristic of the granulite in which most of the hypersthene has been destroyed. Plane polarized light, dia. 6 mm.

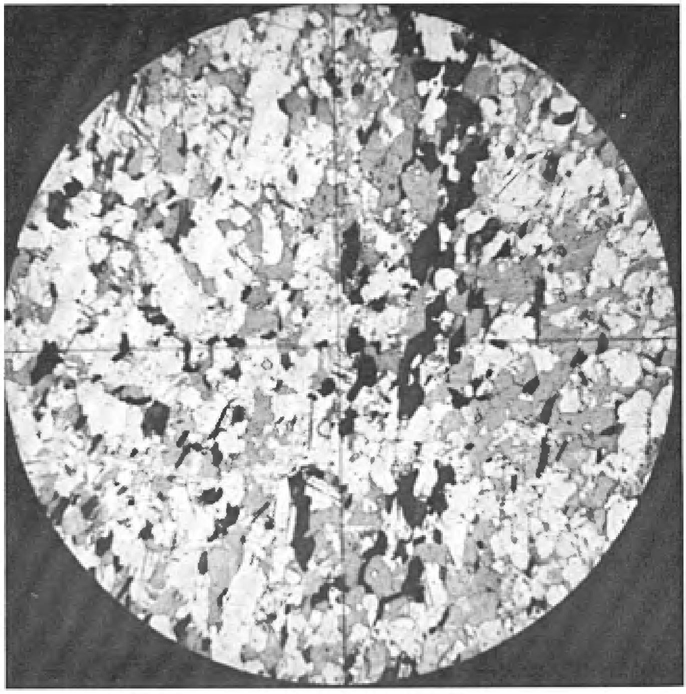


A- Photomicrograph of segregated gneiss in which a layer of biotite, with minor epidote, calcite and apatite, has separated from the surrounding quartz and feldspar. Plane polarized light, dia. 6 mm.

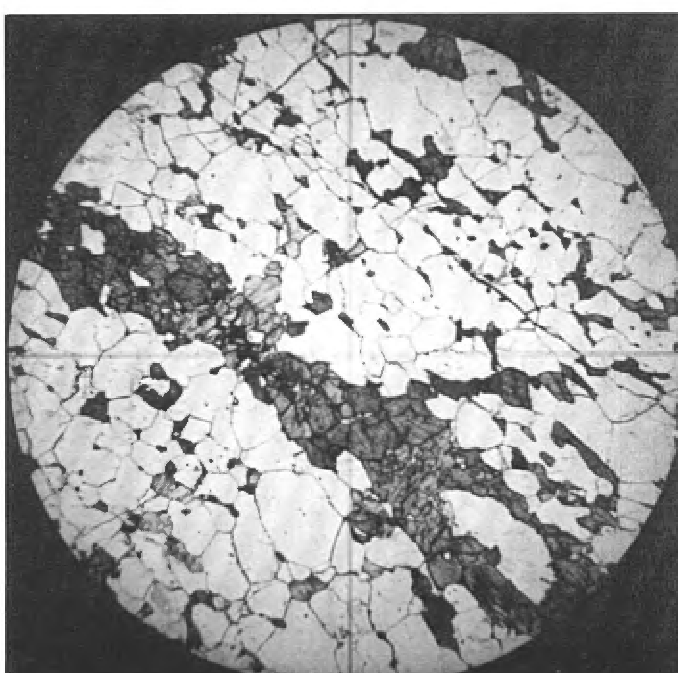


B- Photomicrograph of lower homogeneous gneiss in which biotite, garnet, quartz and feldspar are evenly distributed. Plane polarized light, dia. 6 mm.

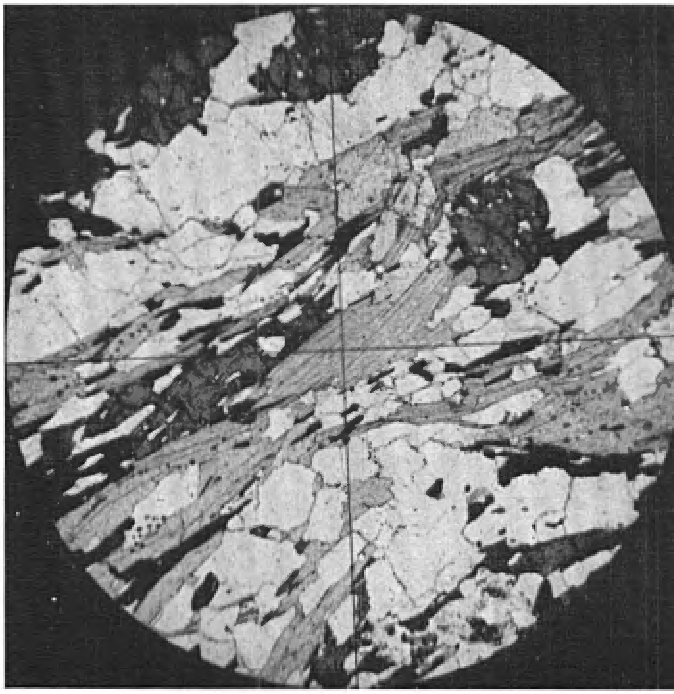
Plate VIII



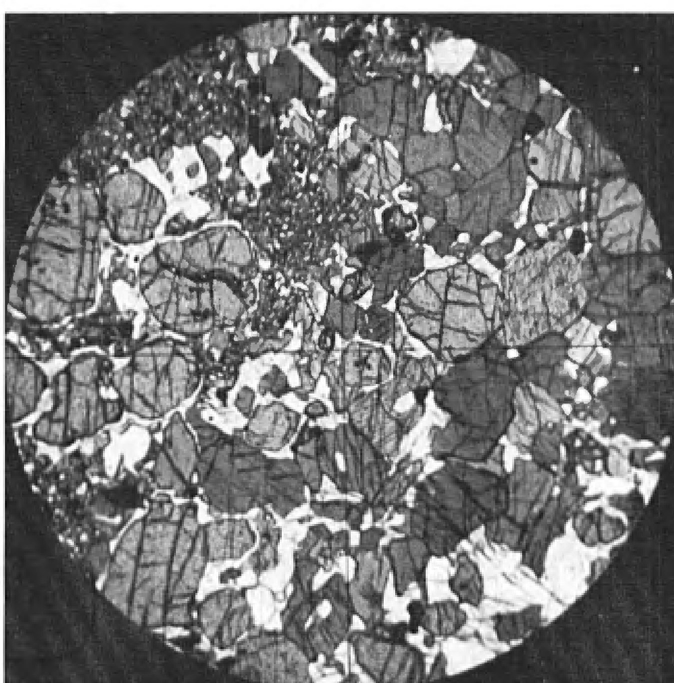
A- Photomicrograph of potassic gneiss. Stained thin-section shows typical texture. Mafic minerals are hornblende, biotite and magnetite. Plane polarized light, dia. 6 mm.



B- Photomicrograph of silicate-carbonate facies of Wabush Lake iron-formation. Layers of hypersthene alternate with mosaic quartz. Plane polarized light, dia. 6 mm.

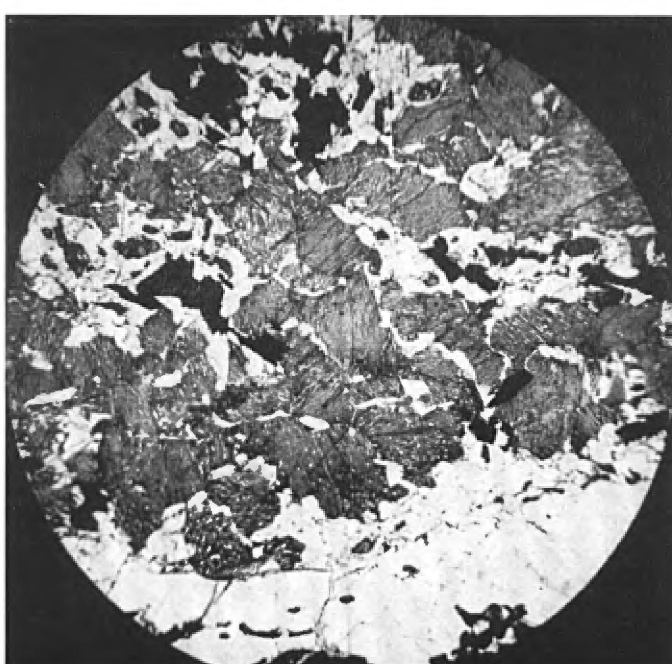


A- Photomicrograph of quartz-mica-kyanite schist. Aligned crystals of muscovite, biotite, kyanite and graphite bend around a swelling of quartz and garnet. Plane polarized light, dia. 6 mm.



B- Photomicrograph of hornblende-garnet rock, composed of garnet and hornblende and symplectitic intergrowths of clinopyroxene and plagioclase. Plagioclase also occurs interstitially to the mafics, and as a thin coating on the garnet. Plane polarized light, dia. 6 mm.

A- Photomicrograph of gabbro coronite. Olivine core is surrounded by successive haloes of orthopyroxene, uralite, and garnet in contact with laths of altered plagioclase. Reaction rims also form between augite and plagioclase. This gabbro still shows an ophitic texture and is less altered than most of the gabbro seen. Plane polarized light, dia. 6 mm.



B- Photomicrograph of acidic orthogneiss (stained). Plagioclase-mafic speckles lie in a groundmass of very perthitic K-spar. Mafics are hornblende, garnet, aegirine-augite, biotite and magnetite. Plane polarized light, dia. 6 mm.

Flat-topped gabbro hill near south end of Gras lake.

Plate XI

Chute over granitized gneiss on Moisie river below Félix lake.

Plate XII

## Table 8

### (a) Mineral Compositions of Duley Marble

| Sample | Location | Qtz | Opx | Cpx | Cumm | Trem | Carb | Mag | Hem | Phlg | Others | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C-1-5-60 | 52°15'N.;67°05'W. | 40 | | 40 | | 15 | 5 | | | | | Cpx may be white or green |
| C-6-34-60 | 52°28'N.;67°10'W. | tr | | 75 | | 15 | 10 | | | | | Hand spec. has 60% carb |
| C-30-185-60 | 52°26'N.;67°20 1/2'W. | 5 | | | | 2 | 90 | 1 | | | | |
| C-39-250-60 | 52°17'N.;67°20 1/2'W. | 1 | | | | | 95 | | | 3 | Chl 1 | |
| D-26-100-61 | 52°15 1/4'N.;66°47 1/2'W. | | | | | | 65 | | | 1 | Talc 10,Antig 25 | Talc and antig after olivine |
| D-26-101-61 | 52°15 1/4'N.;66°47 1/2'W. | 10 | | 50 | | 10 | 10 | | | | Plag 20 | |
| C-5-18-61 | 52°31'N.;66°51 1/2'W. | 1 | | 3 | | 8 | 85 | | | 1 | | |
| C-8-27-61 | 52°33'N.;66°59'W. | 1 | | 1 | | 2 | 96 | | | | | |
| C-16-74-61 | 52°24'N.;66°48'W. | | | | | | 100 | | | | | Dol 95%,Cal 5% |

### (b) Mineral Compositions of Wapussakatoo Quartzite

| Sample | Location | Qtz | Opx | Cpx | Cumm | Trem | Carb | Mag | Hem | Phlg | Others | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C-14-73-60 | 52°29'N.;67°05'W. | 93 | 4 | ? | | | 2 | | | | Rut tr | |
| C-29-179-60 | 52°21'N.;67°23'W. | 90 | | | | | tr | | 5 | | Anth 3,Musc,Zr,Ap,Tour tr | |
| C-30-153-61 | 52°15 1/2'N.;66°48'W. | 70 | | | | | | | | | Bio 7,Py 3,Gr 9,Garn 10 | Sheared and altered |
| C-32-169-61 | 52°15 1/2'N.;66°53'W. | 95 | | tr | 2 | | | | | | Gr 3 | |
| D-32-120-61 | 52°26 1/2'N.;66°43'W. | 99 | | | | | | | | | Epi tr | |

### (c) Mineral Compositions of Wabush Iron-formation (Oxide Facies)

| Sample | Location | Qtz | Opx | Cpx | Cumm | Trem | Carb | Mag | Hem | Phlg | Others | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C-36-227-60 | 52°27'N.;67°20 1/2'W. | 60 | | | | | | | 40 | | | |
| C-47-297-60 | 52°30'N.;67°26 1/2'W. | 60 | | | | | | | 15 | | Musc 20,Bio 2,Tour 1,Zr 1 | |
| C-9-32-61 | 52°28'N.;66°59'W. | 75 | 10 | tr | | | tr | 15 | | | | |

the present area, containing the quiet-water facies of the iron-formation sequence, most of the quartzite is recrystallized chert.

## Wabush Lake Iron-formation

### Oxide Facies

This facies, the economically important member of the Gagnon Group, occurs in the Don Lake and Demi-Mille Lake bands, at Fire lake and, to a lesser extent, on Hobdad and Lamêlée hills, east of Midway lake, and south of the westward bend in Petite Manicouagan river.

The iron occurs as blue-gray specular hematite or black magnetite, depending on the oxidation state of the original sediment. The quartz-magnetite facies of iron-formation is gradational between the quartz-hematite and silicate-carbonate facies.

Most outcrops are banded, with 1/4- to 1-inch layers of mixed quartz and hematite alternating with layers of gray glassy quartz. Thin layers or streaks of green actinolite may occur beside the hematite bands, and cummingtonite or hypersthene accompanies the magnetite. Quartz-magnetite iron-formation is generally finer grained, more massive, and thinner than the quartz-hematite type. The iron-formation contains between 10 and 45% iron oxide, and generally averages about 30%.

Thin-sections show layers of mixed quartz and fine-to medium-grained (0.2-2 mm.) hematite or magnetite alternating with thicker layers of quartz. The quartz has a weak undulose extinction and a mosaic texture, and may be slightly elongated parallel to the foliation. Hematite forms coarse tabular grains parallel to the foliation, or finer grains included in the quartz. Magnetite forms equant anhedra, which are commonly rimmed or veined by hematite. Minor amounts of carbonate, mica, actinolite, cummingtonite, hypersthene, tourmaline and zircon make up the rest of the rock.

Table 8c gives compositions of three thin-sections of oxide facies iron-formation — two hematite-rich and one magnetite-rich. Sample C-47-297-60 is gradational with the overlying mica schist. The tourmaline occurs in the micaceous parts of this rock. The zircon forms small grains with a length to width ratio of about 3:1.

### Silicate-carbonate Facies

This rock occurs with the Duley marble in the Pékans River valley, west of Carheil and Moisie rivers, southwest of Hope lake, and near Midway, Keg, Lamêlée and Hobdad lakes. Measured thicknesses range from 40 to 400 feet, the thickest being near Pékans river.

It is composed essentially of quartz, a brown (hypersthene) and a green (diopside-hedenbergite) pyroxene, cummingtonite, carbonate, and magnetite, plus minor amounts of garnet and graphite. Its color is brown or green depending on which pyroxene is predominant. The quartz and iron-silicates form alternating layers or irregular masses (Plate IVB). Magnetite occurs in both the quartz and iron-silicate portions. In some rocks carbonate occurs as rusty-weathering bands or lenses. Carbonate-rich outcrops are generally low in quartz. Most varieties of the rock are resistant to erosion, and thus tend to form hills with good outcrops.

The silicate-carbonate facies of the iron-formation has an extremely variable composition. Field data give the following range in composition: 10-30% orthopyroxene, 0-40% diopside-hedenbergite, 25-70% quartz, 0-10% carbonate, 10-30% cummingtonite, 5-10% magnetite, 0-5% garnet, and 0-3% graphite. These are common compositions, but any of the above minerals may be absent from individual specimens. Table 9a gives estimated mineral compositions of 24 thin-sections of silicate-carbonate iron-formation. The compositional range is large, and few of the individual sections are close to the average.

The most common variety of the rock contains layers of medium-grained (1.5 mm.) quartz with minor pyroxene and magnetite, alternating with fine-grained (0.5 mm.) quartz and about 35-50% pyroxene, with or without magnetite. The quartz layers are made up a mosaic of equidimensional grains with sutured borders, and generally even extinction (Plate VIIIB). The orthopyroxene is brownish pink, orthorhombic, optically negative, and not strongly pleochroic. It ranges in composition from ferrohypersthene to eulite, and commonly forms large (2-4 mm.) poikilitic grains. The green pyroxene is monoclinic with an extinction angle of 42 to 55°. It is optically positive, and has a strong basal parting. Most of the clinopyroxene is ferrosilite, but some is salite. Cummingtonite commonly replaces the hypersthene, but may also occur as discrete grains in the silicate layers. It is colorless to light brown, with polysynthetic twins inclined to the c axis, and has an extinction angle of 17 to 23°. Carbonate is generally partly altered to limonite.

Magnetite makes up 5-10% of the rock, but is more abundant in the western part of the area. It reaches 30% over thicknesses of 20 to 30 feet in the small synclines southeast of Demi-Mille lake, south of the south bend of Petite Manicouagan river, and on Hobdad and Lamêlée hills.

Olivine-pyroxene-carbonate Facies

A distinctive rock characterized by large pyroxene porphyroblasts, and olivine grains set in a groundmass of chlorite or amphibole, occurs in places at the top of the iron-formation. This rock was found at the south end of the Y-shaped lake lying between Gras lake and Pékans river, at the top of Hobdad and Lamêlée hills, and in the southwest corner of the area.

## Table 9

### (a) Mineral Compositions of Wabush Iron-formation (Silicate-carbonate Facies)

| Sample | Location | Qtz | Opx | Cpx | Cumm | Carb | Mag | Oliv | Antig | Chl | Others | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C-1-1-60 | 52°16'N.;67°06'W. | 3 | 65 | 25 | 5 | | 2 | | | | | Otc. has Qtz 50,Cpx 40,Opx 10 |
| C-1-3-60 | 52°16'N.;67°05'W. | 2 | 45 | | 6 | 35 | 7 | | | | Scap 4 | |
| C-2-13-60 | 52°17'N.;67°02'W. | | 60 | 30 | | 10 | | | | | | |
| C-3-16-60 | 52°19'N.;67°04'W. | 55 | 12 | 23 | 5 | | | | | | Gr 5 | |
| C-3-18-60 | 52°19'N.;67°03'W. | | 65 | | | 8 | 7 | | | | Bio 5,Hnb 15,Garn 2 | |
| C-6-35-60 | 52°28'N.;67°09 1/2'W. | tr | 75 | 10 | 15 | | tr | | | | | Hd.spec.-Cpx 45,Opx 35,Mag 10 |
| C-10-59-60 | 52°28'N.;67°04'W. | | 75 | | | | 5 | | | | Bio 5,Gr 5,Garn 10 | |
| C-13-67-60 | 52°28'N.;67°00'W. | 15 | 70 | | 8 | 5 | | | | | | |
| C-19-111-60 | 52°23 1/2'N.;67°05'W. | 45 | | 40 | 2 | 5 | 2 | | | | Gr 3 | |
| C-26-162-60 | 52°17'N.;67°12 1/2'W. | | 50 | 20 | | 25 | 5 | | | | | |
| C-34-212-60 | 52°26'N.;67°16 1/2'W. | | x | x | x | | x | | | | | Section not representative |
| C-35-217-60 | 52°26'N.;67°17'W. | 54 | 15 | 20 | 2 | | 11 | | | | | |
| C-35-222-60 | 52°26'N.;67°17'W. | 40 | 10 | 20 | 3 | | 25 | | | | | |
| C-39-251-60 | 52°17'N.;67°20 1/2'W. | 50 | | | 40 | 10 | 1 | | | | Lim tr | |
| C-40-256-60 | 52°16 1/2'N.;67°25'W. | 15 | 30 | 2 | 5 | | 50 | | | | | |
| C-44-272-60 | 52°22'N.;67°28'W. | 46 | 37 | | | 13 | 1 | | | | Lim 1,Py 1,Minn tr | |
| C-44-277-60 | 52°21'N.;67°28 1/2'W. | 40 | | 30 | 7 | 3 | 15 | | | | Chl 8 | Representative |
| L-3-10-60 | 52°15'N.;67°05'W. | 5 | 60 | 30 | tr | | | | | | Gr 2 | Comp. from hand spec. |
| D-1-4-61 | 52°32'N.;66°56 1/2'W. | 70 | 25 | | | 3 | 2 | | | | | |
| D-24-84-61 | 52°18'N.;66°49'W. | 8 | 25 | | 30 | | | | | | Plag 8,Bio 1,Garn 27 | |
| C-12-48-61 | 52°27'N.;66°49'W. | 85 | 5 | 1 | 10 | | tr | | | | Gr tr,Bio tr | |
| C-16-77-61 | 52°24'N.;66°46'W. | 89 | 6 | 1 | 4 | | tr | | | | Gr 1,Ap tr,Stilp tr | |
| C-18-83-61 | 52°23'N.;66°45 1/2'W. | 60 | 40 | tr | | | | | | | | |
| C-32-170-61 | 52°15 1/2'N.;66°53'W. | 62 | | 6 | 31 | 1 | | | | | Gr 1/2 | |
| Mean of 23 | | 32.4 | 30.5 | 11.2 | 7.5 | 5.1 | 5.8 | | | | 4.6 | |
| Mean Deviation | | 27.7 | 23.7 | 11.8 | 7.7 | 6.0 | 7.0 | | | | | |

### (b) Mineral Compositions of Wabush Iron-formation (Olivine-pyroxene-carbonate Facies)

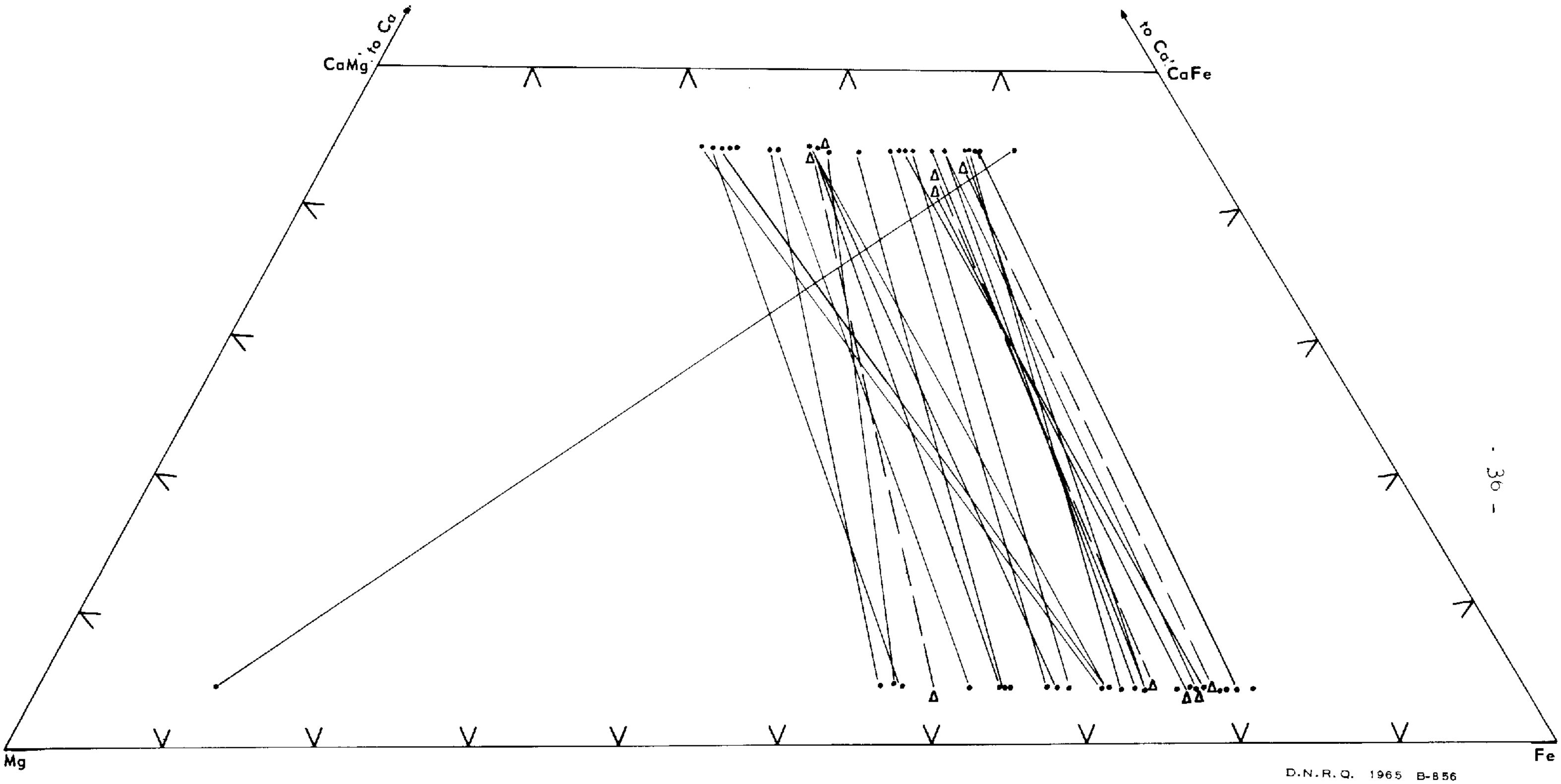
| Sample | Location | Qtz | Opx | Cpx | Cumm | Carb | Mag | Oliv | Antig | Chl | Others | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C-6-36-60 | 52°27'N.;67°09'W. | | 45 | | | 35 | 10 | 10 | | | Bio tr | Carb pod in I.F. |
| C-38-246-60 | 52°16'N.;67°28'W. | | 10 | | | 3 | 15 | 5 | | | Hnb 65,Spinel tr | Opx ens? Pigeonite? |
| C-44-273-60 | 52°22'N.;67°28'W. | | 35 | | 5 | 27 | 9 | 17 | | | Bio 5,Spinel 2,Zr tr,Garn tr | |
| C-46-284-60 | 52°25'N.;67°29'W. | | | | | 3 | 7 | 1 | 50 | 35 | Lim 2,Garn 2 | |

The rock is coarse grained, dark green to black, and rusty weathering. Some varieties are tough and resist weathering; others weather easily, leaving the pyroxenes projecting from the surface. South of Petite Manicouagan river the rock is cut by thin stringers along which the pyroxene is altered to hornblende and garnet. In shears the rock alters to soft chlorite schist.

Table 9b gives the mineral compositions of three thin-sections of the rock and one comparable section from an olivine-carbonate pod in the common type of silicate-carbonate iron-formation. These rocks are characterized by the presence of olivine or its alteration products, and by the absence of quartz. In general, the composition of unaltered sections falls in the range: orthopyroxene, 17-43%; dolomite, 10-44%; olivine, 7-15%; magnetite, 10-14%; up to 5% cummingtonite; and traces to a few per cent of biotite, garnet and spinel. The orthopyroxene and cummingtonite are richer in magnesium than the usual silicate iron-formation. The orthopyroxene is bronzite, generally full of schiller magnetite. Olivine is optically negative, has a 2V of $70^{\circ}$, and forms rounded grains which may be colorless or reddish brown. The brown color seems to be a staining or an alteration product, but does not affect the optical properties of the mineral. Chlorite, carbonate and, in one thin-section, hornblende form the groundmass separating clots of olivine and orthopyroxene. Garnet and green spinel are accessories.

Lamêlée and Hobdad hills are capped by a striking variety of this rock, termed 'hobdadite'. It is made up of 3-inch rosette-like nodules of gray hypersthene set in a groundmass of green chlorite and buff iron carbonate (Plate VA). Some of the chlorite flakes have been bent by the growing hypersthene. In places the rock is sheared, with accompanying development of fibrous brown cummingtonite and brittle green mica. This variety of iron-formation was first described and named by Kranck (1961).

Forty-one samples of silicate iron-formation, well spread over the Gras Lake - Félix Lake, and Normanville (Clarke, *) areas, were chosen for further study. The refractive indices of cleavage fragments of their amphiboles and pyroxenes were determined, and partial analyses of coexisting pyroxenes of six of the samples were made. These pyroxene compositions are plotted in Figure 8. Tie lines join coexisting pairs of pyroxenes. The great majority of the pyroxenes lie within the composition range: enstatite$_{19-43}$-ferrosilite$_{81-57}$, and diopside$_{27-58}$-hedenbergite$_{73-42}$. In coexisting pairs the clinopyroxene generally has a slightly higher $Mg^{++}:Fe^{++}$ ratio than the accompanying orthopyroxene. The $Mg^{++}:Fe^{++}$ratio is also greater in diopside than in coexisting cummingtonite, and greater in cummingtonite than in coexisting orthopyroxene. Earlier work by Kranck (1961) on samples collected near Fire lake and Mount Reed and that by Mueller (1961) on samples from Bloom lake in the Normanville area show similar compositional range and $Mg^{++}:Fe^{++}$ distribution. The relative concentration of $Mg^{++}$ in the calcium-rich silicate has been explained by Ghose (1962). He shows that $Fe^{++}$ fits better than




• Optical determination

Δ Chemical determination

FIGURE 8

COMPOSITIONS OF COEXISTING PYROXENES FROM WABUSH LAKE IRON-FORMATION

$Mg^{++}$ in the structural site generally filled by $Ca^{++}$ in amphiboles and pyroxenes. A mineral that contains little calcium, such as cummingtonite or orthopyroxene, will have this site free to accept $Fe^{++}$, and thus will have a lower Mg:Fe ratio than a coexisting calcium-rich pyroxene or amphibole.

The Mg:Fe ratio of the silicates studied was plotted on a small-scale location map, but no systematic areal variation was apparent. There may be a stratigraphic variation but sampling was not detailed enough to determine it. K.L. Chakraborty* made a detailed study of the iron-formation in the nearby Wabush Lake deposit. There it changes from carbonate, through silicate, to oxide facies, in places within 10 feet, and the Mg:Fe ratio in cummingtonite varies in the same distance from 11/89 in the oxide to 21/79 in the carbonate facies.

## Intrusive Rocks

### General

Two main families of igneous intrusives are recognized in the Gras Lake - Félix Lake area. They are: 1) granitic (quartz monzonite) sills injected mainly into the lower gneisses, and 2) a basic suite (Shabogamo) comprised mostly of gabbro but with associated ultrabasic, intermediate and acidic differentiates. The granitic rocks are scattered through the western part of the area, and the basic suite occurs mainly east of Moisie river. The granitic rocks and the acidic intrusives derived from the gabbro are described together for comparison.

### Quartz Monzonite

Bodies of pale pink, generally gneissic granite, or more correctly quartz monzonite, occur throughout the western two-thirds of the area. They are most abundant in the lower gneisses but also intrude rocks of the Gagnon Group and the upper gneisses. Most of the contacts are conformable, and the bodies appear to be lenses or sills from tens to thousands of feet wide. Foliation is parallel to that of the enclosing rock. Few of the quartz monzonite bodies are homogeneous; most contain remnants of gneiss, and in places grade through migmatite into gneiss.

Table 10a gives estimates of composition of five thin-sections of the quartz monzonite. An average composition of these rocks is: plagioclase ($An_{24-30}$), 22-50%; microcline, 18-38%; quartz, 20-27%; biotite, 3-5%; muscovite, 0-5%; and small amounts of hornblende, garnet, epidote, apatite

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* Personal communication at the Geological Survey of Canada (1962).

and sphene. The plagioclase feldspar is commonly sericitized, but the microcline is invariably fresh. Microcline exsolves from, and replaces, the plagioclase. The plagioclase may also be replaced by large flakes of muscovite. A rim of albite separates microcline and plagioclase. Biotite is generally light brown, and occasionally chloritized. Hornblende has the pleochroic formula: X = yellow; Y = green-brown; Z = slightly bluish green; and extinction angles ranging from 17 to 32°. Most grains are anhedral and embayed by feldspar.

The quartz monzonite differs from the lower gneisses in having less mafic minerals, and a higher proportion of potash feldspar. It was probably formed by partial remelting of the lower gneisses, followed by injection of the fluid portion. The fluid also mixed and reacted with the country rocks, forming migmatites and hybrid gneisses. Sample L-35-145-60 is an example of a hybrid rock formed by the action of potash fluids on a hornblende gneiss.

Where iron-formation was injected, large red garnets developed. Local concentration of iron and reduction of hematite to magnetite took place at the granite contact. A very iron-rich quartz-hematite-magnetite outcrop 1 1/2 miles south of Keg lake probably formed in this way.

Granite East of Moisie River

The granite found east of Moisie river is pinkish gray and is distinguished from similar rocks by fine speckles of red stain, in places surrounding black non-metallic cores (allanite). These "granites" include gneissic types, but most are fine grained and massive. They weather white or red. About the same amounts of microcline, quartz and plagioclase occur in this granite as in the quartz monzonite in the western part of the area; however, the plagioclase of the granite is more albitic. Also, in contrast to the monzonite, the granite has about 1% opaque oxide, large euhedral zircon crystals, and extremely pleochroic biotite and hornblende. Its plagioclase has well developed albite twins, and microcline is twinned in an even cross-hatch pattern. Mineral compositions of six thin-sections are given in Table 10b. Average rocks from this group fall in the compositional range: plagioclase ($An_{5-20}$), 25-47%; microcline, 27-33%; quartz, 20-33%; 1 or 2% biotite; 1% magnetite or ilmenite; and traces of apatite, sphene, zircon and allanite. Some samples contain hornblende or muscovite. These minerals also occur in the acidic orthogneiss described below and it seems possible that both types of rock are genetically related.

There is a zone of red-stained potash-metasomatized paragneiss lying east of Moisie river between the outlet of Félix lake and the southern border. This gneiss, which contains a small amount of igneous granite, was probably formed by fluids rising up a major break lying along Moisie river.

Table 10

Mineral Compositions of Acidic Igneous Rocks

(a) Quartz Monzonite

| Section | Location | Plag | An 10 20 30 40 | K-spar | Qtz | Bio | Musc | Hnb | Opx | Cpx | Garn | Epi | Opaque | Sph | Ap | Zr | Others |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C-24-136-60 | 52°18'N.;67°15 1/2'W. | 20 | ↦ | 45 | 25 | 5 | | 2 | | | 2 | tr | | | tr | tr | |
| C-44-275-60 | 52°21 1/2'N.;67°30 1/2'W. | 42 | ↦ – | 26 | 22 | 3 | 5 | | | | | | | | | | |
| L-35-145-60 | 52°25'N.;67°27'W. | 30 | ↦ | 21 | 22 | 3 | | 21 | | | | 1 | | 1 | tr | tr | |
| G-5-16-60 | 52°19'N.;67°02'W. | 25 | ↦ - | 35 | 30 | 5 | | | | | 1 | | | 1 | | 1 | Chl 2 |
| C-30-156-61 | 52°17'N.;66°49'W. | 66 | ↦ - | 13 | 18 | | | 1 | | | tr | | tr | | tr | tr | Chl 2 |
| Mean | | 36.6 | | 28.0 | 23.4 | 4.0 | 1.0 | 4.8 | | | 0.7 | 0.3 | | 0.4 | 0.3 | 0.5 | |
| Mean Deviation | | 14.1 | | 9.6 | 3.3 | 1.6 | 1.6 | 7.5 | | | 0.7 | 0.4 | | 0.5 | 0.2 | 0.2 | |

(b) Granite East of Moisie River

| Section | Location | Plag | An 10 20 30 40 | K-spar | Qtz | Bio | Musc | Hnb | Opx | Cpx | Garn | Epi | Opaque | Sph | Ap | Zr | Others |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C-15-88-60 | 52°17'N.;67°08'W. | 15 | ↦ | 35 | 25 | 15 | 5 | | | | | | 5 | | tr | tr | |
| C-28-142-61 | 52°17'N.;66°41'W. | 42 | ↦ | 29 | 26 | 2 | | tr | | | | | tr | tr | tr | | |
| C-39-205-61 | 52°21'N.;66°30 1/2'W. | 57 | ↦ | 24 | 13 | 1 | | 1 | | | | | 1 | | tr | tr | |
| C-40a-213-61 | 52°23'N.;66°32'W. | 43 | ↦ | 32 | 23 | 1 | | | | | | tr | 1 | | tr | tr | |
| C-42-222-61 | 52°22'N.;66°43'W. | 32 | ↦ | 32 | 33 | 1 | | | | | | | 1 | | | tr | |
| C-43-228-61 | 52°24'N.;66°44'W. | 29 | ↦ | 27 | 41 | 1 | | | | | | tr | tr | | tr | tr | Chl 1 |
| Mean | | 36.3 | | 29.8 | 26.8 | 3.7 | 0.8 | 0.2 | | | | | 1.5 | | tr | tr | |
| Mean Deviation | | 11.0 | | 3.2 | 6.8 | 4.0 | 1.4 | 0.3 | | | | | 1.1 | | 0.1 | 0.1 | |

(c) Acidic Orthogneiss Associated with Gabbro

| Section | Location | Plag | An 10 20 30 40 | K-spar | Qtz | Bio | Musc | Hnb | Opx | Cpx | Garn | Epi | Opaque | Sph | Ap | Zr | Others |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C-15-90-60 | 52°16 1/2'N.;67°08'W. | 35 | ↦ | 4 | 25 | 6 | | 20 | | | tr | | 2 | 5 | 5 | | |
| C-24-122-61 | 52°15 1/2'N.;66°40'W. | 47 | ↦ | 40(1/3 plag) | | | | 2 | tr | 4 | 6 | | 1 | | tr | | |
| C-25-129-61 | 52°15'N.;66°39'W. | 14 | ↦ | 66(1/3 plag) | 16 | tr | | 4 | | tr | tr | | tr | | | tr | |
| C-26-131-61 | 52°17'N.;66°41 1/2'W. | 31 | ↦ | 42(1/4 plag) | 3 | 2 | | 5 | 7 | 7 | 2 | | 1 | | 2 | tr | |
| C-29-148-61 | 52°16'N.;66°43 3/4'W. | 36 | ↦ | 48(1/4 plag) | | tr | | 1 | 2 | 4 | 5 | tr | 1 | | 1 | tr | |
| C-29-149-61 | 52°16'N.;66°44 1/2'W. | 38 | ↦ - | 48(1/2 plag) | | tr | | 6 | 1 | 4 | 3 | tr | 1 | | tr | tr | |
| C-33-177-61 | 52°19 1/2'N.;66°40 1/2'W. | 12 | ↦ | 57(1/4 plag) | 25 | tr | | 2 | tr | 1 | tr | | tr | tr | tr | tr | |
| Mean | | 30.4 | | 43.6 | 9.9 | 1.4 | | 5.7 | 1.6 | 2.9 | 2.5 | | 1.0 | 0.8 | 1.4 | tr | |
| Mean Deviation | | 10.0 | | 13.0 | 10.4 | 1.4 | | 4.2 | 1.7 | 2.1 | 1.9 | | 0.3 | 1.2 | 1.3 | 0.1 | |

Acidic Orthogneiss Associated with Gabbro

A third type of acidic intrusive occurs; it is associated with the gabbro in the eastern part of the area. This is a medium-grained orthogneiss containing lenses of gray quartz and mafic minerals set in a matrix of sugary brown feldspar. Owing to its dark color and the sugary texture of its felsic minerals, the orthogneiss megascopically resembles the Archean granulite, but the two are easily distinguishable in thin-section. The orthogneiss is much younger than the granulite and occurs in a different part of the area.

Most samples are slightly gneissic, showing thin bands of mixed mafic and felsic minerals alternating with thicker felsic bands, or a preferred orientation of mafic speckles or quartz lenses.

Table 10c gives composition estimates of seven thin-sections of the rock. Most samples contain: plagioclase ($An_{10-15}$), 20-40%; perthitic microcline, 30-56%; quartz, 0-20%; biotite, 0-3%; hornblende, 2-10%; hypersthene, 0-3%; aegirine-augite, 1-5%; garnet, 1-4%; about 1% opaque oxide; and traces of apatite, zircon and sphene.

Microcline perthite forms 1.5 mm. equant grains in which the plagioclase fraction forms fine lamellae or is exsolved to grain boundaries. One-quarter to one-half the volume of the perthite is plagioclase. Plagioclase occurs also as 0.2 to 0.5 mm. clear equant grains interstitial to the perthite (Plate XB). It is more albitic than the plagioclase found in any of the other rock types. Biotite and hornblende both have very strong pleochroism. Biotite is pleochroic from yellow to black, and hornblende, from brownish green to very dark brown. Hypersthene is weakly pleochroic from pink to green. The clinopyroxene is light green to bottle-green aegirine-augite, with an extinction angle ($Z_{\wedge}c$) of 53 to 62°. In two thin-sections the clinopyroxene contains lamellae of orthopyroxene, such as form on reversion of pigeonite to two pyroxenes (Hess, 1941). Small dark red garnets grow in the centers of plagioclase clusters; they were never seen in contact with microcline. Zircon occurs as large euhedral crystals associated with the opaque oxide. Some of the hypersthene has altered to a yellow or light brown, uniaxial negative mineral (hematite?). For a rock rich in potash, biotite is rare, probably because little water was available at crystallization.

The acidic orthogneiss is set apart from all the other rock types by its very perthitic microcline, but is associated with the other members of the basic suite in containing extremely pleochroic biotite and hornblende, and relatively large amounts of opaque oxide and zircon. The refractive indices of its biotite ($n_y$ = 1.68-1.70), hornblende ($n_1$ = 1.70-1.72, $n_2$ = 1.71-1.73), and garnet ($n$ = 1.81) are higher than those of the other rock types. The intergrown character of the feldspars indicates that the rock cooled quite quickly and in a dry environment from temperatures high enough to dissolve much of the plagioclase in the microcline. The rock is a high-temperature, water-deficient differentiate of the Shabogamo gabbro. The resemblance between the acidic orthogneiss and the Archean granulite probably results from their both having crystallized in similar dry, high-temperature environments.

Basic Intrusives

Coarse-grained coronitic gabbro, with some associated diorite, occurs throughout the eastern part of the Félix Lake sheet. Smaller isolated gabbro bodies have injected the Proterozoic rocks south of Gentilhomme lake and west of Gras lake. Generally the gabbro forms long sill-like bodies which stand as ridges above the surrounding gneisses (Plate XI). These rocks are probably related to the Shabogamo gabbros described by Fahrig (1960).

The texture of the gabbro varies widely throughout the region. It was originally ophitic, and near Mount Wright (Clarke, *), the ophitic texture is still easy to recognize. Alteration accompanying the Grenville metamorphism produced coronas of fine secondary minerals surrounding the primary mafic grains. With continued alteration the primary minerals were destroyed, and the rock became a brown pyroxene-garnet-feldspar gneiss.

Few gabbros in the present area have retained their ophitic texture. Those that have contain 1/4-inch laths of light green, altered plagioclase penetrating black pyroxene and biotite. Rims of fine, red garnets have grown between the mafic minerals and the feldspar.

Thin-sections of the coronas (Plate XA) show olivine cores surrounded by an inner layer of fibrous orthopyroxene, followed by fine-grained secondary clinopyroxene or mixed clinopyroxene and uralite, and an outer layer of garnet in contact with the feldspar. Rims of secondary amphibole and garnet may also coat the pyroxenes and magnetite.

Two generations of plagioclase are present in the less altered specimens. The primary laths are untwinned and are full of tiny tablets of clinozoisite, which probably cause the green color seen in hand-specimen. Clusters of small (0.5 mm.) polyhedra of clear, twinned, secondary plagioclase occur between the larger grains. These grains are less calcic than the primary plagioclase.

Where recrystallization is advanced, the garnet rims of adjacent coronas may merge, forming networks or paths through a matrix of pyroxene and feldspar. Further recrystallization is accompanied by the development of a crude gneissosity parallel to the foliation of the surrounding rocks. The

Table 11

Mineral Compositions of Intermediate and Basic Igneous Rocks

(a) Intermediate Intrusives

| Section | Location | Plag | An 10 20 30 40 | K-spar | Qtz | Bio | Hnb | Opx | Cpx | Oliv | Idd | Garn | Epi | Opaque | Sph | Ap | Zr | Others |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C-15-91-60 | 52°16 1/2'N.;67°07'W. | 75 | ├─ - | tr | | 8 | 12 | | | | | 3 | | 2 | | | | |
| G-7-18-60 | 52°17 1/2'N.;67°07'W. | 58 | ├──┤ | | | 4 | 16 | | 8 | | | 5 | | | | tr | | Scap 7,Py tr |
| D-36-133-61 | 52°17'N.;66°34'W. | 57 | ├┤ | 1/10 plag | 5 | 9 | 1/2 | 1 | 13 | | | 12 | | 1 | tr | | tr | Scap 1 |
| D-37-134-61 | 52°16'N.;66°38'W. | 60 | ├─┤ | 1/15 plag | | 8 | 5 | 2 | 9 | | | 10 | | 4 | | 1 | | |
| D-37-135-61 | 52°16'N.;66°38'W. | 60 | ├──┤ | | | 15 | 2 | | 11 | | | 5 | | 3 | | 2 | | |
| C-12-53-61 | 52°28'N.;66°51 1/2'W. | 80 | ├┤ | | 2 | 6 | 4 | | 1 | | | 3 | | tr | | tr | tr | |
| Mean | | 65.0 | | | 1.1 | 8.3 | 6.6 | 0.5 | 7.0 | | | 6.3 | | 1.8 | | 0.7 | | |
| Mean Deviation | | 8.3 | | | 1.5 | 2.4 | 5.0 | 0.7 | 4.3 | | | 3.1 | | 1.3 | | 0.6 | | |

(b) Gabbro and Altered Gabbro

| Section | Location | Plag | An 10 20 30 40 | K-spar | Qtz | Bio | Hnb | Opx | Cpx | Oliv | Idd | Garn | Epi | Opaque | Sph | Ap | Zr | Others |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *C-15-84-60 | 52°17'N.;67°07'W. | 20 | ├ | | | 10 | 20 | 12 | 10 | 7 | | 5 | 10 | 5 | | | | |
| C-15-87-60 | 52°17'N.;67°07'W. | 60 | ├┤ | | | 5 | 10sec | 5 | 5 | | | 10 | 5 | | | | | Spinel tr |
| *C-5-15-61 | 52°31 1/2'N.;66°51'W. | 55 | ├┤ | | | 3 | 5 | 9 | 18 | | | 10 | | | | | | Pyrr 2 |
| *C-5-16-61 | 52°31 1/2'N.;66°51'W. | 48 | ├──┤ | | | tr | tr | 18 | 11 | 1 | 7 | 13 | | | | tr | | Sp tr,Pyrr 1½ |
| C-26-132-61 | 52°17'N.;66°41 1/2'W. | 46 | ├ ─ | | | 3 | 4 | 12 | 10 | | | 15 | | 7 | | | | |
| *C-26-133-61 | 52°17'N.;66°41 1/2'W. | 53 | ├┤ | | | 3 | 3 | 5 | 20 | | | 13 | | | | tr | | |
| C-34-185-61 | 52°21'N.;66°39'W. | 65 | ├─┤ | | | 1 | 20 | | 2 | | | 12 | | 1 | tr | tr | | |
| C-39-207-61 | 52°20 1/2'N.;66°31'W. | 56 | ├─┤ | | | 4 | 20 | | 3 | | | 15 | | 1 | | | | |
| C-39-208-61 | 52°22'N.;66°33'W. | 30 | ---├─┤-- | | | 15 | 38 | 2 | 4 | | | 5 | | 3 | | 1 | | |
| C-39-209-61 | 52°22'N.;66°33'W. | 55 | ├─┼─┤ | | | 5 | 10 | | 7 | | | 17 | | 2 | tr | tr | | |
| C-44-230-61 | 52°28'N.;66°30'W. | 45 | ├══┤ | | | 7 | 11 | | 14 | | | 20 | | 2 | | tr | | |
| C-44-232-61 | 52°28 1/2'N.;66°31'W. | 28 | ├┤ | | | 5 | 2 | 2 | 29 | | | 25 | | 7 | | 1 | | |
| C-44-233-61 | 52°28 1/2'N.;66°31'W. | 60 | ├─┤ | | | 15 | 2 | 2 | 7 | | | 12 | | tr | | | | |
| Mean | | 47.8 | | | | 5.9 | 11.2 | 5.1 | 10.8 | 0.6 | 0.5 | 13.2 | 1.5 | 2.2 | | 0.3 | | |
| Mean Deviation | | 10.0 | | | | 3.8 | 8.2 | 4.7 | 6.4 | 1.0 | 1.0 | 4.0 | 2.6 | 2.0 | | 0.3 | | |

* Relatively unaltered

(c) Metagabbro Amphibolite

| Section | Location | Plag | An 10 20 30 40 | K-spar | Qtz | Bio | Hnb | Opx | Cpx | Oliv | Idd | Garn | Epi | Opaque | Sph | Ap | Zr | Others |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C-10-54-60 | 52°28'N.;67°04'W. | 29 | ├┤ | | 5 | 14 | 34 | | | | | 8 | | 7 | | 2 | | |
| C-15-80-60 | 52°17'N.;67°05 1/2'W. | 23 | ---├─┤ | | 5 | 15 | 50 | | | | | 2 | | | | 2 | | |
| C-29-176-60 | 52°21'N.;67°23'W. | 43 | ─ | | 9 | 7 | 15 | | | | | | tr | 13 | 6 | 2 | 1 | |
| C-44-278-60 | 52°21'N.;67°29'W. | 50 | ─ | | | 8 | 30 | | | | | 5 | | 7 | | 2 | | |
| Mean | | 36.3 | | | 4.8 | 11.0 | 32.3 | | | | | 3.8 | | 6.8 | 1.5 | 2 | | |
| Mean Deviation | | 10.2 | | | 2.4 | 3.5 | 9.8 | | | | | 2.8 | | 3.4 | 2.3 | 0 | | |

resulting gneiss has a matrix of plagioclase polyhedra and small euhedral garnets enclosing streaks of clinopyroxene, biotite, hornblende and magnetite. Garnet may rim the mafic streaks. Large green euhedral porphyroblasts of aegirine-augite grow in some samples of the streaked gneiss.

Table 11b gives the composition of 13 thin-sections of gabbro and altered gabbro. Relatively unaltered samples in which an ophitic texture can still be recognized are marked with an asterisk. An average composition for the gabbro in this table is: 38-58% plagioclase, 2-10% biotite, 3-19% hornblende, 0-10% orthopyroxene, 5-17% clinopyroxene, up to 8% olivine or iddingsite in less altered samples, 9-17% garnet, 0-4% magnetite, and small amounts of apatite, spinel and, in some samples, pyrrhotite. The compositional range is large as the percentages include primary and secondary forms of feldspars, amphiboles and pyroxenes, and are averaged from rocks in different stages of alteration.

The biotite in the gabbro is red-brown, with a refractive index $n_y$ = 1.645-1.670. Primary hornblende is pleochroic from yellow-brown to dark brown, whereas secondary varieties are green. Green hornblende replaces clinopyroxene, and biotite replaces orthopyroxene. In unaltered samples the clinopyroxene is augite, with an extinction angle ($Z_\wedge c$) of about 50°, and is full of dusty magnetite inclusions. In more altered samples from east of Moisie river, green aegirine-augite, with an extinction angle ($Z_\wedge c$) of about 65°, is more common. Some samples contain both clinopyroxenes. The garnet always occurs as small clean euhedral grains, with refractive indices between 1.777 and 1.783, and cell edges between 11.556 and 11.575 Angstroms.

## Intermediate Intrusives

Small parts of the basic sills in the Félix Lake area are made up of syenodiorite. This rock is composed essentially of oligoclase with biotite, hornblende, clinopyroxene and garnet in streaks or distributed evenly through the rock. The syenodiorite differs from the gabbro in having more plagioclase and biotite, and less amphibole, pyroxene and garnet. The plagioclase is more sodic than that of the gabbro.

Compositional estimates of six thin-sections are given in Table 11a. A typical composition of the syenodiorite is: 57-73% plagioclase ($An_{15-22}$) some being antiperthitic, 6-10% biotite, 1-11% hornblende, 3-11% clinopyroxene, 3-9% garnet, up to 4% opaque oxide and quartz, and traces of apatite, zircon and orthopyroxene. In two of the sections scapolite replaces plagioclase.

## Ultrabasic Intrusives

Sills of medium-grained black peridotite inject the gneisses at several places along a zone closely paralleling Moisie river in the southern half of the Félix Lake area. The rock is composed of dark green pyroxene, with up to 30% olivine and minor green amphibole. Outcrops weather deeply to a coarse pyroxene sand.

The olivine is partly altered to iddingsite and a mixture of antigorite and magnetite. The pyroxene is light green augite with an optic extinction ($Z_{\wedge}c$) of about 50°. It is intergrown and partly replaced by light green tremolite with an extinction angle of about 20°. A sample from the sill closest to the southern border of the area contains no olivine but has interstitial carbonate and a bronze sulfide (possibly pyrrhotite). Sulfides are also associated with the ultrabasic rocks near Pegma lake. The Pegma Lake peridotite underlies a gabbro body from which it probably differentiated.

## Metagabbro Amphibolite

Thin stratiform bodies of dark green, slightly gneissic amphibolite occur with the basic rocks near Gras lake and Gentilhomme river, and with the Gagnon Group at Fire, Hobdad, Lamêlée and Midway lakes. The rock is not banded but may contain lens-shaped clusters of either mafic or felsic minerals in a matrix of the other. Alignment of the mafic minerals results in a strong foliation.

Mineral compositions of four thin-sections of amphibolite are given in Table 11c. The average range is: plagioclase ($An_{25-30}$), 26-46%; quartz, 3-7%; biotite, 8-15%; hornblende, 22-42%; garnet, 2-6%; opaque oxide, 3-10%; and apatite, 2%. The plagioclase is generally fresh, poorly twinned, and zoned from relatively calcic borders to a sodic core. Hornblende is pleochroic from yellow-green to dark green, with an extinction angle of about 28° and refractive indices $n_1$ and $n_2$ about 1.675 and 1.685, respectively. Biotite is brown or red-brown. Sphene, where present, rims the iron oxide.

The amphibolite probably represents thin gabbro sills injected into competent layers of the Gagnon Group and metamorphosed along with them. Gross (1955) has described the gradation between gabbro and amphibolite near Mount Wright.

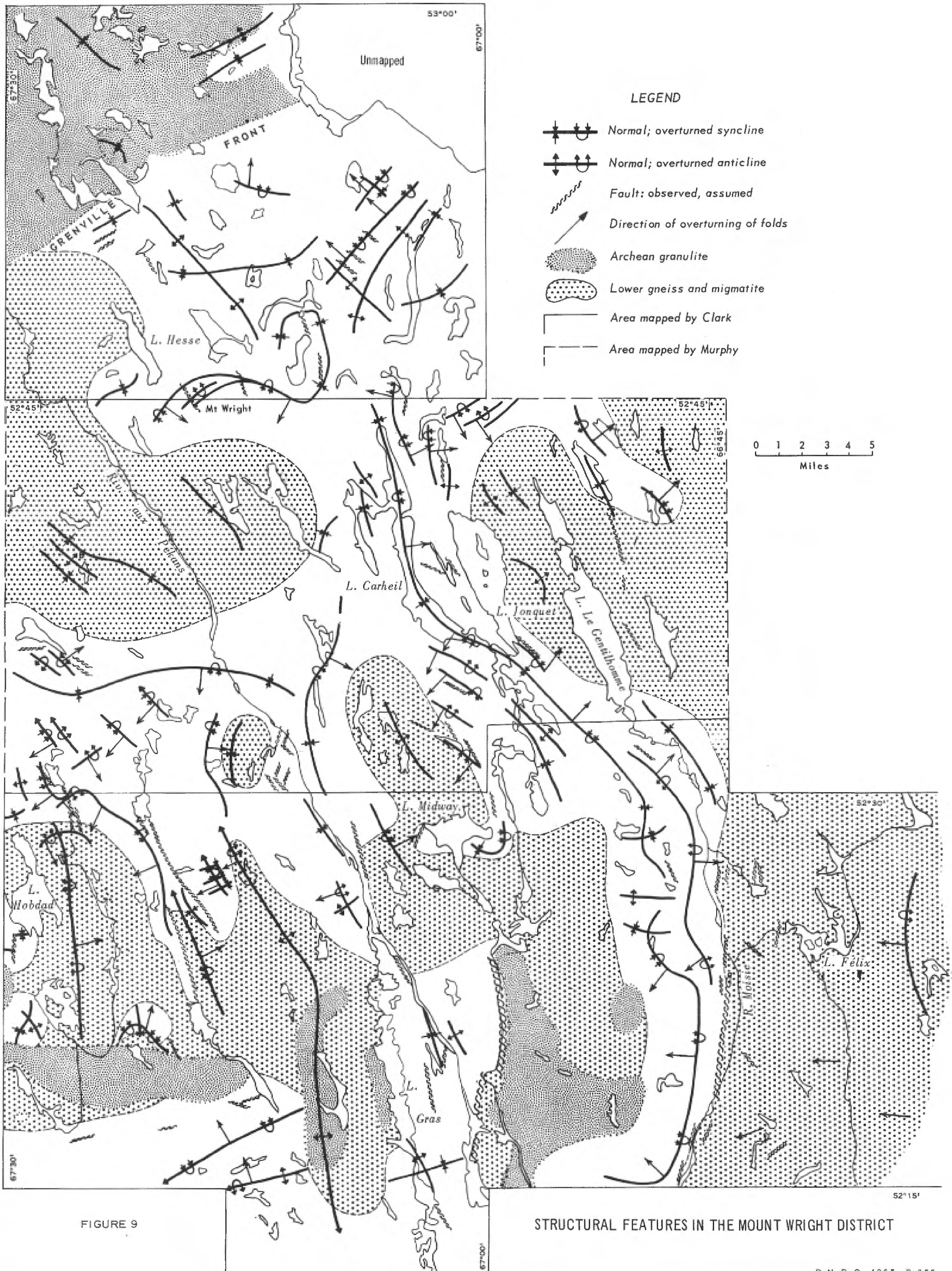


FIGURE 9

STRUCTURAL FEATURES IN THE MOUNT WRIGHT DISTRICT

D.N.R.Q. 1965 B-856

The amphibolite resembles in some ways the metasedimentary hornblende-garnet rock. Table 12 compares the mean values for the important minerals in the two rock types.

Table 12

Mineral Compositions of Hornblende-garnet Rock and Amphibolite

| | Plag. | Qtz. | Bio. | Hnb. | Garn. | Cpx. | |
|---|---|---|---|---|---|---|---|
| Mean. | 16.6 | 4.8 | 3.3 | 37.9 | 19.0 | 14.0 | Hornblende-garnet Rock |
| Mean Dev. | 13.9 | 5.5 | 4.0 | 19.0 | 6.9 | 9.6 | Hornblende-garnet Rock |
| Mean. | 36.3 | 4.8 | 11.0 | 32.3 | 3.8 | 0 | Amphibolite |
| Mean Dev. | 10.2 | 2.4 | 3.5 | 9.8 | 2.8 | 0 | Amphibolite |

In general the amphibolite has more plagioclase and biotite than the hornblende-garnet rock. On the other hand, the hornblende-garnet rock has much more garnet and contains clinopyroxene. Also, its plagioclase is more calcic than that of the amphibolite.

## STRUCTURAL GEOLOGY

### Regional Structure

The main structural features of the Mount Wright district are shown in Figure 9 (attached). The northern and southern areas were mapped by the author, the central one by Murphy (1960). It is with the southern area that this report is mainly concerned.

The Proterozoic rocks are folded about two main directions. In the northern area the main folds trend northeastward, and are intersected by somewhat weaker northwesterly folds. The northwest-trending folds dominate between latitude 52°45'N. and the southern belt of Archean granulite. South of the granulite the folds swing northeastward again.

The local stress pattern was variable and is best understood by its relation to the stratigraphy. Areas underlain by Archean granulite and segregated Proterozoic gneiss are shown in Figure 9. The homogeneous gneiss and Gagnon Group rocks are folded down between these masses of deepseated rocks, and are generally overturned towards them. Thus the lower gneiss and granulite apparently occur in areas of domical uplift towards which the overlying rocks were forced.

Faults strike parallel to the major fold trends. Near the Grenville front the rocks appear to be thrust towards the Archean basement on northeasterly shears. Further south most faults trend northwest. The intensity of the faulting seems to increase southward, and in the southern area fault zones are followed by many of the main rivers. The faults in the southern area are steep-dipping thrusts, on which the east side moved up relative to the west. They commonly develop near synclines of the Gagnon Group, so that the eastern edges of these bodies are in fault contact with lower gneisses.

The interference of the two fold systems developed two main fold types : simple folds where one system is much stronger than the other, and cross-folds where the two systems are of about equal importance. Simple folds give rise to the relatively straight, continuous bands of the Gagnon Group that occur throughout the central and eastern parts of the Carheil Lake, and Gras Lake - Félix Lake areas.

Wnere the two fold systems are of similar strength they form a series of domes and basins (Carey, 1962; O'Driscoll, 1962). The structural geology of most of the Normanville area (Clarke, *), and the area between Tuttle lake (Phillips, 1958), Esker lake (Murphy, 1959), and Fire lake (Clarke, 1961), is characterized by this type of folding. There, basins containing rocks of the Gagnon Group are arranged in a grid-like pattern between domes of the lower gneiss. The grid axes have a 4- to 5-mile spacing and correspond to the local fold axes, trending northeast and northwest in the Normanville area, and east-northeast and north-northwest in the area between Fire, Esker, and Tuttle lakes. Recognition of the regular occurrence of iron-bearing structures is of direct economic importance; these are shown in Figure 10 (attached) and discussed in more detail in the chapter on economic geology. The band of cross-folding corresponds to the zone of near-shore facies sedimentary rocks containing the oxide facies iron-formation. The correspondence between the sedimentary and structural zones may be coincidental, but more probably the type of folding was controlled by the thickness or competence of the sedimentary pile, or its position relative to the developing geosyncline.

## Areal Structure

Only the main structural features of the Gras Lake - Félix Lake area are shown in Figure 9 and described in this report. Persons interested in a detailed discussion of the local structure are referred to the author's thesis (Clarke, 1964).

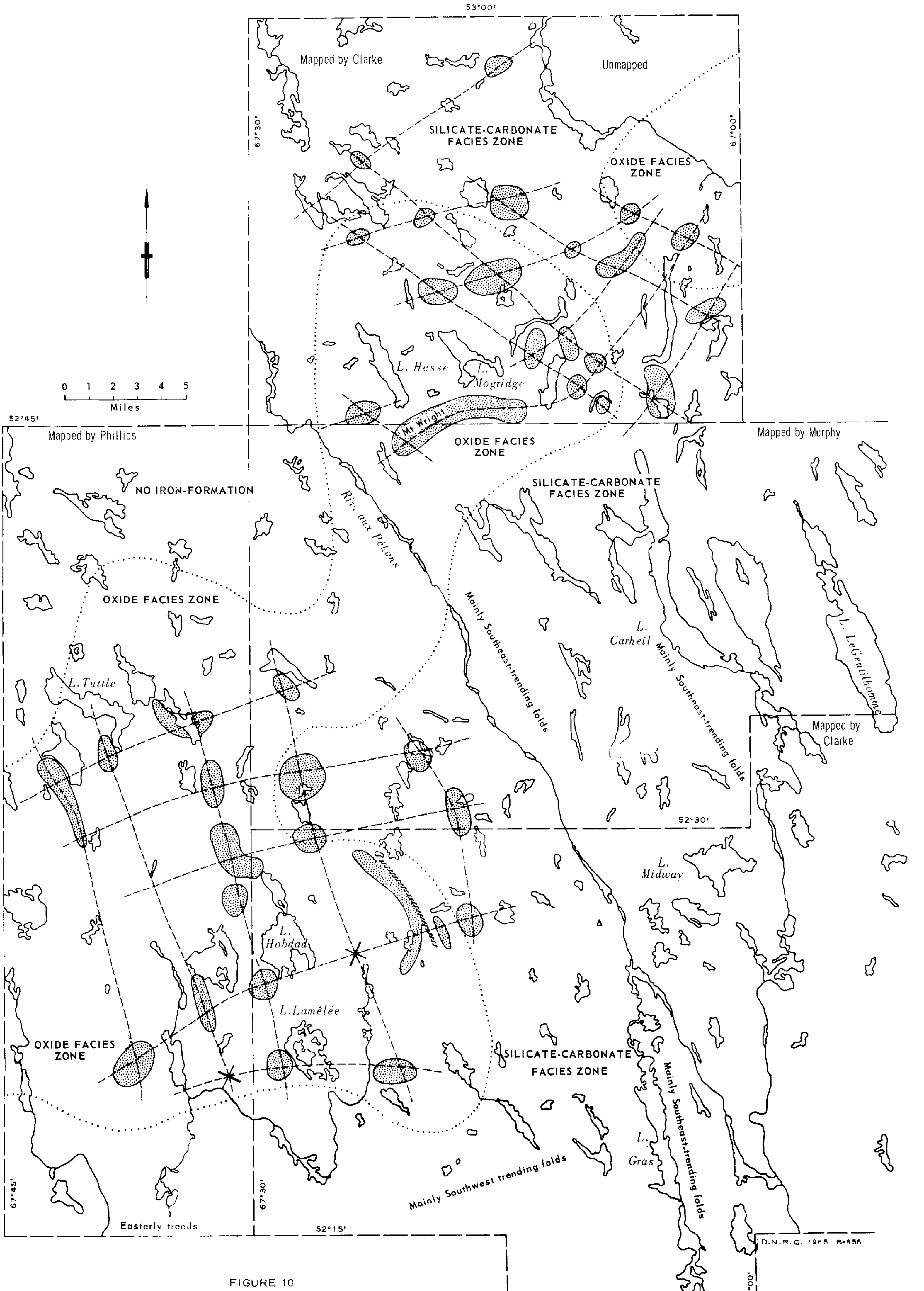


FIGURE 10

Ore-grade float

Drift-covered axis intersection

Oxide facies boundary

Iron-formation bassin

Lines of symmetry (Synclinal axes ?)

Map sheet boundary

STRUCTURAL CONTROL OF IRON DEPOSITS IN CROSS-FOLDED AREAS IN THE MOUNT WRIGHT DISTRICT

Throughout most of the area the rocks are deformed by simple folding. The main fold axes trend south-southeasterly in the northern and central parts of the area, and west-southwest in the southern part.

Major synclines containing rocks of the Gagnon Group and homogeneous gneiss trend southeastward from near Don lake, and along Pékans and Gentilhomme - Moisie rivers. Southeast-trending faults are commonly associated with these folds, and bring the lower gneisses up against the eastern edges of the synclines.

Major anticlines of lower gneiss trend north-northwest between the synclines. One anticline passes east of Hobdad and Lamêlée lakes; another, through Eva lake. An anticlinal nose southeast of Hippocampe lake shows well on aerial photographs. The rocks east of Moisie river strike south-southeast, and dip northeast. They are probably isoclinally folded and overturned towards the west, but lack of marker beds makes more accurate interpretation impossible.

The Archean granulite lies along an east-west-trending band in the southern part of the area. Its foliation strikes generally southeast or east, and dips either north or south. Most lineations plunge southeast. The granulite has undergone several deformations, but the lack of marker beds makes its structure difficult to interpret. However, the younger rocks are folded around and generally overturned towards it, and the granulite probably marks a strongly uplifted zone.

Cross-folding has deformed the rocks in the northwestern quarters of the Gras Lake and the Félix Lake sheets. Some small cross-folds are visible in a single outcrop and others are large enough to show on the accompanying geologic maps. The structural basins at Fire, Hobdad and Midway lakes, between Eva and Demi-Mille lakes, and in the hills west of Gentilhomme river are examples of large-scale cross-folds.

Lineations in the form represented by the axes of small folds and crenulations, elongate minerals, and streaks of minerals occur throughout the area. Small folds occur in all types of foliated rock; crenulations are most common in the micaceous layers of gneisses and schists. Mineral elongation and streaking show best on foliation planes. The minerals most commonly aligned include biotite and hornblende in the well segregated gneiss, felsic clusters in the less segregated ones, actinolite in the iron-formation, and diopside in the marble. All these types of lineation are believed to lie parallel to the regional fold axes, and to define the plunge of structure in their vicinity.

Structures in the northern part of the Gras Lake area plunge northwesterly (azimuths $280^\circ$-$5^\circ$) at angles of $10^\circ$-$35^\circ$. In the southern part of the Gras Lake area lineations plunge either southeast (azimuths $100^\circ$-$165^\circ$)

at angles of $5^{o}$-$55^{o}$, or southwest (azimuths $230^{o}$-$250^{o}$) at angles of $10^{o}$-$40^{o}$. In the Félix Lake area almost all the lineations plunge from $10^{o}$-$60^{o}$ to the southeast (azimuths $120^{o}$-$170^{o}$). Exceptional northeasterly plunging lineations occur east of Moisie river in a zone deformed by faulting near the area's southern border.

## ECONOMIC GEOLOGY

### Iron Ore

#### General

Concentrating grade deposits of iron ore have been actively sought in the Mount Reed - Mount Wright region since the early nineteen-fifties. Large discoveries resulted in the Jeannine Lake, Carol Lake and Wabush Lake mining projects. The plant at Jeannine lake (served by the town of Gagnon) began concentrating and shipping ore early in 1961; the Carol Lake plant (in Labrador), during 1963. Development in the present area, which lies between Jeannine lake and Mount Wright, will probably not begin until more ore is required than can be obtained from the Jeannine Lake deposit.

Iron deposits in the Mount Wright - Mount Reed region were first prospected by United Dominion Mining Company. They staked ground outside the present area during the period from 1947 to 1949. In 1952 a prospecting and staking rush began with the entry of United States Steel Corporation into the area. The iron deposits within the Gras Lake area itself were not found until 1955. That year the Fire Lake, Demi-Mille Lake and Don Lake deposits were staked by Quebec Cartier Mining Company, a subsidiary of United States Steel Corporation.

Of the several types of iron-formation the quartz-specularite type makes the best ore material. It generally contains 25-35% iron over thicknesses of from 10 to 300 feet, and is coarse enough to allow concentration with a 20-mesh grind.

The quartz-magnetite type can be equally rich, but has not been found in as large deposits as the quartz-specularite type. It commonly grades into the uneconomic silicate-carbonate facies. A 100-mesh grind is generally required to separate the magnetite from the rest of the rock. Both types of the oxide facies yield concentrates grading 65-67% iron, and containing little phosphorus, sulfur or titanium.

The silicate-carbonate iron-formation contains as much iron as the oxide facies types, but most of the iron is combined in iron silicates from which it cannot be recovered economically.

Regional Ore Control

The iron-formation and accompanying quartzite and marble were deposited above a thick quartzo-feldspathic sequence. Strong deformation and deep erosion have left the iron-formation in synclines surrounded by the lower gneiss. The iron-formation is a tough rock, and most of the large deposits form hills which rise above the less resistant gneiss.

Regional fold axes trend northeast and northwest. The northwesterly trend predominates through most of the present area, but in the northwestern corner, and in adjoining map-areas to the north and west, the two fold systems are of about equal strength.

The interference of the two intersecting fold systems produced a series of domes and basins, similar to the fold patterns described by O'Driscoll (1962). Synclinal basins of iron-formation lie in a grid-like pattern separated by domes of lower gneiss (Figure 10).

The zone of cross-folding coincides with the near-shore facies zone containing the valuable quartz-specularite iron-formation. The cross-folding may result in structural thickening or repetition of the iron-bearing beds, and so increase mining widths in the synclinal basins.

Figure 10 is necessarily interpretative. The basins may be more linear than circular, and are not all the same size. There are some iron deposits that do not occur at grid intersections. Outcrop patterns depend on the level of erosion and depth of the synclines. Erosion may have been deep enough to remove all the iron-formation from a shallow synclinal intersection, or so shallow that the iron-formation crops out on the limbs of the fold at some distance from the fold axis. The pattern may also be modified by faulting, as it is in the Don Lake and Hippocampe (Pouce) Lake deposits. Despite these disturbing factors there is a strong regularity in the occurrence of the iron-formation; this fact may help in finding additional deposits.

Axis intersections in drift-covered areas are shown at two places in Figure 10. These localities are worth further study. Figure 10 also shows the sites of ore-grade erratics in the present area. These lie outside the zone of known oxide facies deposits, but may be of local origin. Moreover, areas of upper gneiss lying in the zone of deposition of the oxide facies may also contain buried iron deposits.

Mining Properties

Approximate property boundaries, as of November 1963, are shown on the accompanying map (in pocket). The area has now been thoroughly prospected and all of the obvious iron deposits have been staked. As most of the uneconomic claims have been allowed to lapse, the property boundaries shown here should be reasonably permanent. Brief descriptions of the company properties follow.

Quebec Cartier Mining Company

Quebec Cartier Mining Company retains the most important claims in the area. Its main holdings were staked between 1955 and 1958. The economic potential of most of the claim groups has been assessed, and claims judged uneconomic have been allowed to lapse. The claims in good standing include the following groups: Fire Lake, Don Lake, Hippocampe Lake, Demi-Mille Lake - Keg Lake, Lamêlée Lake and Hobdad Lake, and a few claims north of Lamêlée lake that belong to a larger group west of the present map-area.

Fire Lake group - The area's most important iron deposit is exposed in the hill north of Fire lake. It is covered by mining concession 473, comprising 18 claims and three part claims, and is surrounded by 66 additional claims.

The deposit was discovered and staked in 1955, following an aeromagnetic survey of the region. In 1957 it was mapped geologically at 200 feet = 1 inch, and some 1,700 feet of exploratory diamond drilling was done. The following year ground magnetometer and gravity surveys were made, and 35 holes totalling 10,635 feet were drilled. In 1960 the drilling program was completed with an additional 42 holes totalling about 15,800 feet. Forty tons of bulk samples were taken and tested in the company's pilot plant. Ground control for the drilling program was provided by cut and surveyed lines. The base-line was cut at N.30°W. Perpendicular cross-lines were run at 500-foot intervals over the iron-formation hill, and at 1,000-foot intervals farther south. Drill-holes were located on the cross-lines, spaced about 500 feet apart.

This work outlined over 200 million tons of ore grading better than 30% soluble iron. The bed of iron-formation that forms the deposit ranges from 10 to 400 feet thick. It occurs in a cross-folded basin, and provides mining widths great enough to support an open-pit operation to considerable depth.

Don Lake, Hippocampe Lake, and Demi-Mille Lake - Keg Lake groups - These groups consist of 16, 14, and 60 claims, respectively, and cover the iron deposits in the tight synclines passing south from Don and Demi-Mille lakes, and the small synclinal basins northeast of Keg lake.

The deposits were discovered in 1955 by ground parties checking anomalies shown by an aeromagnetic survey of the region. The first claims were staked that year, and others in 1956 and 1957 to form a continuous group. A detailed geological survey of the group was made in 1957. In 1958 an additional ten claims were staked over a magnetic anomaly between Hippocampe and Fire lakes.

In 1961 the deposits were evaluated by a 200 feet = 1 inch geological and magnetometer survey and a diamond drill program. Ground control was provided by a series of surveyed base-lines with cross-lines cut every 250 feet. In all, some 12 miles of base-line and 70 miles of picket-line were cut; 19 holes totalling about 4,600 feet were drilled, and the core assayed.

The survey outlined four main iron-bearing zones: near Don lake, south of Hippocampe lake, south of Demi-Mille lake, and east of Keg lake. Twenty-nine of the claims in the main group, and the ten claims between Hippocampe and Fire lake were allowed to lapse.

Near Don, Hippocampe, and Demi-Mille lakes tight synclinal folds contain iron-formation layers more than a mile long and wider than 200 feet. Average grade is somewhat better than 30% iron.

The Keg Lake iron-formation consists of thin magnetite-quartz beds between thicker iron silicate layers. More detailed study is required to show whether or not this deposit is worth mining.

Lamêlée Lake and Hobdad Lake groups - Steep hills containing beds of magnetite iron-formation lie to the west of Lamêlée and Hobdad lakes. The Lamêlée Lake deposit is covered by 25 claims; the Hobdad Lake deposit, by 37 claims.

The claims over Lamêlée hill were staked in 1954, and transferred to The Cartier Mining Company the following year. The Hobdad deposit was staked by Quebec Cartier Mining Company in 1958. The same year the company made 200 feet = 1 inch geological and group magnetometer surveys of the Lamêlée deposit. There is no known assessment work on the Hobdad Lake deposit.

Most of the iron-formation in these deposits belongs to the silicate-carbonate facies, but there are quartz-magnetite beds in the Hobdad, and both quartz-magnetite and quartz-specularite beds in the Lamêlée deposit. The oxide facies beds crop out over lengths of about 1/2 mile. Field notes record thicknesses of 20 to 35 feet and grade estimates of about 35% iron. The author knows of no attempt to evaluate these deposits.

### Torbuff Exploration Limited

The only other property in good standing belongs to Torbuff Exploration Limited. In the summer of 1962 the company staked 55 claims over the iron-formation hill at the south end of Gras lake. As yet (1963), no assessment work has been reported for this claim group.

The staked ground lies over a thick layer of silicate-carbonate iron-formation. This type of iron-formation does not generally reach ore-grade, but it can contain interlayered magnetite-quartz iron-formation. Although such bands were not noted in the present mapping, detailed mapping guided by a magnetometer survey might uncover some.

## Lapsed Claims

Several other claim groups have been staked in the area. However, assessment work on these failed to outline economic deposits and the claims were allowed to lapse. Claims of this type belonged to Jubilee Iron Corporation, Bellechasse Mining Corporation, and J. Wax.

### Jubilee Iron Corporation

This company held a group of 70 claims on the iron-formation band passing from the south end of Hope lake to the bend in Petite Manicouagan river, and two groups of four claims each on iron-formation near Pékans river, in Esmanville township.

The claims were staked in 1958 over aeromagnetic anomalies. Initial geological and geophysical reconnaissance work was done by the staking party. In 1959 a detailed geological and magnetic survey was made of the Hope Lake - Petite Manicouagan River group. The Bergeron-Hind township line was used as a base-line for most of the survey, and a secondary base-line was cut near Hope lake. Forty-two magnetic profiles were surveyed on cross-lines spaced from 500 to 2,500 feet apart.

The 1959 program outlined three highly magnetic zones in 1 1/4 miles of iron-formation near Hope lake. An 8-foot-thick layer of magnetite iron-formation is exposed near the anomaly, but the anomaly itself is drift covered.

The 41 claims forming the western end of the group were allowed to lapse.

In 1961, two holes were drilled into the strongest anomaly near Hope lake. One hole failed to reach bedrock; the other intersected only lean silicate iron-formation to a depth of 77 feet. The following year the claims were dropped.

No assessment work is reported for the two groups of claims in Esmanville township. They lapsed in 1961.

Bellechasse Mining Corporation

This company has three showings of iron-formation in the area: 23 claims at the east end of Midway lake; 30 claims in Esmanville township near Pékans river (Midway S.A. No. 1); and ten claims near the south end of Hope lake. All these groups were staked to cover aeromagnetic anomalies.

The Midway Lake group was staked in 1955 and preliminary geological and magnetic surveys were made the same year. Pickands Mather and Company optioned the property in 1956. Geological and magnetic surveys outlined three zones, each measuring about 2,000 feet by 100 feet. Zone 1 was sampled by three trenches and five diamond drill holes totalling 302 feet. The samples contained between 28 and 34% iron, over thicknesses ranging from 25 to 70 feet. Magnetic concentrates from minus 100-mesh material graded between 67 and 71% iron. Recovery of iron from a hematite-rich layer was poor by this method. Zones 2 and 3 were not sampled and are presumed to contain less iron than Zone 1. Pickands Mather dropped the option in 1958, and the claims lapsed in 1961.

The showing called S.A. No. 1 was on 30 claims staked in 1956. Most of the claims and all the exposed iron-formation were north of 52°30'N., and were therefore outside of the present area. The property was optioned to Pickands Mather to conduct exploration.

During 1956 and 1958, geological and dip-needle surveys at the scale of 500 feet = 1 inch, stripping, sampling and concentration tests were carried out. One 37-foot hole was drilled. The iron-formation contained 25-29% iron and yielded a magnetic concentrate grading 63-67% iron, 8-19% silica, and 0.015% phosphorus (Janes and Elver, 1959).

Pickands Mather dropped its option in 1958. Bellechasse carried out a ground magnetometer survey in 1959-60, and allowed the claims to lapse in 1962.

The Hope Lake group of ten claims adjoining a larger group belonging to Jubilee Iron Corporation was staked in 1958. Ground magnetometer and geological mapping in 1959 outlined three zones of iron-formation with a total length of 8,400 feet.

Concentration tests, run on material from the three zones, yielded material grading about 67% iron from crude ore carrying between 34 and 36% iron (Janes and Elver, 1959). Thickness or tonnage estimates are not given. The claims expired in 1963.

J. Wax Claims

This group straddled the Faber-Gueslis township line in the northern part of the area. It was staked in 1958 and originally consisted of 154 claims, most of which lay north of the present area. Of this group, 39 claims were retained. In 1959 a magnetometer survey was made over the nose of iron-formation, and some sample pits and packsack drill-holes were sunk.

In 1961, nine holes totalling 393 feet were drilled, and detailed geological mapping and systematic sampling of the main deposit carried out. This work outlined three magnetite-rich bands with an average thickness of 21 feet.*

A - average grade 34% Fe**; average width 19'; length 4,400' (sampled zones - 440' + 650')

B - average grade 31% Fe**; average width 11'; length 2,000'

C - average grade 35% Fe**; average width 35'; length 400'

The bands are separated by lean silicate iron-formation. No mill tests were made.

The claims were dropped in 1963. Part of the claimed ground has been withdrawn from staking to allow for the proposed railway to Mount Wright.

## Sulfide Showings

Sulfide showings, some containing copper, nickel, or zinc, are associated with the basic intrusives near Pegma lake, and with shear zones near Gras lake and on Moisie and Pékans rivers.

The best known occurrence lies about 1/2 mile west of Pegma lake. The deposit was staked in 1954 by prospectors attracted by a large gossan zone. The original property consisted of 77 claims. Bellechasse Mining Corporation acquired the property in 1955 and staked a large group of claims surrounding it.

An aeromagnetic survey of the property was made in the winter of 1955-56. The following summer the geology was mapped at 500 feet = 1 inch, and 27 holes totalling some 2,000 feet were drilled into the main mineralized zone. The survey outlined three mineralized zones (a, b, and c, on the accompanying map). The geology and mineralogy of the deposits are described by Gleeson (1956).

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* Assessment report on file at Quebec Dept. of Natural Resources

** Total iron; soluble iron not reported.

The main showing (c) is a zone, 400 feet long and 30 to 500 feet wide, in which sulfides are disseminated through the peridotitic base of a gabbro sill. In samples taken from this showing, Gleeson identified pyrite, pyrrhotite, magnetite, pentlandite, violarite and cubanite. The core from a hole drilled down the dip of the discovery outcrop assayed: 0.85% Cu for 5 feet, 0.47% Cu for 4 feet, and 0.67% Ni for the first 9 feet in bedrock. None of the other holes gave assays higher than 0.3% Cu or 0.3% Ni.

Showing (a) is a quartzose outcrop, 100 feet by 20 feet, containing disseminated pyrite with minor pyrrhotite and chalcopyrite. Assays of the mineralized rock showed only traces of Cu and Ni.

In showing (b), pyrite, sphalerite and chalcopyrite fill fractures in a quartz vein cutting marble. The mineralization forms discontinuous pods up to 12 feet wide. Assays of grab samples returned up to 14% zinc, but the deposit is too small to be economic.

Assays were made by the Quebec Department of Natural Resources of sulfide-bearing samples from showings near the Pékans river (f), and near Gras lake (g), in the Gras Lake sheet, and from showings (d) and (e) near Moisie river, in the Félix Lake sheet. These returned only traces of copper and nickel, and negligible gold and silver.

These occurrences, though not economic, indicate the presence of base-metal mineralization in the region. All konwn showings occur near gabbro bodies, or in shear zones near the main rivers.

## Kyanite

Graphite and kyanite are present in the schist overlying the silicate iron-formation. Generally they make up less than 5% of the outcrop. However, the mica schist 3/4 mile south of the outlet of Gentilhomme lake contains about 25% kyanite over a 100-foot width. Many large blocks of a unique rock containing about 20% kyanite and 15% pink garnet in coarse-grained cummingtonite were found just south of the hill of silicate iron-formation that is crossed by the Gueslis-Faber township line. These blocks are almost certainly in place, although no outcrop was found.

## Sand and Gravel

Sand and gravel suitable for construction material are available from the eskers and sorted fluvioglacial deposits of the area. These deposits occur in old stream channels which are generally followed by present rivers (Plate VB).

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