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BEETZ LAKE AREA, ELECTORAL DISTRICT OF SAGUENAY

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GEOLOGICAL REPORT 73

BEETZ LAKE AREA

ELECTORAL DISTRICT

OF SAGUENAY

by

PAUL-E. GRENIER

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BEETZ LAKE AREA

ELECTORAL DISTRICT OF SAGUENAY

by Paul-E. Grenier

INTRODUCTION

Location of Area

The Beetz lake area is bounded by the 62°30' and the 63°00' West lon-
gitudes and by the 50°30' and 50°45' North latitudes; these limits encompass a
surface area of approximately three hundred and seventy-five square miles. The
southern limit is approximately fifteen miles north of the village of Johan
Beetz and the southeast corner of the area lies only thirty-three miles north-
east of the village of Havre Saint-Pierre. This latter village, located on the
north shore of the Gulf of St. Lawrence and four hundred and forty miles down
stream from Quebec city, is the most important centre along this portion of the
coast. Its population numbers approximately two thousand and consists mainly
of fishermen. The village boasts a hospital and serves as base of operation
for Quebec Iron Titanium Corporation. It is serviced by ships of the Clarke
Steamship Company and by a regular air service. Since the summer of 1950, Havre
Saint-Pierre has experienced renewed activity as a result of the exploitation
of an ilmenite deposit by Quebec Iron Titanium Corporation. This deposit, lo-
cated twenty-five miles north of the town, is linked to the coast by a railroad
terminating at Havre Saint-Pierre. The village of Johan Beetz, formerly known
as Piashti-Baie, is situated some forty miles down stream in a straight line
from Havre Saint-Pierre which is also located on the Gulf of St. Lawrence. It
is composed of about forty families of fisherfolk and was founded around 1862
(Rouillard,1908, p. 164)[x]. It was once an important centre of fur farming. The
ships of the above-mentioned company call regularly here but, because of the
lack of a wharf, the disembarking of passengers and the unloading of cargo are
accomplished by means of fish boats.

Beetz lake, to which the area owes its name, is located fifteen miles
from the coast of the St. Lawrence and it occupies almost exactly the south
central portion of the area. The lake is V-shaped with the open end toward the
north, the east and west arms measuring nine miles and five miles in length,

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[x]A list of the works cited will be found at the end of this report.

respectively. The drainage is southerly from the base of the V toward the
Gulf of St. Lawrence.

Means of Access

The easiest mode of access to the area is by air since numerous lakes,
suitable for hydroplane landings, are distributed more or less uniformly through-
out the area. Havre Saint-Pierre can be used as a supply base.

The area may also be reached by canoe. Four navigable routes reach the
coast in the vicinity of Johan Beetz.

The first route utilizes Watshishou river which flows into the St.
Lawrence at a point some five and a quarter miles east of Johan Beetz. Initially
the route crosses Véronique lake and then follows the west branch of Watshishou
river as far as a portage which is encountered three-quarters of a mile below
Théobule lake; this portage leads to Prudent lake whose northern extremity lies
within the southeast part of the area. This route involves a total traveling
distance of twenty-one miles and includes thirteen portages, the first one having
a length of one mile.

The second of these routes follows Piashtibaie river, also known as
Grande Baie river, which flows into Quétachou bay three miles east of Johan Beetz.
This river contains many short rapids as well as several falls and it possesses a
very fast current during high water. Upstream the river widens out to form a
chain of lakes connected by short rivers replete with rapids and small falls. In
this way lakes Bellanger, Napoléon and Beetz are traversed. The latter lies ap-
proximately sixteen and a half miles from Quétachou bay.

A third route follows Piashti river, or Petite Piashtibaie, which flows
into the Gulf of St. Lawrence exactly at Johan Beetz. This river is really no
more than a chain of lakes. Tidal effects are felt for a distance of two miles
from its mouth, in fact up to the head of Salé lake. At low tide this distance
is virtually unnavigable in a small canoe because the river bed is flat, wide and
full of boulders. Three miles from the sea a 175-foot waterfall necessitates the
use of a difficult portage. Upstream from this fall to Petit Piashti lake the
river flows quietly except for a short rapid which can normally be run by "roping".
From the head of the lake the river possesses a strong current but it is navigable
for more than a mile, that is, to a point approximately midway between Petit
Piashti and Piashti lakes. Four portages permit completion of the remainder of
the route which eventually reaches Piashti lake whose northern half lies within
the area.

The area may also be reached via Corneille river. The writer is only

slightly acquainted with this route, as it was never followed throughout its length. Corneille river discharges into the Gulf of St. Lawrence at a point eight miles west of Johan Beetz. The east branch of this river affords access to the western part of the area.

Previous Investigations

The only geological investigation carried out in the Beetz Lake area prior to the summer of 1949 was an exploration conducted by Claveau in 1942. Claveau (1943) commenced at Métivier lake which lies north of Beetz Lake area and he then travelled east to the headwaters of the west branch of Piashtibaie river which crosses the central portion of the area being studied. From this point he proceeded southerly, crossing several lakes during the course of his travels including Boiret, Ransonet and Beetz lakes, until he reached the town of Johan Beetz.

W. Erlenborn (1925), in 1924, carried out a detailed examination of the pegmatite deposits of Quétachou bay situated along the coast a few miles south of Beetz Lake area.

In 1941, Retty (1944) explored the Lower Romaine River area, which is situated approximately eight miles west of Beetz Lake area. During the summer of 1942 Longley (1948) mapped Forget Lake area, whose southeast corner touches the northwest corner of the present area.

In 1943, Claveau (1949) examined Wakeham Lake area situated to the east of Forget Lake area and also lying north of the west half of Beetz Lake area. During the same summer, Longley (1950) carried out a geological survey of that portion of the north shore of the Gulf of St. Lawrence lying between Mingan and Aguanish, a straight-line distance of approximately eighty-five miles.

In 1944, Claveau (1950) continued the eastern extension of the geological survey that had been terminated by Longley at Aguanish the previous summer, and this later investigation covered a distance of fifty-five miles, thus reaching Washicoutai bay.

During the summer of 1945, Claveau (1949b) carried out a geological survey of the Upper Romaine river and a few of its tributaries, in order to extend the work started in 1941 by Retty (1944) toward the north.

Allard Lake area, located some twenty miles west of Beetz Lake area, had also been investigated. W. Bourret (1949) reports that Kennecott Copper Corporation had held an option on claims staked on some ilmenite deposits since

1942 and that, in 1944, W.W. Longley examined some of these claims on behalf
of the company. In 1946, Kennco Explorations (Canada) Limited, a subsidiary of
Kennecott, carried out additional investigations which led to the discovery of
an important ilmenite deposit. As mentioned previously, Quebec Iron Titanium
Corporation is presently exploiting this deposit and has been doing so since
1950.

Field-work

The geological data was plotted on a map with a scale of one-half
mile to the inch. Pace and compass traverses were run systematically at inter-
vals varying from one-half to three-quarters of a mile. These traverses were
run in an east-west direction in order to cross the north-south rock structures,
as reflected by the topography. The shore-line exposures of the main lakes and
rivers were examined in detail.

The basemaps used were not too accurate but the information was subse-
quently transferred to maps compiled from aerial photographs, furnished by the
Department of Mines of Quebec.

Acknowledgments

The field assistants during the summer of 1949 were: Owen Owens and
Robin Burger, graduates of McGill University, and André Leclerc, student in en-
gineering geology at Laval University. Walter Harvey, Léonard Tanguay, Napoléon
Harvey, and William Gaudet, all of Johan Beetz, acted as cook and canoemen, re-
spectively. In 1950, the assistants were Gerald Cooper, post-graduate student
at McGill University, William Bonneville, student in engineering geology at Laval
University, and Roger Gingras, also of Laval University. All the members of the
group carried out their respective assignments in a satisfactory manner.

NATURAL RESOURCES

Timber and Agriculture

The principal forest species of the area are spruce, and, in lesser
quantity, balsam and birch. Locally, there are stands of trees of sufficient size
to be used as pulp wood. Some spruce attain twenty-four inches in diameter at
the stump and could be used in construction work.

The best stands are to be found in the central portion of the area:
Tanguay lake and vicinity, near the west shore of Ransonet lake between Beetz
lake and Robe-Noire lake, and also on the strip of land separating Napoléon lake

from Beetz lake, and along the main branch of Piashti river north of Piashti lake.

Five years ago the west part of the area was ravaged by fire which burnt out approximately one hundred square miles.

Because of the thinness of the soil cover on the higher summits, trees are either stunted or even completely absent. The Pleistocene continental glaciers stripped the pre-glacial soil replacing it by only a thin veneer of poor material.

The interval since deglaciation has not been sufficiently long to permit the development of an adequate amount of humus to encourage agriculture.

Game and Fish

Trout is found in Beetz, Piashti, Robe Noire, Iles, and Watshishou lakes but no fish have been taken in Plat lake. From Beetz lake trout becomes increasingly scarce as the outlet of Wakeham lake is approached.

Caribou and bear are relatively scarce since only a few tracks of these animals were observed. Only three caribou and one bear were seen during the summer.

Swamp partridge and hardwood partridge are numerous in the area. Rabbits and porcupine are also relatively abundant.

Few fur-bearing animals were observed during the summer. Two beavers were seen but no recent beaver lodges; evidence of ancient beaver workings is fairly abundant around the smaller lakes. The scarcity of beavers is probably the result of excessive trapping practices. Muskrat are abundant but otter and mink were known to be present only from a few observations of their tracks.

PHYSIOGRAPHY

Topography

The area being described is an uplifted peneplain dissected by numerous river valleys.

The topographic features of the area were studied fairly intensively and their relations with geological aspects are fairly certain. Each rock type possesses a characteristic topographic expression. Gabbro dykes and sills are

resistant to erosion and they form high elongate hills oriented more or less
in a north-south direction, whereas the metasedimentary rocks, being more sus-
ceptible to erosion, occupy the valley bottoms. The granite is fairly re-
sistant to erosion and the batholith in the northwest part of the area forms a
high upland occupying an area of approximately eighty square miles.

The topographic form of the granite batholith is attributable to the
existence of a system of joints, almost horizontal and very well developed,
which is observed in the majority of the exposures unless these joints repre-
sent the sheet type. On the upland surface which is gently undulating there
are to be found isolated knobs or peaks. The principal knolls occur two miles
north of Irène lake where the underlying rock consists of a mixture of gabbro,
metasedimentary rocks, and granite. The metasedimentary rocks and the gabbro
are present as large inclusions in the granite and, in those places where the
gabbro predominates, we have hills of considerable relief standing above the
neighbouring granitic terrain. A similar feature characterizes that section ly-
ing one or two miles southeast of du Vent lake.

The influence of the geological formations on topography is most evi-
dent mainly to the east and southeast of the granite massif. In effect elong-
ate hills are the general features in this region, possessing steep cliff faces
locally bordered by talus (Plate I) and separated by narrow valleys. Those ridges
have a hog-back outline and stretch for long distances. The altitude varies in
the same ridge and, in longitudinal sections, the crest lines resemble sine curves
of small amplitude but of large period (wavelength). The difference in elevation
between the valley bottoms and the adjacent hills varies between 200 and 500 feet
but it does attain 600 feet in a few places.

In the regions where the underlying rock is metasedimentary, differen-
tial erosion is also effective in producing ridges of the more resistant beds.
These features are particularly well developed in that section between Beetz,
Bélanger, des Iles, and Croix lakes but these hills are never as high nor as per-
sistant as the gabbro hills. These physiographic features possess an elongation
parallel to the formational strikes, which is roughly south-southeast in most
cases. West of Paquet lake, near the granite massif, the trend of the hills fol-
lows the direction of the contact between the granite and the other rocks in the
area. The orientation passes, therefore, from south-southeast through south,
swinging to the southwest outside of the area. A divergence from the regional
trend of these hills is also observed in those localities where secondary folds
are superimposed onto the major folding. This phenomenon may be observed three
miles northwest of Piashti lake, south of Plat lake, southwest of Eau Claire
lake, north of à la Croix lake, and in the section north of Robe Noire lake. This
is especially striking in the latter locality as the hill forms the north shore
of the lake and protrudes as a point into the lake turning abruptly to follow a

curve which is easily observed on the aerial photographs. North and south of Piashti lake the hills are not so persistent and their orientation is not so well defined as in the other portions of the area. In these sections the underlying rock was seen to consist almost exclusively of gabbro within which there are a few remnants of sedimentary rocks.

· Except for local irregularities, the area shows a gentle inclination toward the south. From a few elevation readings, supplied by the Topographic Service of Ottawa, it is seen that the highest peak is situated one mile south of Plat lake, and it attains 1,200 feet above sea level, whereas the lowest elevation is recorded at Grand Piashti lake with an elevation of 247 feet above sea level.

The lakes have the following special forms which occur in an area underlain by granite, quartzite, or gabbro. In the granite area the lakes are of two types. Small lakes generally occupy depressions in the form of a wash-basin. Their shores are low and rise with a gentle slope toward the higher ground. The large lakes, on the other hand, occupy deep depressions. The shorelines are generally straight and change direction with sharp angles. The banks are steep and in several localities they form vertical cliffs. 'Irène lake, shaped like an irregular cross and with high banks, illustrates this type of lake very well. Vertical joints, generally very well developed in the granite, are probably the principal factor which determines the shape of these lakes. Where the strike of the joints parallels the shore vertical cliffs result, whereas elsewhere the banks are less steep.

In that sector where the bedrock consists of an assemblage of metasedimentary beds and gabbro sills the lakes are generally long and narrow with their long axes trending parallel to the geological formations. As mentioned above, these lakes are the result of differential erosion between the resistant gabbro and the less resistant metasedimentary rocks, or of alternating resistant and weak metasedimentary layers. When the shores coincide with the contact line between the resistant and weak rocks, they usually develop as steep cliffs. If, on the other hand, the shoreline is in the weak rock, then the resulting bank has a gentle inclination until it meets the resistant rock which then forms a steep escarpment. Proulx and François lakes (Plate II) are good examples of the case where the shoreline coincides with the contact, whereas a small lake situated one and a half miles west of Plat lake illustrates a lake with its shoreline still in the weak rock. Nevertheless, there are places where vertical banks of metasedimentary rock exist. These cliffs do not extend for long distances because of the heterogeneous character of the metasedimentary formations which favors the action of erosive agents. Thus, on the east shore of the southwest bay of Gendron lake there is a vertical cliff composed of metasedimentary rocks in which waves have worn a cave (Plate III) roughly 35 feet deep and 15 feet high.

Narrow elongate shapes are characteristic of lakes in an area consisting of an assemblage of metasedimentary rocks and gabbro, but exceptions do exist. These exceptions are encountered among the larger lakes of the area, such as Robe Noire, Beetz, and Piashti lakes. These lakes are characterized by a shoreline indented by numerous deep bays and long points (Plate IV). A large number of islands are present, except in Piashti lake. These lakes also result from differential erosion but assisted this time by the peculiar structural conditions of the formations. These three lakes are crossed by the traces of the three major folds of the area.

Southeast of Piashti lake the bedrock is gabbro. The lakes occupy irregular depressions between gabbro hills and they possess steep banks. In the eastern part of the area, within gabbro sills, there exist narrow elongate lakes similar to those already described above. The form of these lakes may have developed through the complete removal of large inclusions of metasedimentary rocks or else by differential erosion within the gabbro sills. In effect, along the west shore of Watshishou lake (Plate VIA) and also, in other places, certain sills of gabbro were seen to be composed of layers of varying hardness.

Hydrography

The entire drainage of the area is toward the gulf of St. Lawrence via four different drainage basins. These basins divide the area into four zones oriented more or less north-south whose mutual boundaries are undulating lines.

The width of the western zone varies from four miles in the north to three-quarters of a mile in the south. The drainage from this zone flows into Corneille river whose course lies to the west of the area and it discharges into the St. Lawrence river at a point approximately eight miles west of Johan Beetz.

The eastern band measures approximately three and a half miles in width at its northern extremity, widening gradually toward the south where it attains a width of five miles. The lakes in this section drain to the St. Lawrence by means of Watshishou river whose outlet lies five and a quarter miles east of Johan Beetz.

The central portion of the area is subdivided into two additional zones drained by Petite Piashti and Quétachou rivers. The width of the first zone varies from three to four miles in the north to approximately eight miles in the south. The zone drained by Quétachou river has a width of eleven miles in its northern part and nine miles in its southern end. As mentioned previously Petite Piashti river flows into the St. Lawrence at Johan Beetz, whereas Quétachou river discharges into Quétachou bay which lies three miles east of this village.

The Beetz Lake area does not possess a well integrated drainage system.

A multitude of lakes, generally occupying deep valleys, receive the run-off
which flows from one lake to the other by means of fortuitous depressions
containing short segments of rivers replete with rapids and falls (Plate V).
A few of these chains of lakes have been designated as rivers because·they
pass gradually into typical rivers upon approaching the gulf of St. Lawrence.

Physiographic History of·the Area

Beetz Lake area occupies the southeast part of the Canadian Shield,
normally described as a broad amphitheatre-like area possessing a U-shape,
rises sharply at the outer margin, and falls away with a gentle inclination
toward the large central.basin of Hudson bay. The general physiographic features
of ·the Shield should therefore be found in Beetz Lake' area since it forms a part
of the Shield. The physiographic history of the Shield has been studied mainly
by A.W.G. Wilson (1903), M.E. Wilson (1919), and Cooke (1929, 1931).

No proof could be found in the Johan Beetz area that it had been sub-
merged during post-Precambrian epochs. On the other hand, it is entirely possi-
ble that Ordovician and Silurian seas did inundate certain portions of Beetz
Lake area, as suggested by observations made by Twenhofel (1927), Longley (1950),
and Hammond (1946). Twenhofel (1927) has found Ordovician rocks up to an eleva-
tion of 625 feet on Anticosti island, 35 miles south of Beetz Lake area. He
found· some along the shore of the St. Lawrence in the vicinity of Havre St. Pierre
and on the Mingan islands, the last of which, composed of Palaeozoic rocks, is
situated about fifteen miles southwest of Beetz Lake area.

Along the shore of the St. Lawrence in Mingan Islands area, the eastern
limit of the Palaeozoic formations is at Sauvage point. However, as far as twenty
miles down-stream from this point, which is fifteen miles south of the area,
Longley (1950) found sandstone dykes filling fractures in the underlying Pre-
cambrian complex; these sandstones are similar to the basal beds of the Palaeozoic
formations of Mingan. According to Longley (ibid.) also, the summit of Mont Ste-
Geneviève, 15 miles southwest of the area, is covered by Ordovician rocks which
are exposed at an altitude of·332 feet above sea level.

Finally, Hammond (1946) found rocks of Black River age at Manicouagan
and Mouchalagan lakes which lie approximately 235 miles west-northwest of the area,
at elevations of 685 and 830 feet respectively (according to the Geological Map of
New Quebec, 1929). The distance between Beetz lake and these two lakes is consid-
erable. Nevertheless, from the foregoing observations, we can reasonably suppose
that at' least a portion of Beetz Lake area had been invaded by the Ordovician sea.
Certain portions of the area lie at elevations below 625 feet,and Piashti lake,
for example, stands only 247 feet above sea level.

A.W.G. Wilson (1903) points out that the uniform surface of the
Canadian Shield truncates the structure of the metamorphic, igneous, and sed-
imentary rocks, regardless of their hardness or their attitude, and this is a
distinctive characteristic of a peneplane. In Beetz Lake area there is a uni-
form surface that truncates the summits of similar hardness only. The dissec-
tion of this surface by numerous valleys containing rivers that are full of
falls and rapids (Plate V) or narrow elongate lakes indicate a youthful drain-
age. These two physiographic features cannot belong to the same geomorphic
cycle. It is essential for the area to have been subjected to peneplanation
first, followed by an uplift which rejuvenated pre-existing streams. Added to
the effect of the uplift is that of glaciation which determines, in certain
places, the development of a new system of drainage. In Beetz Lake area it is
difficult to determine whether one or another part of the drainage system is due
to normal erosion following uplift or to glaciation, but there are a few places
where the action of the one or the other of these factors can be recognized.

Within the area there is a well-defined valley occupied by Vent lake,
a portion of Irène lake along with a small stream which has its origin north of
Irène lake. The erosive action of this small stream and of these two lakes is
insufficient to have produced this valley. It is believed that this valley and
several other valleys less well-defined were developed during a pre-glacial pe-
riod. The western branch of Quétachou river with its deeply embanked sections
and its falls and multitudinous rapids (Plate V) cut into bedrock seems to be a
rejuvenated stream.

The foregoing facts lead to the conclusion that peneplanation of the
Beetz Lake area was followed by an uplift prior to glaciation, which subse-
quently caused a rejuvenation of the pre-existing drainage system.

There is nothing in Beetz Lake area to indicate the age of the uplift.
Several authors (e.g. Cooke, 1929) considered that the uplift of the Laurentian
peneplane occurred in the Pliocene. Kay (1942), after investigations in the
southern part of the Shield, considers the uplift as having taken place in Upper
Cretaceous or Lower Tertiary time. Claveau (1944), in his study of the area of
Forget and Wakeham lakes, is inclined to place the uplift somewhere between the
estimates of Cooke and Kay.

Pleistocene glaciation, which affected the Canadian Shield, did not
by-pass Beetz Lake area and one of its physiographic effects was to modify, in
certain places, the pre-existant drainage system. Thus, at the southern extrem-
ity of Watshishou lake, there is a till deposit which prevents the lake from
draining to the south and forces it to discharge to the east into Holt lake be-
fore flowing to the south. The top of this deposit is about five feet above
the lake level and only fifty feet south a small stream flows sluggishly toward

the south. It is probable that this stream is fed in part by water percolating through the till from Watshishou lake. This creek joins Watshishou river three and a half miles further to the south.

Beetz Lake area does not provide definite proof of epeirogenic movements since the Pleistocene. On the other hand, Cooke (1929) has stated that the Shield in general has been subjected to such movements.

In the northwest bay of Beetz lake a terrace composed of clay rises fifteen feet above lake-level. This terrace, exposed for a distance of 75 feet, stands 385 feet above sea-level but no fossils were found therein. Its formation may be due to the Champlain sea or to Beetz lake. In effect, the glacier, at the time of its retreat, may have deposited material which would have blocked the Beetz lake outlet and also would have raised the level of the lake permitting it to form this terrace. Such glacial deposits could subsequently have been removed by erosion.

In brief, the physiographic history of Beetz Lake area is as follows: during Precambrian time subaerial erosion reduced the area to a peneplane. Low amplitude undulating movements of the land permitted the Ordovician and Silurian seas to inundate at least a portion of the area to deposit sediments. The same movements then brought about the retreat of the sea. This is followed by subaerial erosion which then became active in the area stripping the Palaeozoic cover which had been deposited. The period of erosion continued to the Pliocene when an uplift of approximately 1,200 feet took place. This uplift caused rejuvenation of the streams and from this moment a new geomorphic cycle was initiated. During the Pleistocene, continental glaciers advanced over the area from the north. They accentuated the pre-existing topography, modified the drainage system, and brought about a subsidence of the land as a result of the weight of the ice. The glacier subsequently retreated northward and the Champlain sea covered a portion of the area, producing terraces. After retreat of the ice sheet, the continent tended to return to its previous isostatic balance by slow uplift. This uplift has been from 260 to 590 feet measured relative to actual sea-level, but to obtain the true uplift it would be necessary to know the amplitude of the oscillations which affected the sea bottom during this epoch and which brought about a variation in the sea-level. The area continued to rise up to the present time and it should rise an additional 600 feet before reaching the level which obtained at the end of the Pliocene.

GENERAL GEOLOGY

Table of Formations.

Cenozoic (Pleistocene or Recent)	Clay, sand, gravel, boulders	

Great unconformity

		Pink biotite granite, pegmatite
Precambrian	Intrusive rocks	Intrusive contact
		Fresh gabbro; altered gabbro including uralite gabbro, dioritic facies, gneissic gabbro, and schistose gabbro
	Intrusive contact	
	Metasedimentary rocks	Calcareous quartzite; phyllite. White quartzite Impure quartzites and related rocks including glassy quartzite, slightly recrystallized quartzite, black quartzite, quartz-mica schist, hematite-rutile quartzite, biotite gneiss, and cordierite hornfels

All the consolidated rocks of the area are of Precambrian age.

Four-fifths of the area is underlain by an assemblage of metasedimentary rocks and altered gabbro. The gabbro is present mainly as large sills and subordinately as dykes and small discordant masses. The metasedimentary rocks underlie an extent of slightly less than half of the area. The remainder of the area is composed of granite belonging to two massifs. One of these, with an areal extent of 80 square miles, extends beyond the limits of the area to the north and west (Longley, 1948, and Claveau, 1949a). The other mass of granite, smaller than the first and probably related to it at depth, is located in the southwest part and continues outside the southern limit of the area.

The gabbro intrusion appears to be cotectonic, i.e. contemporaneous with the folding of the metasedimentary rocks, but it is virtually impossible to determine to which stage of the folding the gabbro is related.

The granite is younger than the gabbro (Plates VIB and VIIA) and the metasedimentary rocks (Plate VIIB). Most of the alteration observed in the gabbro seems to have been caused by the granite since it is more intense in those areas adjacent to the granite.

The metasedimentary rocks are, in general, less altered than the gabbro, probably because they are composed dominantly of quartz. On the other hand, certain of the formations are less siliceous and contain such minerals as scapolite and cordierite, the presence of which is attributed to the action of the granite intrusion.

Metasedimentary Rocks

General Statement

The metasedimentary rocks are considered to be the oldest rocks in the area.

The stratigraphic succession is not evident anywhere else except in Robe Noire Lake syncline, in the north part of the area. On the west flank of this syncline, north of Beetz lake, three lithographic units can be distinguished. The lowermost unit consists mainly of impure quartzite together with a small amount of quartz-mica schist, but it also contains minor amounts of hematite-rutile quartzite and biotite gneiss. These rocks occupy a four-mile wide belt adjacent to the granite batholith. On the other hand, the stratigraphic succession in this section of the syncline is confused because of secondary folding.

The middle unit consists almost entirely of the fine-grained white quartzite. This unit outcrops over a width of two miles. The upper unit is characterized by calcareous quartzite interstratified here and there with thin phyllitic beds. In addition this group contains a large amount of white quartzite identical to that of the middle group; it outcrops over a width of four and a half miles.

The different rock types which compose these three groups are found in all parts of the area. The established correlations, however, cannot be considered as being definite, since there are no actual marker horizons in any of these groups. Rocks of the upper and middle units are found in succession on the east limb of Robe Noire Lake syncline. Near the eastern border of the area, beds of impure quartzite are found in a few places; it is thus possible that rocks similar to those of the lower unit outcrop to the east of the present area. The middle group is also found between the axes of Beetz Lake anticline and Piashti Lake syncline. West of the axis of Piashti Lake syncline, rocks of the lower unit predominate.

The groups pass from one to the other without any lithological discontinuity. They have a marine origin; thus the rocks which form them are well sorted, of uniform composition over extensive areas, and exhibit cross-bedding and ripple marks in several places (Plates VIII A-B).

Impure Quartzite and Related Rocks

The principal rock types of the lower group are glassy quartzite, slightly recrystallized quartzite, black quartzite, quartz-mica schist, hematite-rutile quartzite, biotite gneiss, and cordierite hornfels. In several localities the different types of impure quartzites are interstratified with thin beds of quartz-mica schist.

Glassy quartzite

The glassy quartzite, found in several places near the granite batholith, is a holocrystalline rock with a massive aspect whose thick beds are difficult to recognize because of recrystallization. It is a medium-grained grey rock with a glassy appearance on a fresh surface.

Under the microscope an intimate interpenetration of irregular quartz crystals is observed (Plate IX A), indicative of an advanced recrystallization. The rock is composed of 85 per cent quartz, 5 per cent potash feldspar, and 10 per cent of accessory minerals which include epidote, chlorite, garnet, muscovite, biotite, magnetite, and sphene, but all the accessories are not necessarily found in every one of the thin sections.

The quartz grains have an average diameter of approximately 3 milli-
meters, whereas the other constituent minerals generally range in size from
0.1 to 0.4 mm. The accessories are normally found to occupy interstitial posi-
tions between quartz grains but feldspar, chlorite, garnet, and magnetite can
also occur as inclusions within the quartz.

The composition of the glassy quartzite, the remains of former bed-
ding, and the fact that it is interstratified with other sedimentary rocks of
lower metamorphic grade strongly favor a sedimentary origin for these rocks.

Of all the metasedimentary rocks, the glassy quartzite is the most re-
crystallized (Plate IX A). Since the glassy quartzite is found nowhere else
except in the vicinity of the granite batholith, it is quite probable that the
recrystallization is a contact metamorphic phenomenon related to this intrusive.
All beds, however, do not exhibit equal amounts of recrystallization.

Slightly Recrystallized Quartzite

The slightly recrystallized quartzites are fine-grained, rugose rocks,
and resemble sandstones. The colour varies from pale grey to dark grey to black.
The pale grey variety is similar to the band of white quartzite which is de-
scribed later in this report. In addition, this type generally is made up of beds
some two or three, and even more, feet thick, whereas the dark variety occurs in
beds only a few inches thick. In several places, but within the pale variety,
there are black beds measuring 1/32-inch in thickness whose colour is the result
of a high concentration of hematite and magnetite. Beds of this type character-
ize those strata that are cross-bedded. The slightly recrystallized quartzite is
exposed in widely separated localities; for instance one exposure is situated
$1^3/4$ miles south of Leonard lake and another, one mile east of the southern ex-
tremity of Ransonet lake. In the granite, half a mile west of Feu lake, there is
an enclave composed of slightly recrystallized quartzite. This inclusion is too
small to be shown on the accompanying map. Grouped with these rocks is a black
quartzite that is exposed on the west shore of Watshishou lake three and a quar-
ter miles south of the first one. This black quartzite has a poorly defined
psammitic texture but the microscopic studies indicate that it belongs with the
slightly recrystallized quartzites.

Under the microscope the thin sections do not all show the same tex-
tures because of the different degrees of recrystallization and also because of
different compositions. Some of the thin sections exhibit a granoblastic tex-
ture in which the grains, of essentially the same sizes, are not in sutured
contact where they are in juxtaposition (Plate IX B). In other thin sections
the texture is characterized by angular and sub-angular quartz grains distrib-
uted in a finer-grained matrix very rich in quartz, mica, and also carbonate in

some instances (Plate X A). This texture is similar to that commonly encountered in psammitic sedimentary rocks in general. The various types of slightly recrystallized quartzites have a quartz content that ranges from 65 to 80 per cent. Certain varieties contain up to 20 per cent feldspar, which includes microcline, orthoclase, and plagioclase with a composition varying between An_{31} to An_{34}. On the other hand, the types rich in micas and epidote contain few feldspars. The slightly recrystallized quartzites also contain biotite, muscovite, a small amount of chlorite, epidote, and carbonate. The micas and epidote combined constitute between 5 and 30 per cent of the rock, whereas the carbonate is present in amounts up to 15 per cent in certain cases. The accessory minerals are rutile, sphene, tourmaline, hematite, and magnetite.

In those thin sections exhibiting a granoblastic texture (Plate IX B) the quartz is in clear grains with an average diameter of approximately 0.2 mm. The range in grain size is from 0.08 to 0.6 mm. In those thin sections showing a psammitic texture (Plate X A) the same variations in grain size are observed. In the latter case, however, the quartz grains of medium size are distributed within a matrix composed of a high percentage of mica, a little epidote, and carbonate in some of the sections, and of small grains of quartz. In all these rocks, the average grain size of the minerals is generally less than that of the quartz grains.

The feldspars are much more highly altered to sericite in the psammitic rocks than in the granoblastic-textured rocks.

As mentioned above the texture of this rock is variable. In certain cases a granoblastic texture is recognized in which the grains are free and show interpenetration only in rare instances (Plate IX B). On the other hand, the psammitic-textured rocks resemble a sandstone or a greywacke whose argillaceous or calc-argillaceous matrix, in certain cases, would have been converted into micas, chlorite, and zoisite by feeble metamorphism which would have brought about recrystallization of the carbonates present. Rocks with textures intermediate between these two extremes are also found. There seems to be a gradation between a sedimentary rock whose matrix alone has recrystallized and possibly transformed mineralogically, and a sedimentary rock completely recrystallized but in which the grains are almost all free. The difference in the degree of recrystallization is possibly due to the difference in the original composition of the rock. Another explanation is possible: the different textures could have resulted from the alteration of the feldspars to sericite and epidote in the highly feldspathic beds but this hypothesis seems improbable.

Black quartzite

Black quartzite is exposed only in a few places. The typical samples

of this rock were collected in the syncline located north of Ransonet lake at a place one mile east of the northern end of Plat lake. Bedding is only slightly visible or not visible at all and, in those places where it was observed, the thickness of the beds varies from one inch to three feet. The grain size varies from very fine to fine and in massive exposures the rock is difficult to distinguish from fine-grained gabbro.

Under the microscope the black quartzite exhibits a granoblastic texture but in a few of the thin sections an alignment of the constituent minerals was observed. Interpenetration of the grains is also marked.

The composition of this rock is variable. It consists generally of a high percentage of angular to irregular grains of quartz with an average size of 0.2 mm. in some cases, and 0.1 mm. in other cases.

Angular orthoclase grains measuring 0.2 mm. in diameter are present in one thin section, whereas slightly sericitized microcline is visible in several of the thin sections. The potassic feldspar content seldom exceeds 10 per cent.

The interstices between quartz and feldspar are filled with biotite, muscovite, magnetite, and sometimes a small amount of zoisite. Brown to green biotite is present to all thin sections and it has a tendency to form idioblastic crystals. Colourless muscovite is distributed as fine flakes of irregular outline. The magnetite occurs as xenoblastic crystals varying from 0.04 to 0.1 mm. in size on the average, but some of the thin sections are peppered by grains less than 0.01 mm. in size. As for the zoisite, it is found in small amounts in only one thin section. It forms agglomerations of xenoblastic crystals measuring 0.06 mm. in size.

This rock probably represents an original sandstone or a siltstone with argillaceous matrix. Under metamorphism the argillaceous material was transformed to mica and the quartz was recrystallized. The possibility that the micas were formed from the alteration of the feldspars is ruled out. As a matter of fact, the micas do not form into clusters reminiscent of former feldspar crystals. On the contrary, the micas are uniformly distributed between quartz grains and in some places there are mica-rich layers alternating with quartz-rich layers. The black quartzite grades into quartz-mica schist with a gradual increase in the percentage of mica.

Quartz-mica schist

Quartz-mica schist is found especially in those areas where impure quartzites are exposed, but it also occurs in other sections of the area as thin interbeds within the other metasedimentary rocks. Exposures of quartz-mica

schist are much less abundant than those of impure quartzite. Since the re-
sistance to erosion of the schist is much less than that of the impure quart-
zite, it is possible that several of the valley bottoms, occupied by lakes or
covered by drift, are underlain by quartz-mica schist. The main exposures of
quartz-mica schist occur on the east shore of the south point of Plat lake, and
on the west shore of the southwest bay of Hamel lake. Sericite schist was also
found on the two little islands of Watshishou lake situated approximately two
miles south of the northern limit of the area.

The quartz-mica schist is a very fine-grained, dark grey rock. From
a casual inspection the rock appears to be massive but a closer study indicates
the presence of schistosity whose planes produce a characteristic micaceous
sheen. The schistosity seems to be parallel to the primary bedding in most cases.
On the small island situated near the west shore of Napoléon lake one and a quar-
ter miles south of the northern end of the lake there are two schistosities. The
first is parallel to the stratification in the rock, whereas the second inter-
sects the first schistosity at an angle of 15°. The intersection of the two
schistosity planes forms a dihedral angle of approximately 40°.

The sericite schist is cut by an excellent schistosity. It weathers
dark grey but on a fresh surface the schistosity planes possess a beautiful green
lustre.

In the majority of thin sections the rock consists of a granoblastic
aggregate in which mica grains are uniformly distributed. In some of the thin
sections the foliate minerals appear as layers from 0.4 to 3 mm. thick separated
by quartz-rich layers. The mica flakes are generally oriented in planes parallel
to the layering. In some of the thin sections the mica flakes have an orientation
which varies within the same layer and the gradual variation of this orientation
produces sinuosities or undulations. These sinuosities represent tiny folds not
visible to the naked eye. Two thin sections from a rock composed of alternating
quartz and mica bands were studied megascopically and found to exhibit the same
type of folding but on a larger scale. One of the specimens comes from the east
shore of the southwest bay of Hamel lake and here the axial planes of the drag
folds are parallel to the bands. In the second, which was collected from the
island in Napoléon lake, the axial planes form an angle of 40° with the bands.
There is an increase in the mica content along the flanks of these drag folds
which also explains the presence of the second schistosity in this rock.

The composition of the quartz-mica schist is characterized by a quartz
content which varies between 55 and 75 per cent. The angular quartz grains mea-
sure 0.1 millimeter in diameter and it is to them that the rock owes its grano-
blastic texture in some of the bands. The rock also contains 20 to 40 per cent
micas, unequally divided among biotite, muscovite, and sericite. Also present

are a little microcline, orthoclase, epidote, tourmaline, apatite, sphene, hematite, and magnetite but these minerals are not present in all of the thin sections.

In some of the thin sections biotite is present in larger quantities than muscovite, whereas in others the latter mineral predominates. In some cases there is a gradual change of muscovite into biotite. As a matter of fact, the central part of a few of the crystals is composed of colourless muscovite, while the outer portions, as well as the zones adjacent to cleavage surfaces, are composed of pleochroic biotite.

The quartz-mica schist, as described above, is a sedimentary rock that has been altered by low grade metamorphism. Like the other rocks of the sedimentary sequence, it contains much quartz and retains traces of primary bedding.

Generally, as the quartz recrystallizes under metamorphism an increase in the average size of the grains is observed. It is thus logical to suppose that, in the sediment from which the schist was derived, the mean diameter of the quartz grains was equal to, or less than, 0.1 mm. From Wentworth's classification (1922), the sediment would have been a very fine-grained sand, a silt, or a clay. This material would have consisted of a high percentage of quartz, together with a lesser percentage of clay minerals. Under the effects of metamorphism the quartz recrystallized, whereas the clay minerals gave rise to muscovite and biotite.

It is possible that the quartz-mica schists, which are found generally in places neighbouring the granite, are the more highly metamorphosed equivalent of the phyllite described below and found further to the east. The two rock types occur as thin interbeds within quartzites, or locally as isolated exposures of slight areal extent. The proximity of the granite could explain the higher degree of metamorphism in the quartzose schist.

Hematite-rutile quartzite

Hematite-rutile quartzite is exposed two and a quarter miles southwest of Cap lake. It is also exposed in other sections as, for instance, on an island in the northwest bay of Plat lake, situated approximately half a mile south of the northern limit of the area and near the west shore of the bay.

The hematite-rutile quartzite exhibits a regular interlamination of black and white layers with an average thickness of 1/32 of an inch. Locally the alternation of these layers is less uniform and white bands an eighth inch in thickness or more are separated by black layers measuring 1/32 of an inch in thickness. In three places black bands were found that have thicknesses of

four, three and two inches respectively.

The white layers are composed of a granoblastic aggregate of quartz and the black layers, of irregular grains of hematite associated with grains of rutile or sphene. The overall composition of the rock is as follows:

Quartz	60 to 70%		Biotite
Hematite	At least 13%		Muscovite
Rutile	Traces to 13%	Accessories:	Apatite
Sphene	Traces to 8%		Zircon
Feldspar	5%		Magnetite

The quartz, which has an average diameter of 0.1 mm., is the product of the recrystallization of the silica present in the original sedimentary rock. The hematite has a tendency to enclose grains of rutile or sphene; it was noted that in those thin sections containing a high percentage of sphene only a small amount of rutile is present and vice versa.

The quartz-hematite association along with the fineness of the grain size could suggest that the hematite-rutile quartzite was derived from a ferruginous chert.

The presence of hematite in sedimentary rocks is easily explained by simple chemical or colloidal precipitation of ferric oxide, but the oxide of titanium is rarely associated with it. The absence, or the presence of only minor quantities, of titanium in hematitic sedimentary deposits is not definite proof that this element cannot be precipitated chemically, along with the hematite in nature, as this relative scarcity of titanium can be explained by the lack or scarcity of titanium in the rocks from which the iron-bearing sediments were derived. On the other hand, however, no extensive titanium deposits are known to occur in sediments that resulted from chemical precipitation.

This concentration of hematite, rutile, and sphene in the quartzite studied could thus be explained more easily on the basis of physical processes alone. The minerals could have been concentrated during their transport and deposition by streams.

The presence of cross-bedding is also explained more easily by mechanical deposition than by a chemical, or even a colloidal, precipitation. It is also possible that the iron had been transported in the form of magnetite which would have been converted to hematite by metamorphism.

The rutile and sphene of this quartzite could have been deposited in

their proper form. It is also possible that the sphene is an alteration product of rutile or vice versa. On the other hand, the titanium and iron may have been derived from grains of ilmenite or titaniferous magnetite which subsequent alteration could have transformed into sphene, rutile, and possibly even hematite. Finally, the titanium could have originally been deposited as brookite to give rutile or sphene (Rankama and Sahama, 1950; Clarke, 1924). But the transformation of brookite or rutile into sphene would require the presence of calcium in the original sediments.

The study of the quartzite here discussed has not furnished any evidence in favor of the one or the other of these hypotheses. Nevertheless, one observation permits us to partially reject the hypothesis of the transformation of sphene to rutile. If the rutile is derived from original detrital sphene, then those thin sections showing a high percentage of rutile should contain a higher proportion of calcium-rich minerals. In effect, sphene changes to rutile with the liberation of calcium. But the high-rutile thin sections are no richer in calcic minerals than are the high-sphene thin sections.

Recrystallization of the original silica in this rock has obliterated the primary bedding. On the other hand, the interlamination of hematite layers with quartz layers suggests the presence of relict primary bedding in certain places. In a few localities cross-bedded structures are also preserved.

Biotite gneiss

This name has been used for a blackish rock, slightly gneissic and of fine granularity. It is sparsely distributed throughout the area. The following description is based on only two exposures. The first is located midway along the west shore of the lake situated west of Ransonet lake and the second is found one mile south of the southwest bay of Plat lake. In the first case the rock is interbedded with impure quartzite and the foliation of the gneiss is parallel to the bedding in the quartzite. In the second case the contact between the gneiss and the impure quartzite, which outcrops twenty feet west and also 75 feet east, is concealed by the topsoil.

Marked differences are observed in the two thin sections of the biotite gneiss that were studied. Consequently, the thin sections are described separately.

In the first, that is to say the one which comes from the exposure to the west of Ransonet lake, the gneissic structure is the result of alternating schistose and granoblastic layers with an average granularity of 0.04 mm. Some lenses and veins with granitic or granoblastic texture are also present, with an average grain size of 0.4 mm. These lenses and veins are parallel to the gneissosity of the rock.

This rock consists of approximately 60 per cent quartz, 10 per cent microcline and an unidentified plagioclase, 18 per cent biotite, 7 per cent opaque minerals and a small amount of sericite, chlorite, epidote, tourmaline, apatite and carbonate. The lenses and veins are composed of a high percentage of quartz, microcline, and a little epidote and carbonate.

The second specimen is gneissic, like the first one, but it does not contain the coarser-grained lenses and veins. The mean grain size is 0.1 mm.

The rock is composed of 15 per cent quartz, 55 per cent microcline, orthoclase and plagioclase, 15 per cent biotite, and 10 per cent chlorite. Minor quantities of sphene, apatite, tourmaline, and opaque minerals are also present.

Microcline, in clear grains, is the dominant feldspar followed by orthoclase, slightly altered to sericite, and then by the unidentified plagioclase which is highly altered to sericite and in which it is difficult to distinguish the albite twins.

The foregoing description indicates that the biotite gneiss is a metamorphic rock that has locally been subjected to injection of granitic material in the form of veins and lenses parallel to the gneissosity.

Cordierite hornfels

Hornfels was found at only one locality in the area. This exposure is situated on the east shore of the lake lying west of Napoléon lake. The rock is dark grey and fine grained, and the surface of the exposure indicates the presence of oval-shaped porphyroblasts that are etched in relief. The large diameter of the porphyroblasts varies from a fraction of a millimeter up to five millimeters. The walls of the cavities left by the removal of porphyroblasts exhibits a micaceous luster.

In thin section the porphyroblastic texture is even more striking. The ovoids of cordierite are encased in a matrix composed essentially of quartz and mica with a grain size of 0.06 mm.

In thin section the rock is seen to be composed of approximately 20 per cent cordierite, 40 per cent quartz plus a small amount of unidentified feldspar, 35 per cent biotite, 3 per cent muscovite, and accessory minerals such as tourmaline, apatite, rutile, garnet, and one or more opaque minerals. The overall percentage of cordierite within the rock is less than that recorded in the thin section studied.

The cordierite is poikiloblastic and contains inclusions of quartz, mica, and rutile. Some of the crystals possess pleochroic aureoles with the formula X = yellow and Y = colourless. Furthermore, the porphyroblasts are surrounded by a mica-rich layer.

The cordierite hornfels has passed through several successive transformations. The mineral association, together with the relative proportions, indicate that the original sediment contained a high percentage of quartz and also a high percentage of argillaceous material. During recrystallization the diameter of the quartz grains probably did not decrease but, on the contrary, it more than likely increased slightly. That is to say the actual grains, with a diameter of approximately 0.06 mm., belong to fine-grained sands, near the upper limit of the silts according to the classification of the Soils Bureau of the United States (Pettijohn, 1949). Prior to recrystallization the diameter was probably silt-size. The mineralogical composition of a medium silt, as calculated by Grout (1925), is as follows: quartz 36.7 per cent, kaolinite and clay minerals 7.5 per cent, sericite and paragonite 16.6 per cent, chlorite and serpentine 8.2 per cent. The total of the last percentage minus the quartz equals 32.3 per cent and the minerals included in this percentage group are capable of forming micas under metamorphism. If the approximate 40 per cent of quartz and the approximate 38 per cent of micas occurring in the cordierite hornfels correspond approximately to the quartz content and to the content of clay matter and mica in the rock prior to metamorphism, then the original sediment would have been a silt in accordance with Grout's classification (1925). Even by including the elements in the cordierite, it is certain that the original sediment was rich in quartz and that it contained a high percentage of clay minerals, micas and probably chlorite.

Cordierite is an anti-stress mineral. According to Harker (1950), cordierite, in the case of regional metamorphism, indicates a release of the shearing forces. Cordierite can also form by hydrothermal metasomatism and the mineral is common in the case of thermal metamorphism.

Cordierite rocks produced by regional metamorphism represent a high grade metamorphism and the mineral is present over fairly extensive areas, in gneisses and mica schists. Cordierite rocks, produced by metasomatism or thermal metamorphism, generally occur only within contact aureoles adjacent to intrusives. The cordierite hornfels of Beetz Lake area is neither gneissic nor schistose and the degree of metamorphism is of medium grade. Furthermore, its distribution is very restricted since it was found in only one place; it is true that this could be explained by a local variation in the original composition of the sediment. Thus, it seems as though the origin of the cordierite of Beetz Lake area cannot be attributed to a release of shearing stresses during regional metamorphism.

Harker (1950) states that it is possible to bring about the development of secondary cordierite by metasomatic processes and he mentions a case where a rock was formed containing cordierite and anthophyllite. In the case of the cordierite hornfels of Beetz Lake area it is impossible to say, on the basis of the information available, if the cordierite is of metasomatic origin or not.

It is known that, under certain conditions, thermal metamorphism of argillaceous sediments promotes the development of large cordierite porphyroblasts (Harker, 1950). Such porphyroblasts generally are developed in sediments containing chlorite together with other minerals such as kaolin, bauxite, or gibbsite. Cordierite can be formed by a reaction which involves chlorite, sericite, and iron oxide. The porphyroblasts are generally ovoidal and are filled with small inclusions mainly of quartz and biotite. With increasing metamorphic intensity a garnet, intermediate in composition between almandine and spessartite, is formed. The cordierite hornfels of Beetz Lake area is a metamorphic rock, with a decussate texture, composed of a high percentage of quartz and biotite containing ovoidal porphyroblasts of cordierite with recrystallized inclusions of quartz, biotite, and rutile. Garnets of unknown composition, tending to be idioblastic, are also found in the matrix. Thus the cordierite hornfels possesses the characteristics of an argillaceous sediment that has been subjected to medium grade thermal metamorphism. This metamorphism was undoubtedly due to the granitic intrusion, which is known to intrude all the other rocks in the area.

White Quartzite

White quartzite is the most abundant metasedimentary rock in the area. In the main it occupies those sectors located east of the west branch of Quétachou river, but some is also found in the sector underlain by calcareous quartzite.

This quartzite occurs in beds that range from 6 inches up to 20 feet in thickness. On the other hand, the bedding is not everywhere obvious and is possibly in large part obliterated. It is a fine-grained rock with the colour varying from pale gray to white. It is massive with characteristic conchoidal fracture.

Under the microscope the rock is seen to possess a granoblastic texture. The composition is fairly uniform throughout, the minor variations being caused by minerals that are present in only small quantities. The composition of the rock is as follows: 77 per cent quartz, 10 per cent orthoclase, 3 per cent plagioclase (An_8), and 5 per cent opaque minerals. These minerals are the essential constituents but others are present which do not appear in

all of the thin sections. Among the latter are chlorite, biotite, muscovite, sphene, apatite, and carbonate. This last mineral is found in the white quartzite that outcrops near the axis of Robe Noire Lake syncline.

The quartz is in xenoblastic grains and its granularity varies from one slide to the other. The limiting sizes are from 0.06 mm. to 0.4 mm.; the average grain size is approximately 0.2 mm.

The white quartzite was probably originally a feldspathic sandstone containing a few grains of iron oxide and a few flakes of sericite and chlorite. Thus it was a compact sandstone with almost no interstitial material. During metamorphism the quartz and feldspars were recrystallized and the other minerals, such as the iron oxide, chlorite and sericite, which were present in minute quantities, were unable to combine to form biotite. That is the reason why this latter mineral appears only rarely as rims around some chlorite flakes.

Calcareous Quartzite and Phyllite

The calcareous quartzite predominates in that section situated east and south of Leclerc lake. It is also found in lesser quantity in other sections such as between Beetz lake and Gerry lake and also west of des Isles lake.

It is a dark gray, fine-grained rock with a pitted weathered surface. It contains carbonate lenses attaining one-quarter of an inch in diameter. Thin carbonate veinlets are visible along stratification planes and the matrix itself seems to contain carbonate since it effervesces upon application of hydrochloric acid. A specimen of this rock, decomposed and dissolved in hydrochloric acid, lost 14 per cent of its previous weight and this would correspond to the amount of carbonate present since the other constituents are mainly quartz, feldspar, and mica. In certain places the quartzite is of finer granularity and occurs in very thin beds which alternate with phyllitic beds. These exposures very closely resemble those of the phyllite described below.

Under the microscope the calcareous quartzite possesses a granoblastic or schistose matrix cut by lenses and veinlets, and it has a granoblastic texture of coarser granularity than the matrix. The average composition of the rock is as follows: 45 per cent quartz, 25 per cent muscovite, 14 per cent carbonate, 10 per cent orthoclase, 3 per cent plagioclase, 3 per cent opaque minerals, a little biotite and microcline.

The quartz occurs in angular or sub-angular grains ranging in size from 0.04 to 0.6 mm. The mean grain size of the quartz, within the matrix of the rock, is 0.08 mm., whereas within the lenses and veinlets it is 0.2 mm. The larger quartz grains exhibit undulatory extinction which is not present in the small grains.

The muscovite is in flakes measuring 0.04 to 0.1 mm. that tend to be oriented in parallel planes. It is distributed between quartz grains to which it is moulded.

The carbonate is generally in irregular grains but a few of them exhibit a tendency to form idioblastic grains.

As for the other metasedimentary rocks, the calcareous quartzite is considered to have a sedimentary origin, based upon its mode of emplacement, its high quartz content, and its essentially uniform composition over large distances.

Phyllite outcrops mainly in the following locations: immediately east of Ransonet lake; on the west bank of the west branch of Quétachou river two miles northeast of the northern extremity of Boiret lake; on the point and on the island located on the extension of this point, which is situated in the northeast bay of Beetz lake; on the large island situated in the middle of François lake; and in a few localities in the south central part of de la Robe Noire Lake syncline.

The phyllite occurs generally as thin beds or as discontinuous lenses with a maximum thickness of one and a half inches and interstratified with quartzite. On the other hand, on the point in Beetz lake and on the island of François lake, exposures of phyllite are at least 10 feet thick. It is a very fine-grained rock, relatively soft, and pale gray to dark gray in colour. Some exposures possess perfect foliation, whereas in others the foliation is less perfect. The planes of schistosity possess a characteristic micaceous sheen. In certain places, the rock contains tiny scapolite porphyroblasts, ovoidal in shape with the greater diameter measuring up to 2.5 mm. These exposures have pitted weathered surfaces due to the removal of the porphyroblasts.

Under the microscope the phyllite is seen to consist of a microcrystalline aggregate within which there are local distributions of idioblastic (Plate X B) or ovoidal (Plate XI A) porphyroblasts. The elongate minerals of the aggregate, together with the ovoidal porphyroblasts, are oriented parallel to the schistosity.

The composition of the phyllite is very variable and it is extremely difficult to determine the relative percentage of the various minerals present because of the fineness of the granularity. Characteristic minerals are quartz, muscovite, opaque minerals, chlorite and biotite. Microcline, plagioclase, tourmaline, apatite, sphene and rutile are also present in small amounts. Epidote was observed in one thin section, and porphyroblasts of scapolite in two other thin sections.

The quartz is generally in small irregular grains from 0.01 to 0.04 mm. in size, more or less submerged in a micaceous aggregate. Muscovite, in fine scales oriented parallel to one another, is uniformly distributed throughout all the rock. On the other hand, certain zones contain a higher proportion of muscovite and, if these zones are examined under low magnification, the simultaneous extinction of the various flakes which compose the zones produces the effect of large shredded porphyroblasts of muscovite.

The rock is peppered with opaque minerals and a number of them have a rounded outline, but the majority of them are elongated. A very small proportion of these minerals are magnetic. The elongated minerals may possibly represent graphite flakes or hematite, whereas the rounded magnetic grains are probably magnetite.

Chlorite is not present in all of the thin sections. Where present, it is in the form of thin lamellae possessing a weak, pale green to yellow-green pleochroism, very low birefringence, and parallel extinction. The chlorite lamellae are oriented parallel to the mica flakes. In certain of the thin sections a dark brown, slightly pleochroic mineral of low birefringence is found occurring in grains measuring 0.5 mm. This mineral appears to be biaxial negative with a 2V of approximately 5°, and it is probably one of the chlorites. It has a tendency to form elongated porphyroblasts in which the extinction of the central portion is not simultaneous with that of the borders (Plate X B). These porphyroblasts do not have a defined orientation with relation to the schistosity of the rock. Xenoblastic crystals of this mineral also occur in those beds that contain porphyroblasts of scapolite (Plate XI A). X-ray examination of these porphyroblasts of scapolite indicates that they are accompanied by chlorite. It is possible that the brown chlorite replaces the scapolite, and that the central portions of the chlorite porphyroblasts, which are not in optical orientation with the borders, are vestiges of scapolite crystals.

The porphyroblasts of scapolite are generally ovoid in shape (Plate XI A) and the long axis may attain a length of 2.5 mm. In an exposure located 150 feet from the east shore of Beetz lake and two miles south of the end of the northeast bay, several of these crystals are idioblastic and measure up to 1.5 cm. in length. The scapolite ovoids have a poikiloblastic texture and seem to be composed of concentric layers. The general succession of these layers is as follows: a core containing many inclusions of mica, quartz, and opaque minerals and followed by a layer relatively free from inclusions which is in turn enveloped by a layer rich in brown chlorite. The scapolite is colourless and possesses an indistinct prismatic cleavage. Its identity was verified by X-ray which also disclosed the presence of quartz and chlorite.

In a few of the thin sections the rock is traversed by veins with a gran-

itic texture and consisting of quartz, brown biotite, and a few grains of carbonate (Plate XI A). The grain size in these veins varies between 0.1 and 0.4 mm. One of these veins cuts across a porphyroblast of scapolite.

It is believed that the phyllite of Beetz Lake area was originally a shale that was first subjected to regional metamorphism and subsequently to pneumatolytic and hydrothermal alterations. Regional folding caused plastic flowage of the shale which was caught between resistant quartzites, thus producing isolated lenses. The onset of dynamic metamorphism developed a slaty cleavage in the lenses parallel to the surrounding stratification. Thermal metamorphism resulted in the formation of biotite at the expense of muscovite, green chlorite, and oxides of iron.

The formation of scapolite represents the pneumatolytic phase. The orientation of the porphyroblasts parallel to the schistosity may indicate that the shearing forces were still acting during pneumatolysis. The brown chlorite, when it occurs as layers around ovoids of scapolite, also shows alignment of its lamellae parallel to the schistosity but these particular porphyroblasts are randomly oriented and thus these layers were probably developed after the ovoids of scapolite. Quartz-biotite-carbonate veins cut the schistosity and also some of the porphyroblasts of scapolite; they probably represent the last of the igneous material that was involved in the alteration of the phyllite.

<center>

Stratigraphic Thickness

and

Extent of Metasedimentary Rocks

</center>

It is difficult to determine the stratigraphic thickness of the metasedimentary series in Beetz Lake area because of secondary folds within the members of the major folds, and also because the limits of this sedimentary basin are not precisely known.

On the east limb of de la Robe Noire Lake syncline, at the latitude of Eau Claire lake, the thickness of the sedimentary series is about 25,000 feet. This estimate may be inaccurate because of the repetition of beds attributable to secondary folding observed south of François lake. Furthermore, it seems that the eastern limit of the east limb of the syncline lies outside the eastern border of the area studied.

On the west limb of the same syncline, at the latitude of Leclerc lake, and east of the axial plane of the anticline of Ransonet lake, the sedimentary sequence seems to attain a thickness of approximately 18,000 feet. In Wakeham Lake area, at latitude 50°50'N., Claveau (1949a) assigns a thickness of 25,000 feet to

the series, but he casts grave doubts upon the value of this estimate.

The basin occupied by these sediments greatly surpasses the limits of the area being studied, as suggested by the surveys of Low (1895), Retty (1944), Longley (1948 and 1950), Claveau (1949a and 1949b), Grenier (1950 and 1951), Cooper (1952) and Blais (1955). From these surveys, the Wakeham sedimentary rocks outcrop over an area with the following approximate boundaries: on the south, the north shore of the gulf of St. Lawrence; to the west, Romaine river; to the north, a poorly defined line situated 15 miles north of the 51° parallel. As for the eastern limit, only a portion of it lies within mapped ground, this being from coast inland for 20 miles. Cooper (1952) found that it starts from a point two miles east of Petite Watshishou river following a northeast direction which coincides almost exactly with the trend of the river. To the east in the Pashashibou area, Blais (1955) followed the extension of this same line and found that it bends to the north and passes a half mile west of Costebelle lake. The characteristic drainage pattern of this zone persists toward the north so that it is probable that this eastern contact may be extended toward the north to the vicinity of Gaudreault lake; from there it seems to bend toward the northeast and then toward the east into an as yet unmapped area. From the information available it seems that the Wakeham-type sediments outcrop not only in that area lying between Wakeham lake and the coast but also in an oblong-shaped area situated immediately east of Wakeham Lake area. The greater axis of this area lies some two miles south of, and parallel to, the 51° latitude. It measures 90 miles in an east-west direction and approximately 40 miles in a north-south direction. A zone of identical rocks leaves the above-described area at the latitude of Vigneault and Delisle lakes and continues toward the south by following Aguanus river for a short distance; thence through Barbe, Paingout and Kegashka lakes and finally reaches the north shore of the St. Lawrence at Kegashka village. Its width varies from 4 to 10 miles. It seems, therefore, that the Wakeham sedimentary rocks and associated gabbro sills cover an area of approximately 1,500 square miles.

Summary of Origin of Metasedimentary Rocks

The metasedimentary rocks of the area are generally fine grained. This fineness of granularity may be explained in two ways: the sediments were derived either from lands of low relief, or from mountainous areas far removed from the basin of sedimentation. The presence of angular grains of quartz in some of the formations resembling greywacke, situated at the presumed base of the series, indicates that the sediments in certain instances were transported over only short distances. If these fine grains were originally angular it would seem that in the early stages of sedimentation a portion of the eroded terrain was situated near the basin of sedimentation and thus was probably of low relief. The sediments of the upper levels are well sorted suggesting trans-

port over long distances.

The study of the section of the west limb of de la Robe Noire Lake syncline, which was utilized to derive the thickness estimate of the stratigraphic sequence of the formations, also indicates that the grain size diminishes from the bottom toward the top of the series. The low grade regional metamorphism which produced recrystallization of the rocks did not appreciably modify the grain size. The decrease in grain size can be explained by the progressive denudation of the lands through erosion or by a gradual deepening of the sea.

The stratigraphic sequence, in ascending order, of the rocks occupying the west limb of Robe Noire Lake syncline seems to be as follows: first are the quartzose schists interstratified with impure quartzites, then relatively pure quartzites, succeeded finally by calcareous quartzites and phyllitic beds interstratified with pure quartzites. In other words sedimentation began with argillaceous-arenaceous sediments which were followed by orthoquartzitic sediments; the depositional period ended by an alteration of argillaceous-calcareous and orthoquartzitic sediments.

The composition of the metasedimentary rocks indicates that they were derived, in large part, from erosion of granitic rocks. The calcium of the carbonates which occur in the upper part of the series might have been derived from alteration of the granite or even from erosion of local patches of calcareous sedimentary rocks lying within the dominantly granitic terrain. Clarke (1924) gives the results of eight chemical analyses of various granites and the CaO percentage varies from 0.15 to 1.28 per cent. The carbonate of the metasedimentary rocks could therefore result from the concentration of the calcium content of the granitic rocks.

The titanium minerals, found in certain of these rocks and apparently of detrital origin, probably were derived from rocks rich in titaniferous minerals, as for example certain anorthosites. On the other hand, it is not definitely known in what form the titanium was transported.

<center>Intrusive Rocks</center>

<center>Gabbro and Derived Rocks</center>

General Statement

Gabbro is the oldest intrusive rock known to exist in the area. It intruded the metasedimentary rocks in sill-like bodies and, locally, also as dykes and small discordant bodies. The gabbro is older than the granite, the

former being cut by several granite or pegmatite dykes issued from the granite batholith (Plate VII A). Many gabbro inclusions have also been observed in the granite.

Gabbro occupies slightly less than one-third of the total area of the region. The individual sills vary from 100 feet to one and a half miles in width; the length is very variable. Thus, the sill lying between Théobule and Prudent lakes crosses the area from north to south, a distance of $17^1/2$ miles. It extends south of the area for an additional $19^1/4$ miles before reaching the shore of the St. Lawrence (Cooper, 1952). This same sill continues outside the northern limit of the area for an unknown distance. On the other hand, other sills are no more than a quarter of a mile in length.

Gabbro dykes are less abundant than the sills and are, for the most part, units joining two sills. Such a dyke is indicated on the accompanying map east of Des Isles lake.

There are also some discordant masses of gabbro in Beetz Lake area. Two of these form the northeast and southeast shores of Piashti lake respectively. Another smaller body is located three miles west of the same lake. South of Plat lake a concordant body of gabbro was found.

The gabbro unit includes a large variety of associated facies which are all derived from the alteration of a relatively fresh gabbro which also constitutes one of the facies. In certain of the facies the alteration has modified only the mineralogical composition, while in others the massive structure has also been changed and the rocks become gneissose or schistose.

The alteration of the gabbroic rocks is attributed in part to autometamorphism but mainly to metasomatism caused by solutions and emanations from the granitic intrusion.

It is possible that the gabbros of the area are not genetically related to the Allard Lake anorthosite, as is believed by Claveau (1949a).

Fresh Gabbro

Fresh gabbro is exposed only in a few localities within the area, as for instance on the north shore of de la Robe Noire lake, one mile and a half south of the northern limit of the area and nine and a quarter miles west of the eastern limit.

The least altered gabbro is a heavy, medium-grained rock with rusty weathered surface and black fresh surface, possessing an ophitic texture. The

samples previously collected by Claveau (1949a) were examined and, in most cases, it is almost impossible to differentiate, with the naked eye, Claveau's fresh gabbro from the altered gabbro of Beetz Lake area, despite the fact that these rocks possess different mineralogic compositions. It is very probable that Beetz Lake area contains other exposures of olivine gabbro similar to that described by Claveau, and that these exposures have been classed along with the altered gabbro.

In the thin section studied the ophitic texture is easily distinguished (Plate XI B) and the rock consists of 18 per cent olivine, 25 per cent pyroxene divided between augite and pigeonite, 45 per cent plagioclase, 7 per cent opaque minerals, with minor biotite, apatite, and goethite.

The olivine occurs generally in rounded grains measuring roughly 2 mm. in diameter but it also occurs as irregular grains penetrated by plagioclase laths. Numerous fractures within the mineral are filled with goethite and magnetite. This olivine is biaxial negative.

The thin section contains two varieties of monoclinic pyroxene and these are augite and pigeonite. The pyroxene occurs as xenomorphic grains generally but, in certain places, they exhibit a tendency to adopt their crystalline form, especially the pigeonite. They both possess the characteristic prismatic cleavage of pyroxenes. The augite is colourless, whereas the pigeonite exhibits faint pleochroism from rose to colourless.

The plagioclase in the fresh gabbro is in prismatic crystals, some attaining 5.5 mm. in length. The crystals have random orientation. Where the plagioclase is in contact with pyroxenes, then its prismatic faces are generally clearly defined and the pyroxenes appear to be moulded onto it but the reverse situation is observed in a few places. The plagioclase has the composition of sodic andesine (An_{38}). On the other hand, this composition probably does not represent the average composition of the plagioclase of the fresh gabbro. In effect, study of Claveau's thin section (1949a) indicates that the average composition of the plagioclase is calcic labradorite (An_{65}).

The opaque minerals occur generally as irregular masses or as small squares and rectangles distributed between grains of the other minerals. The percentage of these minerals is higher in the vicinity of the ferromagnesian minerals. Study of a polished surface showed that the opaque minerals consist of ilmenite and magnetite, the latter being much more abundant than the ilmenite.

Biotite is present as irregular crystals between other mineral grains. It is pleochroic in yellow and reddish brown.

A reddish mineral fills fractures that are present between the grains of

all the minerals in the rock, particularly in the vicinity of olivine and magnetite where it is most abundant. The mineral is slightly pleochroic and is biaxial negative with a 2V of approximately 10°. It is probably secondary goethite.

Apatite occurs as idiomorphic grains with very well developed crystal faces.

The order of crystallization of the minerals in the thin sections of the fresh gabbro was established on the basis of criteria set forth by Grout (1932). Olivine crystallized first and it probably did not react with the residual magma to form pyroxene since no coronas were observed surrounding the grains. The olivine-pyroxene contacts are very sharp. Pigeonite may have preceded augite since crystals of the former mineral have a greater tendency to develop their crystal form than those of augite. It would appear that the pyroxenes and the plagioclase were precipitated simultaneously. The opaque minerals are in irregular masses and interstitial in their distribution and they were, along with biotite, the last minerals to crystallize. On the other hand, the idiomorphic crystal form of some of the opaques may suggest early crystallization. Goethite is probably a secondary mineral resulting from alteration of the rock.

Altered Gabbro

Most of the basic intrusive rocks of the area belong to the type termed altered gabbro. The degree of alteration is nevertheless not the same in all the rocks. On the contrary, a gradation is recognized from a type whose original constituents are only slightly altered to a type having a completely different mineral composition from the original gabbro. Certain of these gabbros yielded to shearing stresses and they have become schistose or gneissic. To facilitate description, the altered gabbro has been subdivided into four principal types: uralite gabbro, dioritic facies, gneissic gabbro and schistose gabbro. It is impossible to impose strict limits between the various types of rocks as there are numerous transitions from one type to another, both compositionally and structurally. Uralite gabbro is exposed in small quantities in all parts of the area where the underlying rock consists of an assemblage of metasedimentary rocks and gabbro. The diorite facies is the most abundant, particularly in the neighbourhood of the granitic intrusive. As for the gneissic and schistose gabbros, the typical locality of these rocks lies in the vicinity of Watshishou lake but they are also found in a few other places.

To sum up, the causes of alteration of the gabbro can be stated as follows. The greater part of the alteration of the gabbro is attributable to hydrothermal solutions which were derived from the granitic intrusive. Some of the

transformations which affected these rocks, such as the uralitization of the py-
roxenes, can be the result of deuteric reactions. Since the alteration is much
more pronounced in the vicinity of the granite, it is concluded that the hydro-
thermal solutions were much more effective than the deuteric reactions. The er-
ratic geographical distribution of the more or less altered types seems to con-
firm the hypothesis postulated by Claveau (1949a) which would have the different
granite massifs that outcrop in Beetz Lake area and its vicinity connected at
depth, the granitic intrusion sending tongues of granite into the metasedimen-
tary and gabbroic assemblage. The regions where the gabbroic rocks are the most
altered would be those places where the granite is closest to the surface.

Uralite gabbro - The typical uralite gabbro is black or dark gray. The variation
in the colour depends on the grain size and upon the composition of the rock.
Thus the fine-grained facies is black, whereas the medium-grained facies is dark
gray. A high plagioclase content imports a gray colour to the rock. This gabbro
is heavy, very tough, and massive, and the original ophitic texture is still rec-
ognizable.

Under the microscope the ophitic texture is even more evident. The thin
sections indicate many varieties. All of them contain practically the same min-
erals but in different proportions. Essential minerals are augite, tremolite-ac-
tinolite, hornblende, a blue amphibole, a plagioclase, biotite, and opaque miner-
als. Small quantities of other minerals are present in some of the thin sections.
These are apatite, chlorite, zoisite, epidote, sericite, calcite, quartz, and
scapolite.

Augite was recognized in only a few of the thin sections. It is present
as colourless grains speckled with opaque minerals and rimmed by green, slightly
pleochroic amphiboles. These amphiboles occur as small pale green acicular crys-
tals and belong compositionally to the tremolite-actinolite series. In certain
thin sections the augite is replaced by needles of tremolite-actinolite occurring
as decussate and pseudomorphic groups. In those rocks of more advanced transform-
ation the tremolite-actinolite needles are replaced by hornblende crystals. This
pleochroic hornblende is a darker green than the amphibole from which it was de-
rived and it seems to have assimilated a portion of the opaque minerals that were
liberated during the transformation of augite to actinolite.

In certain thin sections the hornblende exhibits a greenish-blue border
where it is in contact with plagioclase. Minerals with similar pleochroism as
this blue border were observed in the dioritic facies and gneissic gabbro and the
determinations indicated that they represent sodic amphiboles of varying composi-
tions. It is therefore possible that this blue border has the composition of a
sodic amphibole and that it has formed through reaction between the hornblende
and the plagioclase.

The composition and the degree of alteration of the plagioclase found in the uralite gabbro varies from one thin section to the next. In those types where the transformation of the pyroxene is less pronounced the plagioclase is, on the average, sodic labradorite (An_{51}), whereas in those types where the pyroxene has been replaced by an aggregate of actinolite needles partially transformed into hornblende the plagioclase is oligoclase (An_{25}). Study of several thin sections shows that the plagioclase becomes more and more sodic with increasing alteration of the pyroxene. The calcic plagioclase is generally present as very clear prismatic crystals and, as it becomes more sodic, it becomes cloudy and contains fine sericite scales. The outlines of these grains become more irregular and in certain places they are eaten into by the hornblende.

Biotite is rare or absent. It normally occurs as irregular grains near the hornblende crystals or in hornblende-rich zones. It exhibits a pale yellow to brown pleochroism.

The opaque minerals occur as trains of small grains, as narrow lamellae, or as rectilinear or irregular grains within the swarms of ferromagnesian minerals (Plate XII A). The dominant opaque mineral is magnetite with minor ilmenite. A little pyrite and chalcopyrite were observed in two polished sections.

Apatite occurs as idiomorphic crystals, but it is scarce in the uralite gabbro.

In some places chlorite is found as fine lamellae mixed with actinolite needles. The pleochroic colours are from pale green to colourless.

The thin sections of altered uralite gabbro contain small irregular-shaped grains of zoisite and epidote in small quantities. The plagioclase of these sections is cloudy and contains fine sericite scales. Some calcite is also found here and there.

In several places the uralite gabbro is cut by thin veinlets of quartz and carbonate. In two places, as at the southern end of the point situated in the northwest portion of Robe Noire lake, and also at the northern end of the point located on the west shore of Eau Claire lake two and a half miles from its southern extremity, the uralite gabbro contains scapolite. In the first locality the scapolite forms thin veinlets which cut the rock with random orientation. The grains are xenomorphic, colourless and exhibit prismatic cleavage. At the second locality the scapolite is distributed as xenomorphic grains with a few of them tending to possess their crystal form. The refractive indices indicate a composition in the neighbourhood of dipyre. This scapolite replaces plagioclase.

Dioritic Facies: The dioritic facies represents a more advanced stage of alter-
ation than does the uralite gabbro. The term epidiorite (Tyrrell, 1948) is
applicable to the greater proportion of these rocks. Several of them are in
reality hybrid rocks to which it is virtually impossible to attach an igneous
rock name. Also classed with these rocks to facilitate description are the
enclaves of gabbroic rocks within the granite.

The dioritic facies shows a very great variation in grain size and
colour. In general the granularity is fine or medium but coarse-grained facies
have been found with crystals attaining half an inch in length. As is the case
for the uralite gabbro, colour changes reflect the variation in granularity. In
the fine-grained types the grayish feldspars are more or less masked by the
black amphiboles and the rock is essentially blackish, whereas in the medium-
grained types it is mostly dark gray.

Several of the thin sections show a relict ophitic structure. In some
of the sections the ophitic texture is replaced by a granoblastic texture (Plate
XII B). The composition of the rocks of the dioritic facies is very variable.
Essential minerals are actinolite, chlorite, hornblende, biotite, a blue amphi-
bole, a plagioclase, and magnetite. Also present are zoisite, epidote, sericite,
apatite, tourmaline, calcite, and quartz.

Actinolite occurs in fine needles as in the uralite gabbro but in less-
er quantity. The needles are intermingled with chlorite lamellae and light green
hornblende. In the granoblastic facies these minerals yield to a dark green
hornblende forming aggregates of small idioblastic grains distributed throughout
the plagioclase masses (Plate XII B). Brown biotite is present within these ag-
gregates and, in one place, the aggregates consist entirely of biotite.

The swarms consisting of actinolite and light green hornblende are in
places rimmed by greenish blue coronas with fringed borders. In one thin sec-
tion these swarms are completely replaced by large blue amphibole crystals with
poikiloblastic texture. The pleochroic formula for this amphibole is: X = yel-
low, Y = olive green, and Z = greenish blue. The optical properties of this am-
phibole resembles very closely those that apply to an amphibole of the ferro-
hastingsite series described by Billings (1928) as occurring in nordmarkite.
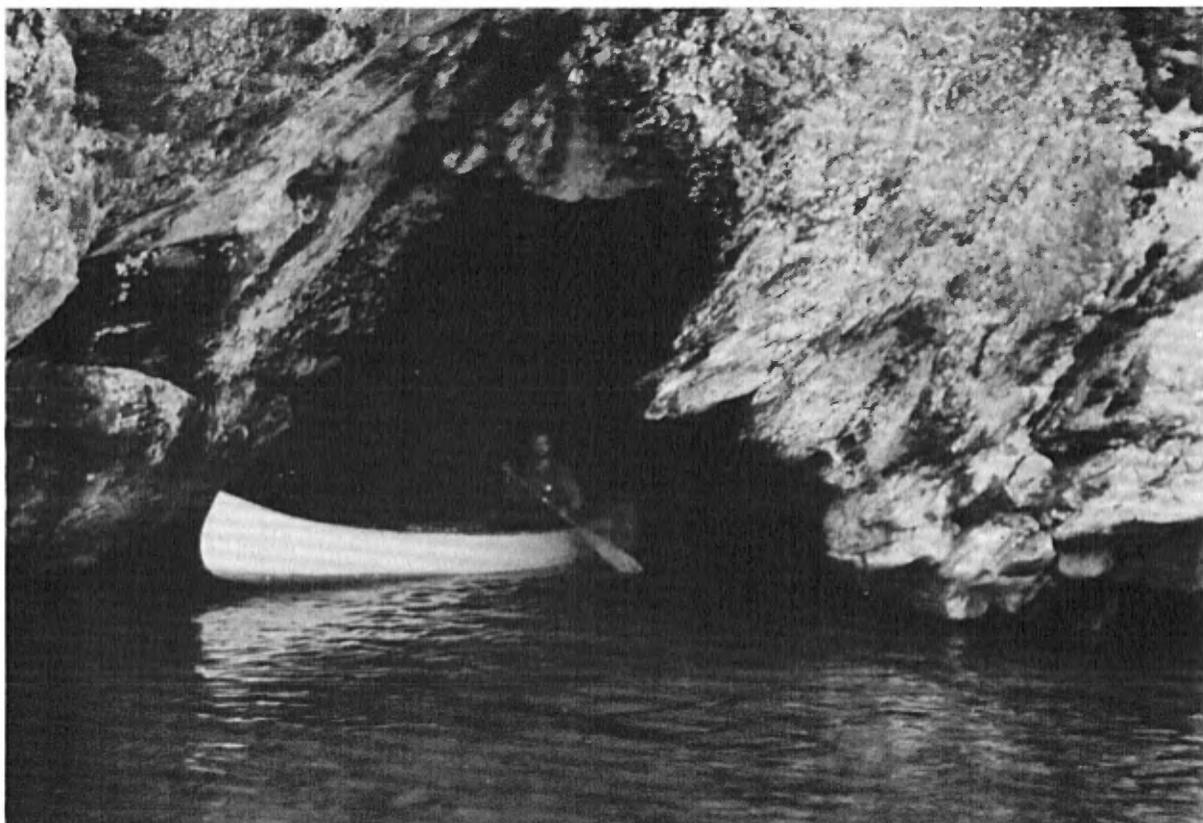
In the dioritic facies the plagioclase does not form as clear and well-
formed prismatic crystals. In some instances it still possesses an elongate form
but the grain contacts are slightly sutured. The greater proportion of the grains
are irregular. The plagioclase is generally cloudy and, in some places, replaced by
a very fine aggregate of zoisite, epidote, mica, and chlorite. The plagioclase also
occurs, in some places, as a mosaic of small, clear or cloudy crystals which are
rarely twinned. The composition of the altered feldspar generally varies between

Talus composed of blocks of gabbro. The man in the circle provides an idea as to the size of the blocks. Northwest part of Tanguay lake.
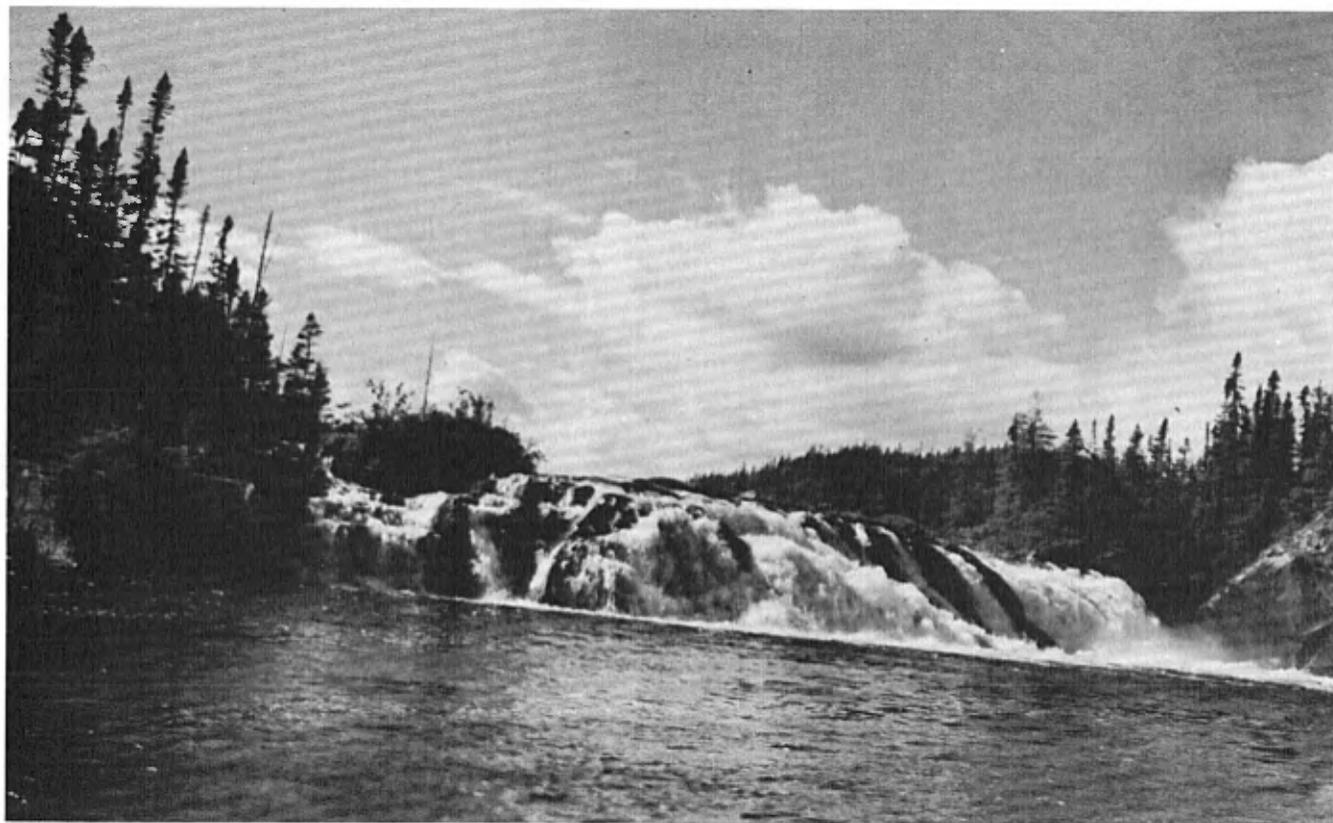
Plate 1

View of Proulx lake toward the north. Typical character of the lakes of the area: elongate with steep cliffs of gabbro.

Plate II

Wave-cut cave in metasedimentary rocks. East shore of the southwest bay of Gendron lake.

Plate III

View facing south on the west side of Beetz lake.

Plate IV
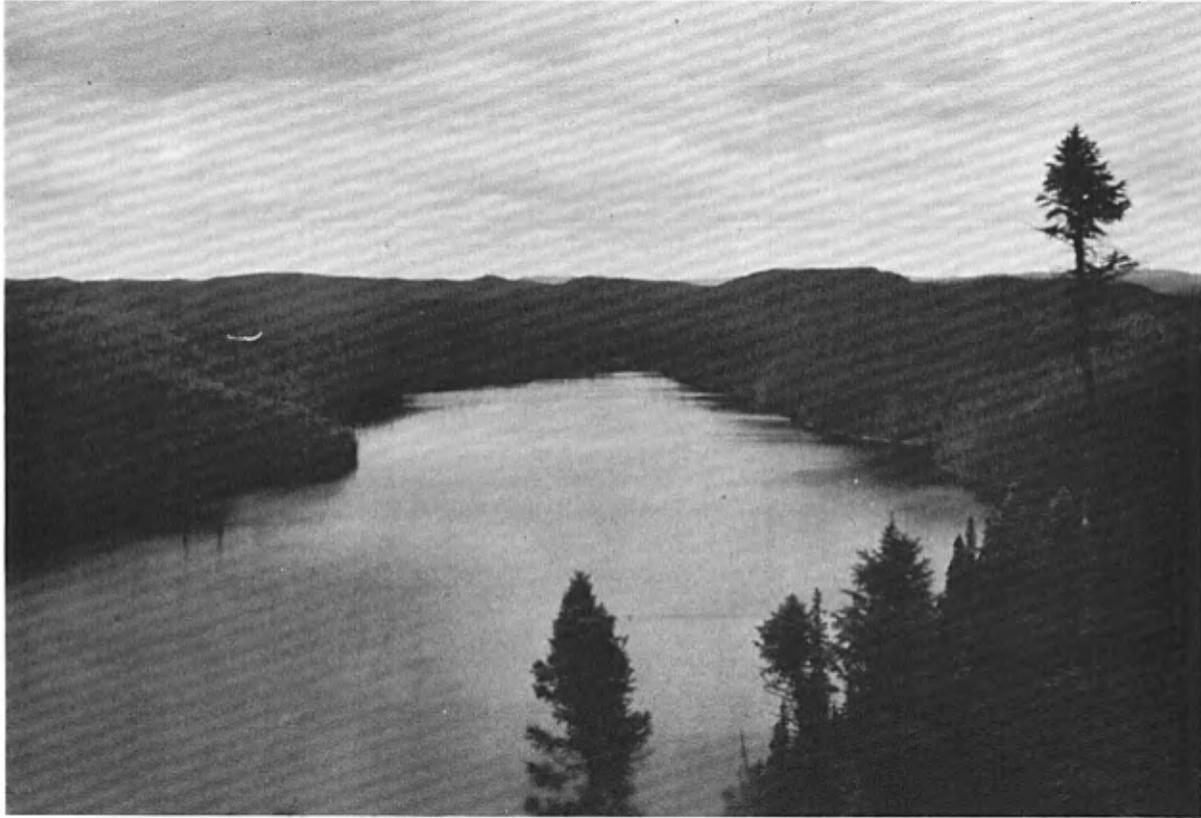
Falls along the west branch of Quétachou river. Second portage north of Beetz lake.

Plate V

Plate VI

A – Differential erosion in the gabbro. West shore of Watshishou lake, two miles from its northern extremity.

B – Gabbro inclusion in the granite. One-half mile west of du Cap lake.

Plate VII

A – Granite apophysis in the gabbro and gabbro inclusion in the granite. One-half mile southwest of du Cap lake.

B – Granite cutting quartzite. One-half mile northeast of du Feu lake.

Plate VIII

A – Cross-bedding. West shore of the triangular lake lying one and a half miles west of Piashti lake.

B – Ripple-marks in quartzite, on the east shore of Watshishou lake near the northern limit of the area.

Plate IX
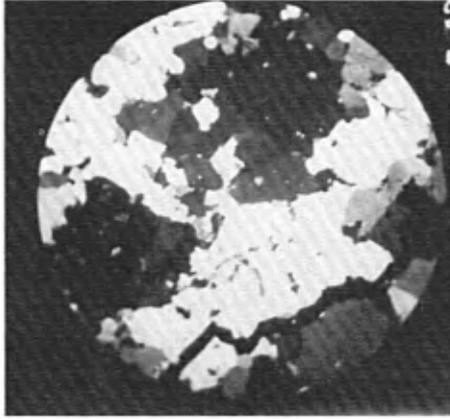
A – Advanced recrystallization in the vitreous quartzite. (X 26) Crossed nicols.
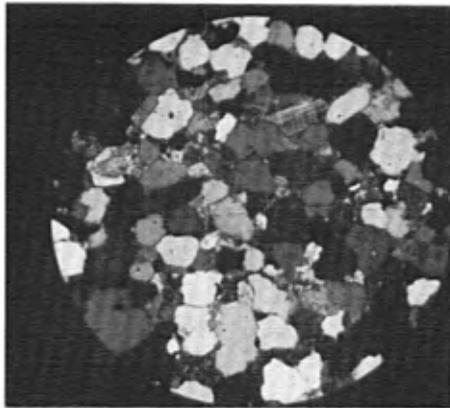
B – Minor recrystallization in the slightly recrystallized quartzite. (X 80) Crossed nicols.

Plate X
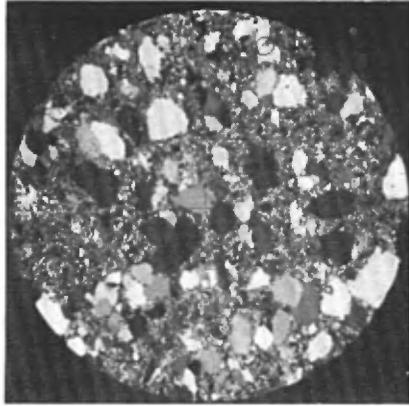
A – Slightly recrystallized quartzite with
a psammitic texture . Quartz grains set
in a micaceous matrix . (X 80) Crossed
nicols .
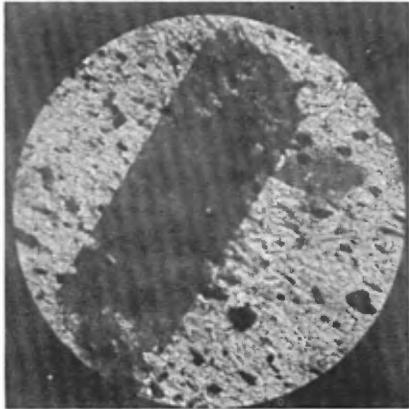
B – Unidentified brown porphyroblast from
the phyllite .   Note the lack of simulta-
neous extinction between the center and
the borders . (X 80) Crossed nicols .
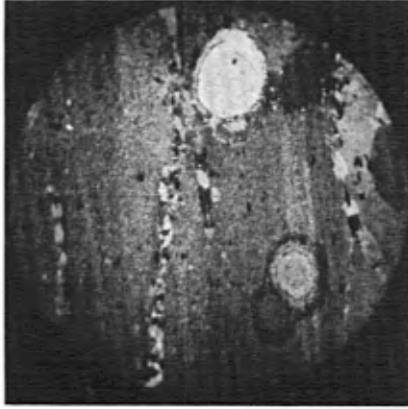
Plate XI

A - Scapolite porphyroblasts in phyllite.
(X 26) Crossed nicols.

B - Ophitic texture in fresh gabbro. Note
the rounded grains of olivine (0) and the
prisms of plagioclase (Pl) that penetrate
pyroxene crystals (Px). (X 26) Crossed
nicols.

Plate XII
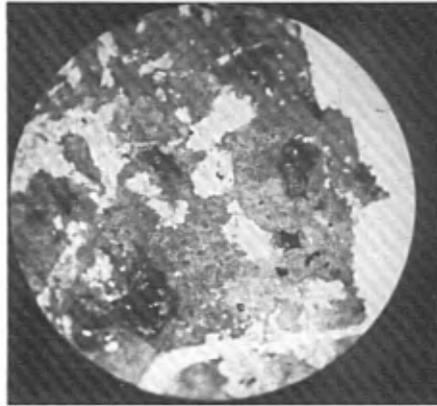
A – Magnetite (black grains) freed during the uralitization of pyroxene and found on the swarms of amphibole. (X 26) Natural light.
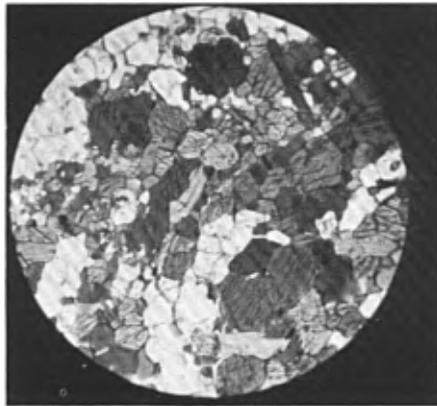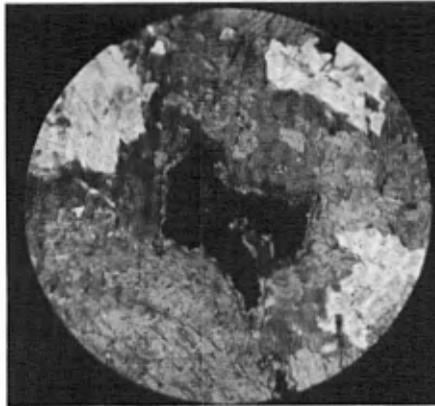

B – Granoblastic texture in the dioritic facies. Note the idioblastic crystals of hornblende. (X 80) Natural light.
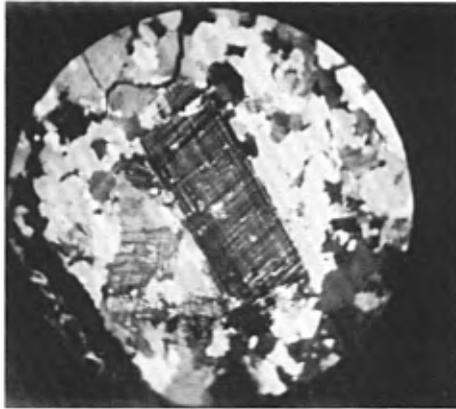
Plate XIII
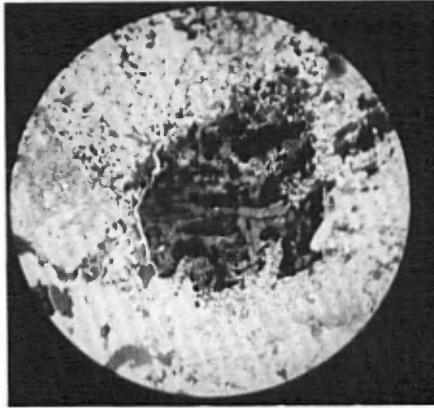
A – Magnetite forming a trellis in horn-
blende. (X 26) Natural light.

B – Corona of sphene around a grain of
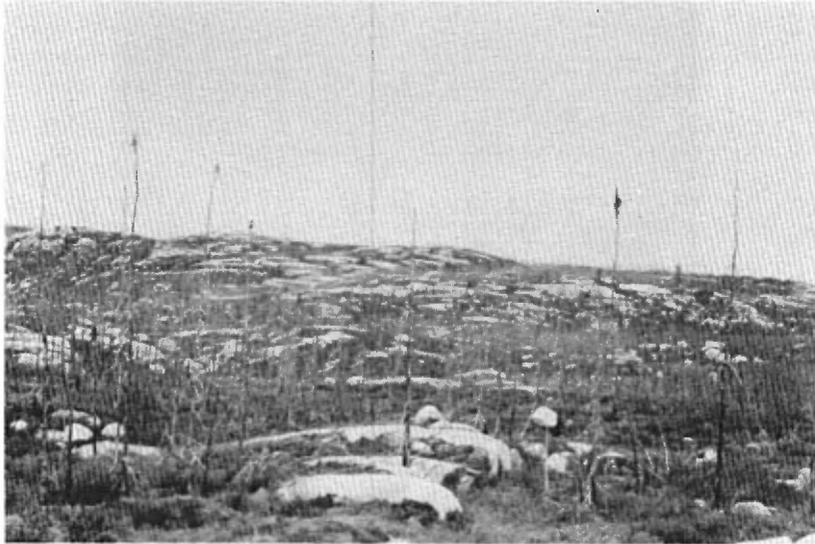magnetite in a swarm of amphibole. (X 80)
Natural light.

Plate XIV

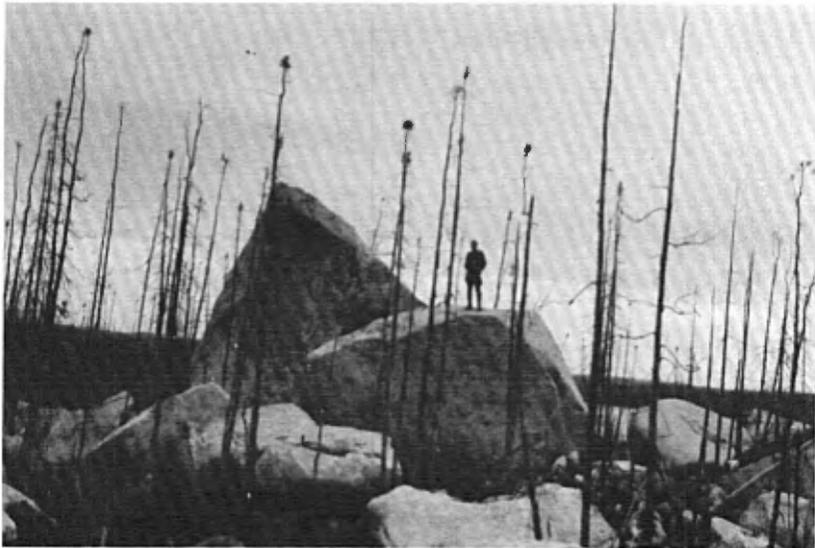A – Phenocryst of microcline in a mosaic of crushed crystals. Granite. (X 26) Crossed nicols.

B – U-shaped valley located one-quarter mile west of Watshishou lake and emerging in the northwest part of the lake.

Plate XV

A – "Roches moutonnées" in the granite region. View facing north from one-quarter mile southwest of du Cap lake.
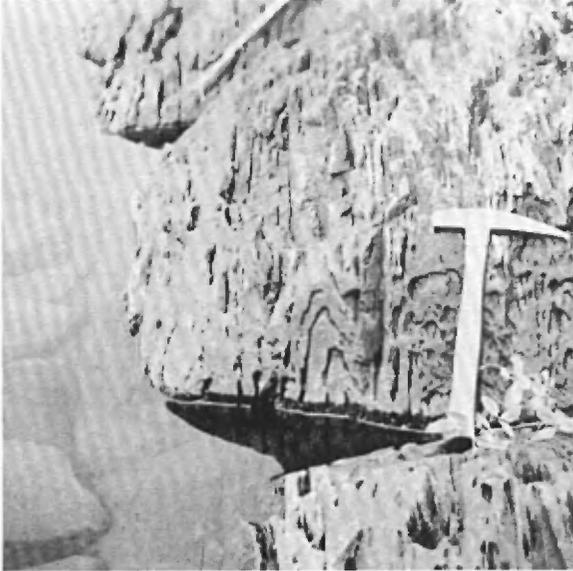

B – Granite erratics. Found 1,000 feet west of du Cap lake.

Plate XVI

A – Crumpling in the quartzite. East shore of Prudent lake, $2\frac{1}{2}$ miles from its northern end.

B – Crumpling in the quartzite. East shore of Prudent lake, 2 1/4 miles from its northern end. .

andesine (An_{35}) and oligoclase (An$_{15}$). In one thin section with a granoblastic texture the plagioclase is labradorite (An_{54}). The composition of the small untwinned grains of plagioclase varies between An_6 and An_{10}. This albite had been introduced into the basic rock.

In one place, on the west shore of Prudent lake, veins and zones of the diorite are somewhat impregnated with acidic material. In the thin sections of this rock there is a twinned plagioclase occurring as irregular, elongate crystals and having the composition of andesine (An_{35}). Another plagioclase is untwinned and has the composition of An_6 and it is seen to fill the interstices between the grains of andesine. It thus seems probable that there has been introduction of albite into the rock at this particular place.

Magnetite occurs in the same form as it does in the uralite gabbro. On the other hand, it seems to have a more pronounced tendency to form a sort of trellis in the interior of hornblende swarms (Plate XIII A). The links of this trellis may represent the pyroxene cleavages of fractures of olivine that has since disappeared. In some places the swarms of amphibole contain large irregular grains of magnetite surrounded by a corona of sphene (Plate XIII B).

Some of the sections contain agglomerations of small grains of zoisite, epidote, and sericite. Apatite and tourmaline are present as small idiomorphic crystals. Minor calcite and quartz occur in some of the thin sections.

Three thin sections from dioritic enclaves in the granite were studied. These rocks are characterized by a granoblastic texture but in one case vestiges of an ophitic texture remain. In one of these thin sections from a locality two and a half miles north of Irène lake the essential minerals are hypersthene, augite, biotite, hornblende and plagioclase. Also present are magnetite, sericite, and quartz. The hypersthene is slightly pleochroic and it is replaced by brown biotite, whereas the augite is replaced by biotite and dark green hornblende. These minerals are distributed in a matrix of fractured and bent plagioclase with the composition An_{45}. Magnetite forms large irregular zones between the ferro-magnesian minerals. The sericite occurs in small quantities associated with plagioclase from which it is derived through alteration. A few scattered grains of quartz are also present.

In the enclave situated one mile northwest of Irène lake there is neither hypersthene nor hornblende but the percentage of biotite and magnetite is higher than in the first case.

Finally, the enclave situated a quarter of a mile west of du Feu lake is only very slightly altered. It contains a few grains of olivine surrounded by a corona of light green amphibole. The pyroxenes are also altered to a light

green amphibole and there is very little biotite.

Gneissic Gabbro.- Gneissic gabbro is exposed on the shores of Watshishou lake
and on the east shore of Napoléon lake.

The weathered surfaces of this gabbro are black and characteristically
rough and pitted. On fresh surface the rock is dark gray and possesses a poor-
ly developed to perfect gneissic structure. The gneissic structure is marked by
an alignment of gray lenses which attain a length of 1.5 cm. and a thickness of
3 mm. The grain size varies from fine to medium but in general the rock is me-
dium grained. The term 'flaser-gabbro', as defined by Flett (Tyrrell,1948), is
applicable to the gneissic gabbro.

Under the microscope it is seen that the gneissic structure is due to
a parallel orientation of lenses and discontinuous veins of quartz and feldspar
distributed in a schistose matrix rich in amphiboles and biotite. Certain lenses,
composed entirely of quartz, are characterized by mortar structure, whereas those
consisting of quartz and feldspar are characterized by a 'flaser' structure with
granulation of the quartz being more pronounced than in the feldspar. In addi-
tion to these essential minerals, epidote, sericite, sphene, garnet, apatite, and
magnetite are found.

Quartz comprises 25 to 40 per cent of the thin sections studied and it
generally forms a mosaic of small grains measuring approximately 0.02 mm. in di-
ameter between the porphyroclasts of feldspar. Some irregular quartz grains at-
tain 3 mm. in diameter and exhibit irregular extinction, which indicates that
they have been deformed. A large number of much smaller quartz fragments surround
the porphyroclasts. The quartz was introduced into the schistose rock and a por-
tion of this quartz was crushed by shearing stresses. These shearing stresses are
probably the same as those which rendered the rock schistose; they continued to
act both during and after the introduction of the quartz.

The feldspar content is relatively constant throughout and is approxi-
mately 30 per cent. It occurs within the lenses and veins as large irregular and
cloudy porphyroclasts measuring approximately 1.5 mm. in diameter, but it is also
found as small, clear grains. The porphyroclasts are generally untwinned but in-
distinct twins are sometimes present. The schistose matrix also contains another
plagioclase occurring as shreds full of inclusions with twins that are barely vis-
ible. The porphyroclasts as well as the small clear grains are albite with a
composition between An_6 to An_{10}. On the other hand, in two places some very cloud-
ed porphyroclasts were seen with the characteristic grid twinning of microcline.
The composition of the plagioclase shreds in the schistose matrix was not deter-
mined. They undoubtedly represent altered remains of the original plagioclase in
the basic rock.

Amphiboles form as large jagged crystals or as fine, more or less, parallel needles. The overall content varies between 10 and 35 per cent. The dominant amphibole is a pleochroic hornblende; X equals yellow, Y equals green, and Z equals dark green. It is replaced in a few places by a greenish blue amphibole which probably belongs to the hastingsite group described by Billings (1928).

Biotite may be present in amounts up to 10 per cent. It is found as fine flakes accompanying the amphiboles or as inclusions in the altered plagioclase. It is pleochroic, yellow to dark brown.

Epidote occurs as small, irregular, colourless grains and is found along with fine scales of sericite and a few biotite flakes in those zones where remnants of altered plagioclase are recognized.

Sphene is present in small quantities as irregular grains with neutral colour. It also occurs as coronas around a few magnetite grains, as in the dioritic facies (Plate XIII B).

Minor quantities of garnet are present in the gneissic gabbro. It occurs as colourless grains with high relief in polygonal sections and is highly fractured.

Apatite is also an accessory mineral in the gneissic gabbro. Its colourless crystals are not well formed; they are recognized by their intermediate relief and weak birefringence.

Magnetite, in small quantities, is found generally as irregular grains in hornblende and as small grains between feldspar crystals.

Schistose Gabbro.- Schistose gabbro alternates with gneissic gabbro on the shores of Watshishou lake. Other small masses are present, notably on the northeast shore of Ransonet lake, in the contact zone between the granite batholith and the gabbro-metasedimentary assemblage, and finally in the region of subsidiary folding situated west of Piashti lake. The Watshishou lake occurrence possesses the most perfect schistosity.

In this place the schistosity strikes almost north-south with local variations due to drag-folds. Thin veinlets of quartz and carbonate follow the schistosity planes. The rock is fine grained and dark green. On the small island situated in the south part of Watshishou lake the surface of the schist contains rusted lenses whose diameter may attain three-quarters of an inch. One of these lenses measures six feet in length by three feet in width and it is composed of ankerite.

In the other places, and especially close to the granite, the schistose gabbro is fine grained and black. Well-formed amphibole crystals are easily distinguished with the hand lens.

In the thin sections of specimens of the Watshishou region it is seen that the schistosity of the rock is caused by a parallel alignment of flaky minerals. The parallelism is not everywhere perfectly developed and consequently the schistosity is variable in its perfection.

The rock consists of quartz, plagioclase, chlorite, biotite, carbonates, epidote, and magnetite in varying quantities.

The quartz occurs as small irregular grains measuring 0.04 mm. in diameter in the matrix of the rock. Other grains are present that measure up to 0.4 mm.

Plagioclase is present in two different forms. In one case it occurs as small irregular grains measuring 0.04 mm. in diameter dispersed through the rock along with chlorite. Some faint twinning was recognized in some of the grains. In one thin section, less schistose than the normal, the plagioclase is in larger grains and it has the composition of andesine (An_{33}). In addition to the normal small grains there are, in various places, large irregular grains of a clouded plagioclase, poorly twinned or untwinned. This plagioclase appears to have been introduced and consists of oligoclase (An_{11}).

Chlorite is the characteristic mineral of the schistose gabbro and it is present in amounts varying from 15 to 40 per cent. It forms jagged flakes or lamellae with more or less parallel orientation. It also occurs as fine lamellae within plagioclase which it seems to replace. It is pleochroic in light green and green. It exhibits an abnormal blue interference colour resembling that of pennine.

Biotite is present in very small amounts in one thin section. It forms brown and green pleochroic flakes accompanying chlorite.

The carbonates are present as veins, lenses, or individual grains. The large diameter of these grains varies from 0.04 mm. up to 2 mm. In most cases the carbonate is calcite. On the other hand, in the rocks of the small island in Watshishou lake, some ankerite is also present. The ankerite forms rusted lenses on the surface. This mineral, as analysed, gives 44.5 per cent $CaFe(CO_3)_2$ and 55.5 per cent $CaMg(CO_3)_2$.

Epidote occurs in minor quantities as small, irregular, colourless grains with high relief.

Small grains of magnetite, both within and between the chlorite flakes,

form trains which parallel the foliation. The greatest proportion of these grains occur within the chlorite flakes or in contact with the chlorite.

In the thin sections of schistose gabbro coming from places other than Watshishou lake the rock is a hornblende schist. The schist is characterized by a composition similar to that of the basic enclaves found in the granite, but in this case introduced quartz is present. The amount of quartz introduced along the schistosity planes is variable and in one place south of du Cap lake the amount is so great that the rock is now a hornblende gneiss.

In the hornblende schist the ophitic texture has disappeared and the actual constituents represent recrystallized minerals. The amphiboles are in idioblastic crystals and the rock resembles the diorite in appearance with the massive structure changing gradually to a schistose structure.

Summary of the Alteration of Gabbros

Alteration of Ferromagnesian Minerals.- There is no certainty that the fresh gabbro, as described, represents the original basic rock but it is certainly the one which more closely approaches it from all points. The freshest facies of the gabbro is the one described by Claveau (1944). It is exposed only in a few localities in Beetz Lake area. From Claveau's description and from studies of his thin sections, the ferromagnesian minerals of the fresh gabbro are olivine, hypersthene, and augite. The outcrop of this rock in Beetz Lake area contains pigeonite but not hypersthene. On the other hand, hypersthene is present in the gabbroic enclaves found in the granite.

The first mineral to be attacked in the altered facies is the olivine; this mineral is normally not present in those places where uralitization of the pyroxenes has just begun. The olivine is generally replaced by a colourless, fibrous amphibole with an extinction angle equivalent to that of tremolite (Claveau,1944). This results in the development of swarms of fine needles and they may be either parallel or in decussate clusters. The transformation is accompanied by a release of magnetite in irregular masses or in trains of small grains. The olivine is partially replaced by serpentine in a few places but this type of alteration is very local in its occurrence.

The succeeding stage of alteration involves the uralitization of the pyroxenes whereby the pyroxenes are converted to amphiboles. Hypersthene is changed to bastite (Claveau,1944) and more rarely to light green amphibole. In those places where the transformation is incomplete the hypersthene forms islets with highly altered fringed borders. The principal change that affects the monoclinic pyroxenes is their transformation into light green hornblende or into clusters of slightly pleochroic tremolite-actinolite needles. As the alteration

proceeds the light green hornblende and the tremolite-actinolite needles are re-
placed by dark green hornblende in idioblastic crystals (Plate XII B). In some
cases aggregates of biotite crystals take the place of the granoblastic aggre-
gates of dark green hornblende.

In some places the borders of the amphibole zones, as well as the in-
dividual grains of dark coloured hornblende, are replaced by a blue sodic am-
phibole.

The gneissic gabbro contains hornblende, sodic amphibole in small
amounts, and biotite, whereas in the schistose gabbro the amphiboles have gen-
erally given way to chlorite and biotite.

Alteration of Feldspars.- In the early stages of the alteration of the gabbro
the feldspars are affected to a lesser extent than the ferromagnesian minerals.
In general, during the metamorphism of a basic rock, the recrystallization of
the feldspars on a grand scale takes place subsequent to the uralitization of
the pyroxenes (Harker,1950). The plagioclase of the fresh gabbro tends to oc-
cur in prismatic crystals and this tendency persists into the uralite gabbro de-
spite the fact that the crystals are less well developed. At the stage of the
dioritic facies there are still elongate indented crystals of plagioclase but
most of this mineral occurs as irregular grains. Not only the form but also the
composition of the plagioclase crystals has changed. This transformation, less
evident than the change in form, is marked by an increase of the Ab/An ratio.

Thus in the fresh gabbro the average composition of the plagioclase is
that of labradorite (An_{65}). The feldspar ranges from labradorite (An_{51}) to oli-
goclase (An_{25}) in the uralite gabbro and from andesine (An_{35}) to oligoclase (An_{15})
in the dioritic facies. In certain places within the dioritic facies an intro-
duced plagioclase is encountered with an albitic composition but varying between
An_6 and An_{10}. As for the gneissic and schistose gabbros they seem to contain two
different plagioclases. In one locality one of these plagioclases is andesine
(An_{33}) which represents the original feldspar whose composition has been modified,
whereas the second is an introduced feldspar of the composition of oligoclase
(An_{11}). The composition of the feldspar introduced into the gneissic and schis-
tose gabbros is in general albite whose composition ranges from An_6 to An_{10}.

The feldspars in the gabbroic rocks have been slightly saussuritized and
the degree of this alteration varies with the type of rock. In effect it is no-
ticed that the clear plagioclase grains of the uralite gabbro become progressively
cloudier as the alteration of the ferromagnesian minerals increases. In the more
altered facies some zoisite, epidote, sericite and calcite appear. These minerals,
however, with the exception of sericite, are not generally found in the feldspar
itself. In some portions of the dioritic facies and in the gneissic gabbro the

plagioclase grains are replaced by very fine aggregates of zoisite, epidote, mica, and chlorite.

Scapolitization of plagioclase was observed in two places in the uralite gabbro. In the first locality the scapolite forms veins and clearly was introduced from an external source. In the second locality it forms small disseminated grains in the rock, and may have resulted from impregnations of the rock by fluids carrying chlorine and CO_2.

Causes of Alteration.- The transformation of fresh gabbro into schistose gabbro may have resulted from low-grade regional metamorphism, but it is certain that the fresh gabbro was not derived from schistose gabbro through high-grade metamorphism. Harker (1950) cites the case of basic rocks which, under the effect of regional metamorphism, were successively transformed into albite-chlorite schists, albite-epidote-chlorite schists, albite-epidote-hornblende schists, plagioclase amphibolites and pyroxene granulites. In the case of the basic rocks of Beetz Lake area the progressive alteration of the ophitic texture of the fresh gabbro, as the rock approaches the schistose gabbro, shows that the transformation of the rock was from fresh gabbro to schistose gabbro. Furthermore, as shown above by the progressive advance of the alteration it is seen that the rocks pass gradually from one to the other in the following order: fresh gabbro, uralite gabbro, dioritic facies, gneissic gabbro, and schistose gabbro. It is the presence of uralite gabbro together with its position in the metamorphic sequence which emphasizes the implausibility of the fresh gabbro forming at the expense of the schistose gabbro by metamorphism of increasing intensity. In effect, for the uralite gabbro to be the metamorphic facies that follows the dioritic facies the pyroxene would have to form at the expense of the amphiboles and it is actually the reverse which has taken place.

If it is admitted that the transformation of the basic rocks was from fresh gabbro to schistose gabbro then what is the principal cause of the phenomenon? Is it then an example of autometamorphism of an igneous rock altered by its own magmatic liquors (Sargent,1918)? Among the effects due to the equilibrium readjustments between the minerals of the rock which are already crystallized and the residual liquors, Colony (1923) mentions the impregnation of these minerals by albite and the transformation of the pyroxenes into fibrous amphiboles. Harker (1950) states that the observations of several petrographers indicate that the saussuritization of the feldspars together with uralitization are types of alteration that belong to the final stage of crystallization of an igneous rock. According to Tyrrell (1948), albitization of basic igneous rocks is an autometamorphic phenomenon widespread in its effects, and the example he cites is the case of basaltic lavas of the lower Carboniferous of Scotland described by Bailey and Grabham. In these lavas albitization is attributed to the digestion by the lava itself of its own residual liquid which is rich in soda.

According to Tyrrell (ibid.), Eskola considers the albite of spilites of Karlien as being the resultant of late magmatic reaction. He supports his opinion by the presence of an ophitic texture which shows that the original plagioclase was of necessity a calcic plagioclase since it formed prior to the pyroxene. He states in effect that in the albite-clinopyroxene mixtures the eutectic point should lie very close to the albitic end of the series and consequently the pyroxene should be the first to precipitate in practically all the possible magmas. But the ophitic texture indicates that the plagioclase formed first so he concludes that the plagioclase was necessarily calcic and was subsequently albitized.

In addition to the action of the magmatic liquors there is that of gaseous emanations, that is to say pneumatolysis. Among pneumatolytic minerals there are muscovite, tourmaline, apatite, and scapolite. The first two are generally associated with granitic magmas, whereas the last two generally accompany basic magmas.

The basic rocks of the area are known to be characterized by uralitization of the pyroxenes, saussuritization and albitization of the plagioclases, and the introduction of apatite and scapolite. These rocks thus possess the characteristics of autometamorphism. On the other hand, in several places, it was seen that the basic rocks were cooled fairly rapidly, as evidenced by the chilled margins, fine-grained facies, and the absence of coronas around olivine grains. But rapid cooling of a rock certainly does not facilitate the action of late magmatic solutions. It is thus necessary to find another reason for the alteration of the basic rocks and this other cause might be the phenomenon of metasomatism.

The term metasomatism is used in the manner defined by Goldschmidt (1922): "Metasomatism is a process of alteration which involves enrichment of the rock by new substances brought in from outside. Such enrichment takes place by definite chemical reactions between the original minerals and the enriching substances". In some localities, some albite has been introduced into the basic rocks of Beetz Lake area. In Wakeham Lake area (Claveau, 1944), albite replaces plagioclase of the rocks in two places. The two partial chemical analyses, shown in Table I, indicate that, in the uralite gabbro, there is an increase in the percentage of alkalis and a decrease in magnesia and alumina, as compared to the percentages in the olivine gabbro. Thus there was a gain of alkalis and possibly a loss of alumina and magnesia unless the diminution in the percentages of the latter minerals was due to addition of water accompanying the alkalis. These observations indicate that the basic rocks were subjected to metasomatism in at least a few places and, if the number of chemical analyses could be increased, it is probable that the effects of metasomatism would be recognized as being more widespread and as having affected the majority of these rocks.

Thus it seems that these basic rocks were subjected to a certain a-
mount of metasomatism. What were the character and the origin of the solutions
that were the agents of the changes? They must have been alkaline since albite
has been introduced, and we note an increase in the percentage of the alkalis,
and a relatively widespread distribution of a greenish blue sodic amphibole. In
the gneissic gabbro and the schistose gabbro there was the addition of quartz,
albite, and carbonates. Tourmaline is found in some places in the dioritic fa-
cies. Within the area there is only one intrusive younger than the gabbro that
could have supplied the alkaline solutions rich in soda, in addition to quartz,
lime, small quantities of boric acid, and large quantities of water. This in-
trusive is the granite of sodic nature which is described below and which is
considered to be the rock lying below a large portion of the assemblage of meta-
sedimentary and gabbroic rocks.

Table I

Components	Weight, Percentage	
	Olivine gabbro	Uralite gabbro
Silica (SiO_2)	46.4%	43.8%
Alumina (Al_2O_3)	18.9%	16.8%
Magnesia (MgO)	10.4%	5.3%
Potash (K_2O)	0.01%	1.4%
Soda (Na_2O)	1.6%	3.2%

The sample of olivine gabbro was collected a quarter of a mile north-
west of Stephenson lake (Claveau,1944) and that of uralite gabbro one mile north-
east of Beetz Lake fire tower.

The dioritic inclusions in the granite are generally characterized by
a granoblastic texture. It seems probable therefore that the initial change, as
a result of the heat given up by the granite, was recrystallization of the rock.
The respective transformations - hypersthene to biotite, augite to biotite and
hornblende - indicate a reaction between the pyroxenes and the granitic magma in
whose presence the only stable ferromagnesian mineral was biotite. The hornblende
was probably only an intermediate stage in this transformation. The composition
of the enclaves shows that the granite itself was less effective than its solu-
tions in the alteration of the gabbroic rocks. In effect, pyroxenes and calcic
plagioclase are still present, whereas in several of the rocks altered by solu-
tions the pyroxenes have generally disappeared and the plagioclase is relatively

sodic. It is possible that the dioritic facies, characterized by a granoblastic texture, represents the rocks situated in the neighbourhood of the granite. The presence of hornblende schist near the granite tends to support this hypothesis since it is considered that the hornblende schist represents a diorite in which the massive texture has given way to a schistose structure. The quartz it contains is derived from the granite itself.

From the foregoing it can be concluded that, at the time of their intrusion, the basic rocks of the area were probably gabbroic rocks. These rocks, partially consolidated, could have been somewhat altered by their own residual liquors. Following consolidation of the gabbro the granite was introduced and the solutions and emanations originating in the granite caused the metasomatism of the basic rocks of the area. In those localities where sufficient heat was furnished by the intrusive, then recrystallization of the rock took place to produce the granoblastic aggregate typical of the dioritic facies. The gneissic and schistose gabbros were deformed either before or during the granitic intrusion.

Origin of Gabbro

The basic rocks were introduced, during folding, into the metasedimentary rocks of the area as sills, dykes, and more or less discordant bodies. It has been demonstrated above that most of these basic rocks result from the progressive alteration of the same gabbroic rock which has approximately the same composition as the fresh gabbro that is encountered in a few localities. What then are the relations, if any, between the gabbro and the other basic rocks of neighbouring areas and in particular with Allard Lake anorthosite? In 1944, Claveau considered the gabbro of Wakeham Lake area, which is similar to that of Beetz Lake area, as being genetically related to the anorthosite occurring northwest and west of these areas. In 1949 he was certain of this relationship (Claveau, 1949a).

Buddington (1939) and Osborne (1949) state that the anorthositic rocks are polygenetic. Buddington states that the principal intrusions of anorthosite possess one or the other of the two following forms: they occur in stratiform masses composed of layers of different facies, or else in dome-shaped masses without the characteristic layering of the first type. He considers that the dome intrusives of the Adirondacks, Morin (Adams, 1896), and St. Urbain (Mawdsley, 1927) are probably of the same age. The Allard Lake anorthosite belongs to the dome type of intrusion and it is probably of the same age as the preceding ones. The majority of the gabbroic rocks of the Adirondacks area, which Buddington (1939) considered as being probably related to the anorthosite, are much more altered than those of Beetz Lake area, and the resemblance between these two types of gabbroic rocks is much less striking than is apparently believed by Claveau (1944). According to Osborne (personal communication), the gabbroic rocks associated with

the Morin anorthosite are also more altered than those of Beetz Lake area. It seems therefore that the gabbroic rocks associated with the dome-type anorthosites are more altered than those of Beetz Lake area and consequently these latter are not genetically related to the Allard Lake anorthosite dome. In addition, gabbro sills (Christie and Kesten,1949) are present in other places that are devoid of nearby anorthosite. In the Sooke area (Cooke,1917) there are gabbros and anorthositic facies without any anorthositic domes in the vicinity. The author therefore sees no particular reason for relating Beetz Lake gabbro to Allard Lake anorthosite. On the contrary, the titanium minerals, found in certain of the sedimentary beds, could indicate that the intrusions were separated by a period of erosion and sedimentation.

In effect the hematite-rutile quartzite contains a relatively high percentage of titanium in the form of rutile and sphene. Abundant titanium occurs with the anorthositic rocks of Allard lake. It is thus possible that the titanium of the hematite-rutile quartzite was derived from the erosion of the anorthosite and consequently the latter would be older than the metasedimentary rocks of Beetz Lake area, whereas the gabbro is definitely younger than the latter. The separation of two intrusives by a period of erosion does not constitute proof that they are not comagmatic but their consanguinity is unlikely.

The gabbro of the area could be derived from an unsaturated magma which had approximately the composition of the fresh gabbro. It could also be derived from a more acid magma with the gabbro representing the basic facies, whereas the granite represents the acid facies. There is nothing to indicate that the gabbro and the granite could be comagmatic. This suggestion is purely speculation and is merely presented as one possibility which should at least be considered during future work.

Pink Biotite Granite

This granite occupies an area of approximately 80 square miles in the northwest portion of the area and is known to extend beyond the northern and western limits (Longley, 1948, and Claveau,1949). A few granite exposures were found in the southwest section of the area penetrating through a cover of metasedimentary and gabbroic rocks. It is assumed that these exposures belong to the same magmatic source as the main batholith.

Large and small enclaves of metasedimentary and gabbroic rocks are found within the granite batholith (Plate VI.B). Numerous granite dykes cut the quartzite (Plate VII B) and the gabbro (Plate VII A). Granite dykes are abundant in the vicinity of the granite massif but they are somewhat scarce away from the granite.

The rock is a pink biotite granite, generally of coarse granularity. There is no clearly defined gneissic structure although the biotite tends to segregate into layers and to surround the large feldspar crystals and quartz-feldspar aggregates. Locally, the rock is porphyritic and the feldspar phenocrysts attain a diameter of 2 cm.

The granite exposed in the southwest portion of the area is a pink, medium-grained rock and possesses good foliation. Locally, it contains more feldspar phenocrysts girdled by thin biotite-rich layers giving the rock the appearance of an augen gneiss.

Claveau (1949a) states that this is only a pseudo-porphyritic texture and he interprets it merely as the initial stage in the formation of an augen gneiss and not as truly a porphyritic texture. As described below, the minerals of the granite are generally crushed and, in certain places, quartz veins are found in the fractures of microcline phenocrysts. This observation is not conclusive, but at least suggests a protoclastic texture. Thus, during intrusion, the granite could have consisted of a large proportion of crystalline material, hence the microcline phenocrysts. As consolidation progressed, during cooling, the crystals were ground together and broken as a result of intergranular movement, and the interstitial quartz was deposited in fractures in the form of quartz. The biotite within this semi-solid magma tended to separate into layers and to girdle the more resistant grains. The final result is a rock with a ·more or less developed augen structure, depending on intensity·of the movement and the degree of consolidation during emplacement. The foliation, in those rare places where it is clearly developed, appears to parallel the margin of the granite body. It thus seems to represent a primary foliation, and this supports the foregoing hypothesis as to a protoclastic origin for the texture.

Under the microscope it is seen that the rock has been subjected to pronounced granulation. It has the appearance of a fractured rock, composed of large grains held in a mortar of fine, crushed grains (Plate XIV A).

Because of the large grains it is very difficult to estimate the relative proportions of the various minerals that constitute the rock in thin section. The average composition approximates 30 per cent quartz, 25 to 30 per cent microcline and orthoclase, 30 to 35 per cent plagioclase, and 5 to 15 per cent biotite. The accessory minerals are sphene, apatite, sericite, epidote, and magnetite.

The quartz generally occurs as small grains between the feldspar crystals but it is also present as large irregular grains. These large grains, with few exceptions, are fractured and exhibit undulatory extinction. In certain places the quartz fills fractures in microcline phenocrysts. One thin section contains myrmekite, that is to say, a micrographic intergrowth of quartz and

orthoclase.

Microcline, as large phenocrysts (Plate XIV A) that may attain 2 cm.
in length, is distributed in a finer-grained matrix which also contains some
irregular microcline crystals. The microcline generally contains veinlets and
small spots of albite and in some places it could probably be termed perthitic
microcline.

The orthoclase occurs in small quantities as irregular grains in the
matrix of the rock and, as mentioned above, it also forms myrmekite with quartz
in some places.

The plagioclase occurs as twinned grains of irregular shape. It is
generally zoned and the core has the composition of oligoclase (An_{14}). The core
is cloudy, but it also contains sericite.

The biotite occurs as flakes with jagged edges and it is molded onto
the other mineral grains. It is strongly pleochroic in pale yellow and dark
green.

The sphene is in small wedge-shaped grains and, although it does occur
interstitially, it more normally is found as irregular grains at the edges of
biotite crystals. It also forms aureoles around magnetite grains, as in certain
of the altered gabbro facies.

The apatite is in small idiomorphic grains with moderate relief and
weak birefringence. The sericite, in fine scales, is an alteration product of
the feldspars; locally, interstitial muscovite is present as colourless flakes.
Epidote was recognized in only one thin section and it occurs as small irregu-
lar grains. The magnetite, as idiomorphic grains and irregular masses, occurs
interstitially.

<p align="center">Pegmatite and Aplite Dykes</p>

Pegmatite dykes, and occasional aplite dykes, are relatively abundant
in the neighbourhood of the granite batholith but they become exceedingly scarce
away from the granite. A few are present on the west shore of Watshishou lake,
near the northern border of the area, but even there the granite body lies only
three-quarter of a mile to the north. This distribution of the dykes, in the
immediate vicinity of the granite, indicates that they are probably residual
differentiates of the granite.

These rocks have a similar composition to that of the granite and a-
mong themselves they differ only in grain size. In one thin section of aplite a

porphyritic texture was observed that resulted from phenocrysts of microcline. This aplite dyke cuts the granite on the east shore of the lake situated one and a half miles southeast of Irène lake.

Pleistocene

It is certain that Pleistocene glaciers once covered the area. Their passage is attested to by U-shaped valleys, "roches moutonnées", polished surfaces, glacial grooves, striae, friction cracks, and also by the presence of small unconsolidated deposits of glacial origin.

A lovely example of a U-valley is found a quarter mile west of Watshishou lake (Plate XIV B). This valley trends north-south and it discharges into the northwest portion of Watshishou lake, north of the area.

Numerous "roches moutonnées" are exposed in the vicinity of the granite batholith (Plate XV A), where most of the vegetation has been destroyed by forest fire. The northern face of these rocks is characterized by a gentle slope, whereas the south face is almost vertical.

Polished surfaces are found on the denuded summits of several quartzite hills, whereas the walls of certain north-south valleys have been scoured by remarkable glacial grooves.

Glacial striae and friction cracks were observed in a few places and they indicate that the direction of the ice flow varied between S.5°E. and S.20°E. It is impossible to determine the direction of movement from the striae alone. As for the friction cracks, they dip toward the south, which indicates the direction of movement of the glacier, as is believed by Harris (1943); thus the glacier that formed them was probably moving toward the south.

The deposits of unconsolidated material that occur in Beetz Lake area are all of Pleistocene age. They are small and consist mainly of erratic blocks but some deposits of till, gravel, sand, and clay are also present. The erratic blocks are granitic in composition and are very numerous in the vicinity of the granite batholith where they are found perched on the summits of the mountains, often in unstable equilibrium. Some of these erratics attain 35 feet in diameter (Plate XV B). A mixture of granite, gabbro, and quartzite erratics is found in the vicinity of the contact of the granite batholith with these various rocks and they become less abundant upon leaving this contact zone. On the other hand, several were found in the vicinity and to the east of Eau Claire lake. These blocks may have been derived from the granite massif that occupies the north shore of Watshishou lake, north of the area. The gabbro and quartzite erratics are not very numerous in the eastern part of the area probably because they are

masked by the vegetation.

Only one till deposit was observed in the area and it is found at the southern extremity of Watshishou lake. As mentioned above, this deposit blocks the northern drainage channel of this lake and forces it to discharge into Holt lake to the east. The till consists of rounded blocks, with a maximum diameter of eight inches, mixed with an argillaceous sand.

The sand deposits are few in number. They occur in the eastern part of the area at the bottoms of valleys, and particularly on lake banks where they are well exposed. As mentioned above, a terrace of stratified clay occupies the west shore of the northwest bay of Beetz lake, near the mouth of Quetachou river. This terrace, which rises roughly fifteen feet above lake level, is visible for a distance of 75 feet and it stands at an elevation of .385 feet above sea-level. It may be a feature developed during inundation by the Champlain sea, although no fossils have been found, or it may be a Pleistocene glacial feature. In effect, the glaciers, during their retreat, could have left deposits that dammed Beetz lake so that the level of the lake would have been raised to that of the terrace. These glacial deposits could have subsequently been removed by erosion.

Certain glacial deposits, in particular the clays and sands, were reworked by the present rivers.

The small quantity of unconsolidated material indicates that the glacial effect on the area was mainly erosive. The importance of glacial erosion is difficult to evaluate. It is almost certain that the area was much dissected prior to glacial erosion, and that the work of the glaciers involved stripping of the unconsolidated material from the surface of the area, rounding of the valley bottoms, and modifying their walls and also the summits of the mountains.

The existence of a moderate pre-glacial relief is shown by the numerous deep valleys, whose development cannot be attributed to the small post-glacial streams that presently occupy them. The valley of du Vent lake, described above, is an example of a pre-glacial valley.

STRUCTURE

Folds

The metasedimentary rocks of Beetz Lake area have been folded into synclines and anticlines of varying amplitude and width. The width of one of these folds, lying only partly within Beetz Lake area, is fourteen miles. Elsewhere the width in certain folds is measured in inches. Between these two ex-

tremes, all possible intermediate values are represented. The tectonic frame-
work of the area is composed of three main folds plunging toward the south and
southeast, the amount of plunge varying between 20° and 50°. These include the
two synclines of Robe Noire lake and Piashti lake and Beetz Lake anticline.

The interpretation of the structure of the area is based mainly on
the orientation and the distribution of the metasedimentary beds and gabbro
sills. Approximately 1,000 strike and dip measurements were read and recorded
on the preliminary map. Although cross-bedded structures were observed in sev-
eral localities, this structure is generally poorly defined and does not indi-
cate clearly the tops of the formations. There are exceptions (Plate VIII A),
however, and the tops were determined from some forty exposures. Ripple-marks
were seen in three places but only one of these (Plate VIII B) was of any use in
determining tops. These top determinations indicate that the majority of the
beds occupy normal positions. It thus seems reasonable to rely on the dips of
the formations to determine the major structures.

Robe Noire Lake Syncline

Robe Noire Lake syncline is the major fold of the area. It plunges
toward the south at an angle of 20° to 50°. The axial plane is almost vertical
in the north but dips 80° to the east in the south part of the area. The trace
of the axial plane leaves the south shore of the southeast bay of de la Robe
Noire lake and trends southerly down to Bellanger lake. This fold appears to
lengthen Wakeham Lake syncline, described by Claveau (1949a).

Numerous secondary folds are developed on the major de la Robe Noire
syncline. The best developed are those of Ransonet lake, those to the north of
de la Robe Noire lake and those southeast of Gerry lake. Northwest of Ransonet
lake, a one-mile-wide syncline flares toward the south-southeast, and plunges
35°; a gabbro sill suggests the presence of a complementary anticline, parallel
to the foregoing syncline, southeast of the same lake.

Two synclines, separated by an anticline and having a mean width of
one mile, occupy the centre of the major syncline, north of de la Robe Noire
lake. Their presence is suggested by the position and the distribution of the
formations and by the outline of the gabbro sills. These three secondary folds
plunge at an angle of 20° to 50° to the south-southeast.

One mile southeast of Gerry lake an anticline and a syncline of ap-
proximately one-half mile in width plunge to the south at an angle of approxi-
mately 45ᶜ.

The general orientation of all these secondary folds is more or less

parallel to the major Robe Noire Lake fold. These folds, therefore, conform to the general structure and probably represent dragfolds.

In addition to the secondary folds that have already been described, small crenulations, with a width of only a few inches (Plate XVI), are also found in the metasedimentary formations of Robe Noire Lake syncline. The more highly contorted beds are exposed on the south shore of de la Robe Noire lake and on the numerous islands in the northwest part of this lake. Some were also seen on Gerry, Eau Claire, Prudent and Beetz lakes, and also at a few scattered localities in the vicinity of these lakes. The crenulations are usually very tight and it is very difficult to determine the general strike and the dip of the stratification in those exposures that contain this feature. The axial planes of these crenulations are generally parallel to the bedding. In some of these crenulations the axial line plunges between 5° and 68° to the north but the value of the plunge is usually 20° in the majority of cases. In others, the axial line plunges to the south at an angle of from 4° to 38° but the mean is 25°. Of twenty-two measurements, twelve of them plunge to the south and ten to the north. The reversal in plunge along strike takes place over a short distance. On two small islands about 500 feet apart in the northeast portion of de la Robe Noire lake, the axial lines of the crenulations plunge at 25° but in opposite directions. On the little island situated in the south part of Eau Claire lake the crenulations generally plunge 5° north, but in one case the axial line plunges to the north for a distance of a few feet then becomes horizontal before reversing itself and plunging toward the south at an angle of 4°.

The crenulations thus exhibit two peculiarities. The first is concordance of the strike and dip of their axial plane with the strike and dip of the adjacent formations. The second is the frequent reversal in plunge direction. This latter feature suggests that the crenulations were not developed at the same time, nor by the same forces, as the major structures of the area. The intrusion of the gabbro sills could have compressed and deformed the metasedimentary beds by crumpling them in some manner. The axial planes of the small flexures would be parallel to the walls of the sills, that is to say toward the north, but their axial lines would plunge north or south depending on the fluctuations in the direction of flow of the gabbro intrusive.

Beetz Lake Anticline

Beetz Lake anticline lies west of de la Robe Noire Lake syncline and the east limb of the anticline coincides with the west limb of the syncline. This anticline plunges to the southeast at an undetermined angle. It is a symetrical fold whose axial plane is vertical in the vicinity of Est lake, but inclined at an angle of approximately 70° to the west in its southern portion. The trace of the axial plane is shown on the map in its approximate position

only. From the base of the V formed by Beetz lake, this line trends northwest toward Est lake. Beyond Est lake it is impossible to determine the position of this line because of the inconsistency in the direction of dip of the formations. Toward the south, the axial plane crosses the southern limit of the area one mile east of Napoléon lake.

Secondary folds have developed on the limbs of Beetz Lake anticline but they do not have as large an amplitude as those of de la Robe Noire syncline. The irregularity in the strike and dip of the formations, and the abnormal position of the tops, in that sector south of the point that separates Beetz lake into two bays, suggest the presence of secondary folds. Other similar folds were observed west of Napoléon lake near the southern limit of the area, and this feature is particularly evident on the aerial photographs. These latter persist to the south of the area where they are very well defined.

Piashti Lake Syncline

The western counterpart of Beetz Lake anticline is Piashti Lake syncline. This syncline appears to plunge to the southeast. The trace of the axial plane, as deduced from the strike and dip of the formations, passes approximately half a mile southwest of Paquet lake then heads for Piashti lake, which it more or less bisects. As indicated on the map, the northern limit of the trace of the axial plane lies approximately one mile and a quarter south of the granite-metasedimentary contact. It is probable that the fold continues to the north for a greater distance than shown on the map, but the granitic intrusion, by disrupting the formations, has masked or destroyed the previously existing structures. A small amount of information collected during a rapid exploration to the south leads to the belief that the trace of the axial plane extends almost to Goeland lake, situated six miles south of the area. The angle of dip of the axial plane is undetermined within the area because of the presence of numerous secondary folds in that sector west of Piashti lake. In the vicinity of Goeland lake the axial plane appears to be vertical.

As shown on the map accompanying this report, four parallel secondary folds occupy the west limb of Piashti Lake syncline. These folds trend southeast and plunge to the south at an angle of from 30° to 50°. In all probability they belong to the regional structure but they could also have been caused by the granitic intrusion.

Other Folds

Other folds were mapped in the sector adjacent to the granite batholith. Some of these undoubtedly owe their development to the granitic intrusion, whereas others represent previously existing structures.

South of the granite batholith there is a belt of metasedimentary and gabbroic rocks measuring one mile in width and attaining the elevation of Rousseau lake. Within this belt the strike of the formations varies in the following manner. At Rousseau lake, the strike is north-south then curves gradually to the southwest in conformance to the contact between the granite and the metasedimentary-gabbroic assemblage. Two miles east of the western limit of the area the strike of the formations ceases to parallel that of the contact and diverges toward the northwest. In the majority of cases the formations dip inward toward the contact, that is to say, toward the west or northwest at an angle varying between 15° and 75°. The average angle of dip is approximately 55°. On the other hand, where the formations strike northwest, then the dip is toward the northeast. Three determinations from cross-bedded horizons indicate that the formations are in normal position and consequently their tops are toward the contact. From the foregoing it may be seen that the rocks of this belt are folded, but it is impossible to determine with any certainty the general structure from the information presently available.

In the section lying between the northern extension of the axial plane of Beetz Lake anticline and the margin of the granite batholith, and from the latitude of Rousseau lake up to the northern limit of the area, the strike of the formations is relatively constant but the dip is extremely variable. The general strike is slightly east of south, and from 57 dip measurements there are 33 dipping to the east and 24 to the west. The westerly dips are localized in particular around the granite contact. The dip angle varies between 25° and 90° but it generally lies between 70° and 85°. Four fairly well defined cross-bedded structures were observed. Two of these may be found three-quarters of a mile west of the southwest bay of Plat lake, another is three-quarters of a mile west of the first two, and the last is approximately one and a quarter miles southeast of Irène lake. The first two determinations indicate that the tops of the formations face west, whereas the others indicate that they face east. These observations may suggest the presence of a closed syncline whose axial plane trace would lie approximately one mile west of the southwest bay of Plat lake and trending south-southeast.

Joints

Joints in Metasedimentary and Gabbroic Rocks

The metasedimentary and gabbroic rocks of the area are cut by a variety of joints. The attitude of these joints is normally more regular in the gabbro than in the metasedimentary rocks but there are two well-defined systems of joints that extend from one rock type to the other with more or less persistant strikes. The first joint system trends slightly east of south and it more or less parallels the trend of the majority of the gabbro sills; they dip steep-

ly east or west depending on the locality. The strike of the second set, less persistant than the first, varies within a few degrees north or south of east. As in the first case the steep dip is not uniform in direction but may be either north or south. These two types of joints are well developed in the gabbro at Proulx lake. The first are developed parallel to the orientation of the lake and dip 80° to the east on the east shore and 80° west on the west shore; the second, less abundant than the first, trend east-southeast and dip to the south.

The preceding description suggests the presence of a regular network of joints that indistinctly cut the metasedimentary and gabbroic rocks. In addition to this network, there are also a certain number of irregular joints that do cut the gabbro but are better developed in the metasedimentary rocks. The joints appear to have developed at the same time and as a result of the same forces both in the metasedimentary rocks and the gabbroic rocks. On the other hand, the orientation of the joint systems with respect to the axial planes of the large folds of the area suggests that there may be a relationship between the two structures. The east-west joints, more or less parallel to the compressive force that folded the formations, are possibly extension joints, as defined by Billings (1942). As for the other joints, whose strike is almost perpendicular to that of the first set and parallel to the axial planes of the folds, they could represent dilatation joints (Billings,1942). These last joints could also represent shear joints even if no displacement was observed along them, since shear joints do not necessarily develop at 45° to the direction of the compressive force.

In such a case it is necessary to suppose that the gabbro was introduced almost contemporaneously with the folding of the metasedimentary rocks. Throughout the entire period of folding the metasedimentary rocks were fractured and the diversely oriented joints were the resultant. The gabbro, in a fluid state, was introduced between the metasedimentary beds and was folded along with them. At the end of folding and after consolidation of the gabbro, the development of the above described joints took place.

Claveau (1949a) observed a regular jointing in the gabbro of Wakeham Lake area, north of Beetz Lake area. He states that these joints could be the result of cooling of the rock or, in certain cases, could have been caused by the intrusion of the adjacent granite stock. He dismisses the possibility that folding was the cause of these joints because they are not regionally distributed. The regular joints mentioned by Claveau are not indicated on the map which accompanies his report; hence it is impossible to tell whether they are related to the folding that affected the area. On the other hand, the joints in the anorthosite body situated west of Cométique lake and those of the gabbro sill lying east of Stephenson lake, which he describes in his report, could very

easily belong to the system of joints encountered in Beetz Lake area.

It is probable that certain joints found in the metasedimentary-gab-broic complex are due to the granitic intrusion.

Joints in Granite

The granite of the area is well jointed in nearly all of its expo-sures. In the north part of the batholith, one of the joint systems strikes N.5°W. and dips steeply to the east or the west. Another system, almost per-pendicular to the first, strikes between east and N.65°E. and the dip is steep to the north or the south. In the south part of the batholith, the orientation of the joints is somewhat different to that of the joints in the north. The strike of one of these systems varies between N.50°E. and N.25°E. and the dip is generally vertical. The other system has a general strike of N.60°W., also with vertical dip. Nearly horizontal joints are present in almost all granite exposures. These different joint systems can be seen on the north shore of the east bay of Irène lake.

The origin of the joints developed in the granite poses a problem. Not a single criterion is available to permit the determination of the origin with any degree of certainty. They could be contemporaneous with the consoli-dation of the granite or they may post-date it.

Schistosity and Foliation

The schistosity developed in some of the metasedimentary beds of Beetz Lake area is generally parallel to the bedding, but this was observed only along the limbs of the folds and not on the nose of the folds. On the other hand, study of a thin section from a sample that was obtained from the small island near the west shore of Napoléon lake, roughly three-quarters of a mile south of its north-ern extremity, shows that the schistosity is not everywhere parallel to the bed-ding. In this thin section the quartz-mica schist is composed of alternating quartz- and mica-rich layers. In the mica-rich layers the mica flakes describe irregular sine curves whose axial planes intersect the bedding planes at an angle of 40°. In the exposure, this orientation of the mica flakes produces a schis-tosity that makes an angle of 40° with the bedding.

As mentioned previously, gabbroic rocks that are characterized either by a schistosity or by a schistosity and a foliation are found in the vicinity of Watshishou lake. The schistosity and foliation in these rocks are generally parallel to the bedding in the adjacent metasedimentary rocks. On the other hand, at the tip of the southeast point of the lake, the schistose gabbro is crumpled. The axial planes strike almost north-south and are vertical. Some of their axes

plunge to the north and others to the south, but the majority are vertical.

In the hornblende schists, derived from gabbro and outcropping near the granite, the schistosity is parallel to the contact with the granite, and the dip is generally inward toward the granite body.

In the gabbro of Watshishou lake there is another structure that is not truly a schistosity. This structure was observed in a few places on the north point of the west shore of the lake. Under wave action the rock has suffered differential erosion which has produced a gross resemblance to the texture of ploughed fields. Thus there are beds of approximately fifteen inches in thickness that project above depressions of the same width. The attitude of these beds is conformable to that of the bedding in the metasedimentary rocks that are exposed in the vicinity.

The granite of Beetz Lake area is more or less massive but the biotite has a tendency to separate into layers. This tendency is more noticeable along the edges of the intrusive where there is a slight foliation and even a vague schistosity in certain places. A slight foliation was observed in the granite north of Feu lake near the contact between the granite and the metasedimentary-gabbro assemblage. The strike of this foliation is parallel to that of the contact and it dips 75° west.

A granitic gneiss is exposed south of du Cap lake within the contact zone. It consists of light-coloured layers, one-quarter inch thick, alternating with black layers of the same thickness. The strike of the gneissosity is parallel to the contact of the granite with the gabbro-injected metasedimentary rocks. The gneissic structure dips 65° northwest, that is to say, into the interior of the batholith like that of the foliation of the granite described above.

The origin of the schistosity and foliation in the rocks of the area is obscure and it is impossible to determine it from the available data.

<div align="center">

Modes of Emplacement of Principal Intrusives and

Their Effects on Structure of Invaded Rocks

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Gabbroic Intrusion

The gabbro of the area, in certain places, is present as short dykes that transect the metasedimentary beds. The gabbro also occurs as a few concordant and discordant irregular bodies, but in the majority of cases it was introduced along the bedding planes of the metasedimentary rocks. These sills faithfully follow the bedding planes of the metasedimentary rocks even where they

have been folded. As described above, this phenomenon can be observed south of Plat lake, in the vicinity of Ransonet lake, north of de la Robe Noire lake and southeast of Gerry and des Iles lakes. The gabbro in these localities does not possess any structure that could indicate folding subsequent to crystallization. There is, however, one exception: on the east shore of Ransonet lake where the gabbro is schistose. South of Plat lake there is a mass of gabbro of approximately two miles in width that occupies the apex of a secondary fold. North and southeast of Piashti lake, bodies of gabbro are to be found in the axial zone of Piashti Lake syncline.

It is generally admitted that, during folding, the beds slide past one another on the limbs toward the apex and that this folding tends to cause separation of the individual members around the nose of the fold and thus to produce a zone of reduced hydrostatic pressure. If a plutonic body is introduced during folding there will be a tendency for it to move into those sites of least pressure, hence toward the noses of folds. The bodies of gabbro that have accumulated on the noses of folds in Beetz Lake area indicate that the gabbroic intrusion is probably cotectonic. In addition, the gabbro in general does not show either cataclastic structure, or schistosity, or any other sign of deformation even in those places where the sills are compressed by secondary folds. It is necessary, however, to make an exception for the secondary folds situated west of Piashti lake; there the gabbro has been transformed into a hornblende schist. But it is believed that these folds date from the time of the granitic intrusion and are not related to the regional folding.

As mentioned above, the metasedimentary rocks of the area have been wrinkled and the axial planes of these wrinkles are almost parallel to the bedding and to the gabbro sills. In certain places the crenulations plunge to the north; elsewhere they plunge to the south. Since their direction of plunge is erratic it is believed that these crenulations were not caused by the same forces as produced the major folds of the area. They are attributed to friction generated during the intrusion of the sills. Crenulations so produced would in effect have their axial planes parallel to the walls of the sills, but their axes would plunge to the north or south depending on the direction of flow of the gabbro intrusive.

Granitic Intrusion

The granite batholith occupies an area of approximately 80 square miles in Beetz Lake area. Utilizing the information from geological investigations completed to the north and west of the area (Claveau 1949a, Longley 1948, Retty 1944), it is estimated that the actual surface area of this batholith would approximate 200 square miles. It is a rudely elliptical body with its long axis trending north-south.

During its emplacement the granite thrust aside the metasedimentary and gabbroic rocks but it also digested a few blocks of these rocks. The trend of the formations that encircle the batholith attests to the pressure engendered by the batholith. The metasedimentary formations and the gabbro sills that girdle the granite batholith in Beetz Lake area are inclined toward the interior of the batholith within a zone adjacent to the contact, whereas they dip in a reverse direction outside of this zone. According to Claveau (1949a), the portion of this batholith included in Wakeham Lake area pushed aside a considerable section of the gabbro-sedimentary complex northward and eastward. Claveau (1944) thinks that the original dip of the formations on the west limb of Wakeham Lake syncline, which is the extension of the de la Robe Noire Lake syncline, should have varied between 40° and 50°. These formations now dip to the east at angles between 70° and 80°. The northwest part of Beetz Lake batholith that penetrates Forget Lake area (Longley, 1948) also thrust aside the formations during its intrusion. A large gabbro sill, trending north-south, curves to the east north of Métivier lake. The dip, steeply east, becomes 40° to the south on approaching the batholith. It is believed that, during its intrusion, the granite was introduced almost vertically by pushing aside the pre-existing formations. As the granitic body moved upward into the crust of the earth, the hydrostatic pressure acting on the intrusive body diminished and the granite was enlarged by overturning the surrounding formations; this would then be the explanation of the strata dipping inward toward the interior of the batholith.

The enormous pressure exerted by the granite on the surrounding formations was sufficient to fold them. Certain large secondary folds, such as those found west of Piashti lake, may possibly have this origin.

The schistosity that developed in certain of the metasedimentary formations and in certain facies of the gabbroic rocks, such as the hornblende schist, developed as a result of the intrusion of the batholith. Furthermore, the foliation observed in a few places in the granite is a primary foliation.

The fragmented textures observed in the granite and the gneissic gabbro probably formed at the time of the granitic intrusion, but it is also possible that they post-date the intrusion.

As mentioned above, the appearance of the granite in thin section is that of a fractured rock composed of large grains set in a mortar of fine crushed grains (Plate XIV A). It is not known, however, whether this texture is protoclastic or cataclastic. Certain observations indicate that the texture is probably protoclastic. In effect, a few of the thin sections contain large undeformed quartz grains, and, in one place in particular, quartz fills fractures in microcline phenocrysts. On the other hand, such relationships could exist in a rock where the quartz migrated and where it recrystallized under the

effect of dynamic metamorphism.

The gneissic gabbro exhibits a clastic texture characterized by frag-
mentation of the plagioclases and quartz grains. It is supposed that these two
minerals were crushed at the same time. If the texture of the quartz is proto-
clastic and if the introduced quartz was derived from the granitic intrusion,
then the clastic texture of the gneissic gabbro would be contemporaneous to the
granitic intrusion. If, on the contrary, the texture of the introduced quartz
is of cataclastic origin, then the clastic texture of the gabbro would post-date
the granitic intrusion.

If the clastic textures of the granite and gneissic gabbro are not
contemporaneous to the granitic intrusion, then they post-date this intrusion and
their cause is unknown. They may have resulted from a Pliocene uplift which af-
fected the entire Canadian Shield or they could even have formed as a result of
oscillations of the land during the glacial and post-glacial periods.

From the foregoing discussion it seems evident that the granite belongs
to the rapid type of injection as suggested by Claveau (1949a). The following ob-
servations also confirm this point of view. The granite has a more or less homo-
geneous composition and possesses well-defined contacts. It contains a certain
number of inclusions but it exhibits only minor signs of assimilation. The gran-
ite forcefully thrust aside the enclosing formations. The batholith, as a result,
displaced the obstacles to its advance instead of assimilating them.

Summary on Structure of Area

The metasedimentary rocks of Beetz Lake area have been folded into an
anticline and two synclines, plunging to the south. Southerly plunging second-
ary folds have developed on these major structures. Jointing in the metasedimen-
tary rocks occurred during, and subsequent to, the folding.

The gabbroic magma was introduced during this period of folding and
formed sills, as well as a few dykes and more or less discordant bodies. This
magma tended to occupy the noses of folds because of the lower pressure in these
places. Friction, created by the gabbro sills on the metasedimentary strata dur-
ing their intrusion, wrinkled the latter and produced crenulations in certain
places. As the gabbro became moderately cooled it began to fracture under the
influence of the forces that had produced the folding and continued to act.
Thus, a system of joints was developed in the gabbro.

Later, the granitic magma was introduced in its turn and further de-
formed the metasedimentary rocks and the gabbro. This granitic intrusion proba-
bly caused some local folds and schistosities in the adjacent formations.

The undulatory extinction in the quartz and the crushing of the grains observed in the granite and the gneissic gabbro could be due to the granitic intrusion or possibly to movements that post-date this intrusion.

AGE AND CORRELATION OF FORMATIONS

There is no doubt with regards to the relative ages of the principal rocks of the area. As demonstrated above, the metasedimentary formations are the oldest rocks and they are followed by gabbro and finally by granite, which is the youngest rock. The absolute age of these rocks is unknown except in the case of the gabbro. Claveau (1944) considers the absolute, but approximate, age of the gabbro as being 1,500 million years. This age determination, made by Dr. N.B. Keevil, is based on the helium content of a sample of fresh gabbro. The value of such age determinations that are based on the method used by Keevil has been considered questionable by certain authors (Hurley and Goodman, 1943). Lane and Urry (1935) determined the approximate age of the Keweenawan as being between 510 and 560 million years. This determination is based on the study of the helium content of a number of specimens but some of their results produced figures that are considerably higher than the estimate, for instance 1,190, 1,290 and even 1,865 millions of years. It thus seems that the absolute age of the gabbro of Beetz Lake area, which is based on only one determination, can not be considered as definitely known.

All attempts at correlation between the rocks of the area and those of other parts of the Canadian Shield are hindered by the normal difficulties of correlation in the Precambrian. The main criteria that can be used in such an attempt at correlation are: 1) lithologic similarities; 2) the position occupied by rocks in a similar series encountered in several areas; 3) the relationship with respect to regional unconformities or with respect to intrusive rocks; and 4) the degree of metamorphism (Dresser and Denis,1946).

According to Retty (1944), the metasedimentary rocks found to the west of the area are of Grenville age. Longley (1948 and 1950) also considers them as Grenville but he is not certain of this. The opinion of these geologists is based on the fact that the rocks are highly metamorphosed and that they are granitized in certain localities. As pointed out by Claveau (1944), the above characteristics are typical of the rocks found along certain portions of Romaine river and also in the west part of Forget Lake area, but he is certain that in Wakeham Lake and Beetz Lake areas the metasedimentary rocks are not granitized and they have suffered only moderate metamorphism.

In 1944, Claveau suggested that the rocks described by Retty and Longley could be Grenville but that the rocks of Wakeham Lake area and those in the east half of Forget Lake area are probably younger. They would have been

folded along with the Grenville but would have suffered less metamorphism. He added that the relationships between these rocks and the typical Grenville could be the same as those that exist between the Grenville and the Bristol facies (Wilson,1924), which is exposed in the southwest portion of the province of Quebec. In 1949, Claveau (1949a) wrote: "There is considerable doubt as to the possible equivalence of the metasedimentary rocks of Wakeham lake with even the upper part of the Grenville series". On the other hand, he hesitated to dissociate completely these metasedimentary rocks from the Grenville and he considered them as probably equivalent to the Hastings of Ontario (Wilson,1925). It must be admitted that certain lithologic similarities exist between Beetz Lake rocks and those of the Hastings series (Miller and Knight,1913). In effect, cross-bedding and ripple-marks are found in both cases. The two localities also contain quartzites with the characteristics of greywacke, and Beetz Lake phyllite is comparable to the slates of the Hastings series, according to the description. Conglomeratic bands are not as common in Beetz Lake rocks but a few have been mapped (Longley,1950, and Claveau,1949a). On the other hand, no calcareous rocks are found in Beetz Lake area. Claveau's reluctance to separate the metasedimentary rocks of Wakeham lake from the Grenville series is due to the fact that he considered the gabbro to be related to Allard Lake anorthosite and that this anorthosite has all the characteristics of rocks belonging to the Morin series.

As discussed above, there is no strong reason for relating the gabbro of Beetz Lake area to Allard Lake anorthosite and, on the contrary, certain observations indicate that the two rocks are probably not comagmatic.

It is highly probable that the metasedimentary rocks of the area do not belong to the Grenville series. First, they are found a considerable distance away from the type locality as studied by Logan (1863), they are only slightly metamorphosed, and none of the typical Grenville formations, with the exception of quartzite, are present. Even the quartzite is different from the Grenville quartzites as the former contain excellent cross-bedding and ripple-marks. The titanium in the hematite-rutile quartzite was possibly derived from erosion of the anorthosite massif that lies west and north of the area. Thus an unconformity should exist between the anorthosite and the metasedimentary rocks. No such unconformity was recognized as the two rocks were not seen in contact with each other but it is possible that one does exist. In this case, the metasedimentary rocks would occupy a position above the Morin in the stratigraphic column and they might be of Lower Huronian age.

During a meeting of ACFAS in 1948, Claveau demonstrated the possibility of correlation between the metasedimentary rocks of Wakeham Lake area and those of the Labrador Trough, the approximate southern limit of which lies 200 miles further to the north. In 1950, Béland (1950) compared the geology of Wakeham Lake area with that of Gabbro Lake area situated near the southern limit of the

Labrador trough. He concludes that Wakeham Lake series was possibly formed dur-
ing the same era and possibly during the same geological epoch as Gabbro Lake
series, that is, lower Huronian. Béland nevertheless noted certain differences
between the two series. He states that the lower formations of Wakeham Lake
series are more highly metamorphosed than the greywacke of Gabbro lake. This is
true for these formations occupying the west part of the area adjacent to the
granite, but it is assumed that these formations recur on the east limb of the
de la Robe Noire syncline where the metamorphism is less advanced. The coarse
conglomerate of Gabbro lake which, according to Béland, does not have an analogue
in the Wakeham series, could correspond to the one described by Longley (1950).
Béland also notes that there is very little phyllite in Wakeham Lake area, where-
as such types seem to be relatively abundant in Gabbro Lake area. It is to be
noted that the proportion of phyllite increases from Wakeham Lake area toward
Beetz Lake area. It seems therefore that correlation is possible between the me-
tasedimentary rocks of Beetz Lake area and those of Gabbro lake, and they may
belong to the Lower Huronian.

A striking lithologic similarity exists between the metasedimentary
rocks of Beetz Lake area and certain rocks of the Meguma series, which are con-
sidered to be Proterozoic in age. The Meguma series (Douglas and Campbell, 1939)
outcrops from Canso to Yarmouth, a distance of approximately 275 miles along the
southeast coast of Nova Scotia. It is possible that the Avalon series, occupy-
ing the eastern part of Newfoundland, represents the continuation of this series.

In addition to the lithologic resemblance, the Meguma series is also
injected with basic sills and dykes in certain places and it is also cut by gran-
ite (Malcolm, 1929), just as the metasedimentary rocks of Beetz Lake area. The
relative ages of the basic and granitic rocks that occur in the Meguma series is
not definitely known, but it is believed that the granitic rocks are younger than
the basic rocks. Wright (1912) states that there are two types of granite sepa-
rated by an intrusive contact in New Ross area. The older of the two is a por-
phyritic granite containing phenocrysts of microcline distributed in a medium
grained matrix composed of plagioclase, orthoclase, quartz and biotite. From the
description, the New Ross granite would resemble that of Beetz lake. According to
Malcolm (1929) certain of the granitic intrusions are of Devonian age. On the
other hand, as suggested by Wright (1912), all the granites introduced into the
Meguma series are not of the same age. Would it not be possible for some of
these granitic rocks to be of Precambrian age? As regards Beetz Lake granite it
is considered to be of probable Precambrian age. This age is based on the fact
that a similar granite is found on the north shore of the St. Lawrence near the
Paleozoic rocks (Longley, 1950) and that no granitic dykes are found in the Pa-
leozoic rocks.

In summary, it may be said that a great similarity exists between the

Meguma series and the metasedimentary formations of Beetz Lake area. In addi-
tion to the striking lithologic resemblances, the rocks of the two localities
are injected by basic sills and dykes and they are cut by granitic intrusions.
These observations are not in themselves sufficiently conclusive for purposes
of correlation but it is worthwhile noting them so that they will be considered
during subsequent investigations.

If the metasedimentary rocks are of Lower Huronian age, then what are
the respective ages of the gabbro and the granite? It is impossible to place
accurately the upper limit of these two intrusives in the stratigraphic column
since the youngest sedimentary rocks are represented by the unconsolidated
Pleistocene sediments. Just as the Keweenawan is a period characterized by nu-
merous basic intrusions terminating with the Killarney revolution, which was
accompanied by granitic intrusions, the gabbro is considered to be of Keweenawan
age and the granite as equivalent to the Killarney granite. As mentioned above
the granite in the area is considered to be pre-Paleozoic because granite dykes
are absent in the Paleozoic rocks of the Mingan islands (Longley, 1950), although
a similar granite to that of Beetz Lake area outcrops nearby.

MINERAL DEPOSITS

Chalcopyrite

Chalcopyrite was found in a number of places throughout the area, ei-
ther as disseminations in the gabbro or as veinlets cutting the gabbro. One of
these mineralized exposures is located on the north side of the falls of Qué-
tachou river, situated roughly one mile northeast of the southern end of Plat
lake. The chalcopyrite is found in the gabbro, sixty feet east of the contact
between this rock and quartzite, and it occurs in a small quartz vein measuring
two inches to one and a half inches wide which also contains a little pyrite.
This quartz vein is cut by a stringer of massive chalcopyrite, one-eighth inch
in thickness and trending parallel to the gabbro-quartzite contact.

In the southeast part of Ransonet lake there is a gabbro sill that
penetrates a large point and, in fact, acts as its north shore for a short dis-
tance. In the shore exposures both north and south of the point, disseminated
chalcopyrite is present in the gabbro, which also contains veinlets and blebs
of quartz. The mineralization in the southern exposures covers an area of ap-
proximately four square feet and it is more abundant than in the exposures of
the bay.

An eight-foot-square segment of gabbro was found to contain dissemi-
nated chalcopyrite on the east shore of the small elongate lake that lies north
of Est lake. This gabbro also contains pyrite, ilmenite, and magnetite.

In the entire area pyrite is of sparse but persistant distribution within the gabbro sills, and it is always found also with the chalcopyrite occurrences; thus it seems as though these two minerals were transported by the same solutions.

The fact that chalcopyrite and pyrite are so widely distributed throughout the area mapped, as well as in neighbouring areas (Longley,1944 and 1948; Claveau,1943 and 1949) to the northwest and north, and also along the shore of the St. Lawrence, indicates that copper-bearing solutions were abundantly circulated through the rocks of the area.

The concentrations of chalcopyrite, as well as of pyrite, seem to be localized in the gabbro in the vicinity of its contact with the quartzite or at the contact itself. It is probable that the hydrothermal solutions followed the plane of the contact. It would therefore benefit prospectors to follow the zones of contact between the gabbro and the quartzite in the hope of finding commercial concentrations of chalcopyrite.

Magnetite

Magnetite is an accessory constituent of all the pegmatites. In certain places it occurs as nodules attaining one-quarter inch in diameter.

In certain cases the magnetite is present in fairly high concentrations within the gabbro. Thus, on the east shore of the small elongate lake situated north of Est lake, magnetite is found associated with chalcopyrite. Specimens from this locality affect the magnetic needle.

The magnetite content of the pegmatites is very minor. Since these pegmatites are not very numerous, it is unlikely that they could have given rise to important magnetite deposits in the area. As for the magnetite found in the gabbro, it is not impossible that considerable concentrations could be found.

Hematite

Specular hematite is a frequent constituent in the quartz veins that cut the metamorphosed sedimentary rocks of the area. This hematite occurs as thin flakes occupying fractures in the quartz and is present in very minor quantities. It is virtually only of mineralogical interest.

Certain of the hematite-rutile quartzite beds contain hematite. Thicker beds than the average are found in the following three locations: one mile east of the southern extremity of Boiret lake, on the northwest shore of Napoléon

lake, and also fifty feet from the west shore of the lake situated two miles west of Napoléon lake. These three beds measure four, three, and two inches, respectively, in thickness. At the first and third localities, the beds are exposed over a length of six feet, then they disappear beneath the overburden. The bed on the shore of Napoléon lake is visible for five feet. Its southern end penetrates into the lake where it seems to end in a point, whereas the northern end disappears below the overburden.

In the first locality, the bed is composed of approximately 70 per cent hematite, 10 to 15 per cent sphene, and 15 to 20 per cent quartz, whereas in the other two places the sphene is replaced by rutile.

It is probable that no extensive hematite deposits exist in the area. The rock exposures are so numerous that many more than three hematitic beds would have been mapped if this mineral were present in any great quantity. The hematite in the already-mentioned beds is present in small amount and by itself does not have any economic importance. Nevertheless, the presence of sedimentary hematite in the area interstratified with quartzite arouses a certain amount of interest. The possibility of finding commercial iron deposits in similar metasedimentary rocks of adjacent areas should not be rejected.

Titanium

Ilmenite, rutile, and sphene are the three principal titaniferous minerals found in the area.

The ilmenite is an accessory mineral in the gabbroic rocks and it occurs in minor quantities in all the localities where it was seen.

Of these three minerals found in the area, rutile seems to offer the most promise for economic possibilities. It is found associated with hematite in the hematite-rutile quartzite. In one case it comprises 13 per cent of the bulk composition of the rock but in general it is seldom present in excess of 5 per cent. The mean diameter of the grains of rutile is approximately 0.05 mm. If it were desired to separate the rutile from the quartz and hematite by mechanical processes, then probably the necessary fineness of grinding would be an important economic consideration.

In certain places sphene is present in excess of rutile, which may be present in only very minute quantities in the hematite-rutile quartzite. As discussed previously, it is not known whether the sphene is a result of the alteration of rutile or vice versa or whether the two minerals were deposited or were formed independently of each other.

CONCLUSIONS

The sediments from which the metasedimentary rocks of Beetz Lake area were formed were derived from the erosion of a massif, in large part granitic, in which there could have been remnants of calcareous rocks and possibly even anorthositic masses. The initial sediments deposited consisted of arenaceous clays which were succeeded by orthoquartzitic sediments, and these were followed by alternating calcareous clays and ortho-quartzitic sediments. These different sediments were deposited in a basin of sedimentation which measured at least 85 miles in length, in an east-west direction, by 60 miles in width in certain places. After lithification of the sediments and during the course of regional folding, the sedimentary rocks were intruded by gabbro. This gabbro is, in all probability, not genetically related to Allard Lake anorthosite. The combined influence of folding and gabbroic intrusion may have been responsible for the metamorphism of the metasedimentary rocks. Later, the granite was introduced into the metasedimentary and gabbroic rocks. Definite evidence is lacking relative to the geological events to which the area was subjected between the introduction of the granitic intrusion and the advance of the Pleistocene glaciers that traversed the area from north to south. However, as mentioned above, Ordovician and Silurian rocks are present along the shore of the St. Lawrence (Longley,1950), fifteen miles southwest of the area. At Mont Ste-Geneviève these rocks are exposed at a higher elevation than some parts of Beetz Lake area. It is thus concluded that the Ordovician and Silurian seas could have covered the area, if the actual relative altitude between Mont Ste-Geneviève and the area represents the relative altitude that existed between these two sectors during Ordovician and Silurian times.

The presence of relatively large quantities of titaniferous minerals in some of the metasedimentary rocks indicates that there could be an unconformity between these rocks and Allard Lake anorthosite. This proposed unconformity and the lithologic similarity with the rocks of Gabbro Lake area suggest a possible Lower Huronian age for the metasedimentary rocks. The resemblance between the metasedimentary rocks of Beetz Lake area and those of the Meguma series suggests that they may be of the same age, and the Meguma series is considered as being of probable Proterozoic age.

The granitic intrusion is probably responsible for the more intense metamorphism of those metasedimentary rocks situated adjacent to the granite batholith. Most of the alteration of the gabbroic rocks is believed to have been caused by the action of solutions and emanations arising from the granite mass, because the alteration is sodic, and the granite is also sodic; furthermore, it is the only intrusive of any consequence that post dated the gabbro.

The conclusions drawn by Claveau (1944) were confirmed by the present investigations. He concluded that, during the alteration of the gabbro, the olivine tends to change to tremolite and the pyroxenes, into uralitic products which are represented mainly by a light green hornblende. The original feldspar is gradually changed to a more sodic plagioclase by the action of solutions that dissolve and remove the calcium. The characteristic ophitic texture of the fresh gabbro persists even into a fairly advanced stage of alteration before yielding to a granoblastic texture in the highly altered facies.

The forces generated by the granitic intrusion were adequate to produce a few secondary folds and fractures in the consolidated rocks of the area. These forces are also responsible for the development of certain schistosities.

Concentrations of chalcopyrite and pyrite appear in the gabbro next to its contact with quartzite or at the contact itself. It is probable that the contact acted as a channelway along which the mineralizing solutions travelled.

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