DP 511

THE GEOLOGY OF THE MICHAUD LAKE AREA (DUPLESSIS COUNTY)

EXPLORATION GÉOLOGIQUE

MINISTÈRE
DES RICHESSES
NATURELLES

DIRECTION GÉNÉRALE
DES MINES

MICHAUD LAKE AREA

DUPLESSIS COUNTY

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1977

DP-511

THE GEOLOGY OF THE MICHAUD LAKE AREA

DUPLESSIS COUNTY,

QUEBEC, CANADA

by

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1960

Document déposé au fichier ouvert en juillet 1977. Distribution sur demande seulement / *Document placed on Open file in July 1977. Distribution on request only.*

TABLE OF CONTENTS

Page

Page

INTRODUCTION

General Statement

The Lake Michaud area, situated on the north shore of the Gulf of St. Lawrence, was mapped during the summer months of 1958, 1959, and 1960. All the consolidated rocks of the area are of Precambrian age. They consist of a "Grenville - type" metamorphosed sedimentary and granitic complex, the schists and quartzites of the Wakeham Group and such intrusive rocks as gabbro, granite, and pegmatite. Three sets of folding are recognized. Several small occurrences of economic minerals were noted.

Location of Area

The area is about 190 miles east-northeast of Sept Iles, the largest town on the North Shore, and about 575 miles northeast of Québec City. *It includes all of the Lac Michaud sheet of the National Topographic series (longitudes 62°05' - 62°30' and latitudes 50°30' - 50°45'), part of the Pashashibu Bay sheet (longitude 62°00' - 62°10' and latitudes 50°15' - 50°30'), and 5 minutes to the east and 2 minutes to the south of the latter. This is the Aguanus Area of McPhee, 1959. The effective southern limit of the area is Jacques Cartier strait, lying between the North Shore and Anticosti. The total area included is about 600 square miles.

The northern or Lake Michaud proper part of the area is not divided into townships. The smaller southern part includes most of La Richardière and Yoynish townships and a small part of Costebelle township.

Means of Access

The coastal section of the area can be reached by fishing boat from Natashquan, which is 15 miles southeast of Aguanish village and is serviced regularly throughout the navigation season by ships of the Clarke Steamship Company Limited, sailing from Montreal and Quebec. In 1959 a road was completed between Aguanish and Natashquan. Natashquan is the most convenient base for the shipment of food supplies and equipment.

Access to the interior is best accomplished by float-planes which have bases at Havre St-Pierre and Longue Pointe de Mingan, respectively 65 and 83 miles west-southwest of Lake Michaud. Numerous lakes throughout the area and sections of the Aguanus and Nabisipi rivers provide suitable landings for float planes.

The eastern part of the area may be reached by a canoe route along Aguanus river; Nabisipi river provides access to the central part of the interior including Lake Michaud and flows along the boundary of the Aguanish area. Two canoe routes provide access to the western part of the area. The western boundary may be reached from Grand Watshishu river which empties into the Gulf of St. Lawrence 5-1/4 miles east of Baie Johan Beetz village. The second route is along Little Watshishu river which drains Auger and Gallienne lakes. These four water routes to the interior all include numerous portages and are particularly difficult during the late summer when the water level is low.

Previous Investigations

The only geological investigation carried out in the area prior to the summer of 1958 was a geological reconnaissance of the north shore of the Gulf of St. Lawrence by Longley in 1943 (Longley, 1950). In 1944 Claveau (1950) continued the eastern extension of the survey from Aguanish to Washicoutai bay. The geology of the shoreline of the Aguanish area (McPhee, 1959), is included in this study.

In 1949 and 1950 Grenier (1957) mapped the area west of the northern, or Lake Michaud proper, part of the area. Blais (1955) mapped an area west of Aguanish.

Elenborn (1925) examined in detail the pegmatite deposits of Quetachou bay situated on the coast near the village of Baie Johan Beetz.

In 1943 Claveau (1949) examined the Wakeham Lake area situated northwest of the present study. The Johan Beetz area was mapped in 1951 and 1952 by Cooper (1957).

Field Work

Mapping of the area was done at a scale of one inch to one-half mile on maps prepared by the Surveys and Mapping Branch of the Department of Mines and Technical Surveys, Ottawa. With the exception of the southern swampy part the area was covered by a system of pace and compass traverses which were spaced at intervals of approximately one-half mile and were planned, as far as possible, to cross the trend of the formations. The exposures along the coast, rivers, and more accessible lakes were examined in detail.

Vertical Royal Canadian Airforce photographs (1:37,000 to 1:42,000) were used to accurately locate rock exposures and to predict structural trends.

Acknowledgements

The field assistants during the summer of 1958 were: Pierre Gauvin, graduate of the University of Montreal, Abie Achtman, student at McGill University, Raymond Barbeau of Ecole Polytechnique, and Jacques Jobin, student of Quebec City. Armand Bouchard of Sheldrake acted as cook.

In 1959 the assistants were: David Mason, graduate student at the University of Western Ontario, Taun Robertson and Gordon Drummond, students at McGill University, Roger Blais of Laval University and Claude Giguere of Sherbrooke University. Rodolphe Touzel of Sheldrake was cook.

In 1960 the assistants were: Randolph Burke, graduate student at University of Minnesota, Warman Castle, student at Mount Allison University, Jean-Marie Tetrault, student at University of Montreal, and Michel Hamel, student at Laval University. Alfred Devost of Sept Iles was cook.

During the three summers, Moise Bond and Horace Bouchard, both from Sheldrake, served as most efficient canoemen.

DESCRIPTION OF THE AREA

Settlements

Within the area there are two settlements, both on the coast. Aguanish, with a population of 230, is at the mouth of Aguanus river. Michon, with a population of 90, is 3-½ miles east of Aguanish. Neither village has wharf facilities; they are supplied by fishing boats from Natashquan and, since 1959, by road. Aguanish is on the North Shore telegraph service which links it with the rest of the province.

Industry

Fishing provides the chief means of livelihood for the inhabitants of the area. Salmon are caught during the early part of the summer by a few families that have the fishing rights at the mouth of Aguanus river. Cod fishing, formerly an extensive operation along this part of the coast, has now diminished considerably due to the low prices for the catch. Lobster are caught locally and canned.

Agriculture is almost non-existent. Most families have a small garden and grow enough potatoes, turnips, and cabbages for their own use, and a few families have cows. The severe climate and lack of suitable soil are largely responsible for the poor agricultural conditions. The growing season is short owing to lat springs and the early appearance of frost in the autumn.

There are no extensive areas of timber near the coast. Along some of the valleys bordering the rivers and lakes there are stands of black spruce, balsam, poplar, and minor amounts of white birch. Most of the trees are small and so are only suitable for firewood and pulp. A small saw-mill on the coast near the southeast corner of the area provides some of the lumber needed locally.

Fur-bearing animals, chiefly fox, mink, otter, muskrat, and beaver are trapped along the rivers and lakes during the winter. There are no moose or deer. Cariboo are fairly numerous in the interior but are scarce along the coast.

Topography

Three distinct topographic units characterize the area: the southern coastal zone, the northwestern section, and the rest of the area.

The southern coastal zone is relatively flat and extends inland from the coast of 4 to 9 miles. The shoreline from the mouth of Nabisipi river to ½ mile west of Michon has an even, arcuate outline whereas the shoreline to the east is intricately indented and has numerous small, off-shore islands. A prominent feature of this coastal zone is a series of flat sand terraces (raised beaches) that are underlain by clay. The terraces vary in height from 20 to 50 feet. They are gently arcuate in outline, are parallel to the coast, and extend from Nabisipi river to the southeastern corner of the area. The smaller off-shore islands and points of land were probably once covered by sand but have now been swept clean exposing the bedrock. Some of the larger islands still have a thick cover of sand. Another prominent feature of the coast is the bay-mouth bar at Aguanish; this is more than a mile long and has been produced by shore currents caused by the prevailing southwesterly winds.

Between the raised beaches along the coast and the northern part of the area the surface is flat with only a few small hills projecting above the surrounding plain. This part of the area is underlain by peat and covered by pond-dotted muskeg.

Two topographic divisions are displayed in the northern part of the area: the area underlain by quartzites and gabbro sills and the rest of the area underlain by granitic and metasedimentary rocks.

A pronounced ridge and valley topography characterizes of most of the area underlain by quartzites and gabbro. Long north to north-northwest trending ridges of gabbro or resistant quartzite alternate with valleys underlain by more easily eroded quartzites or schists. The north-northwest trend of the schists and quartzites has been disturbed by the Lake Gallienne granite stock which has an irregular arcuate outline. The trend of the surrounding metasedimentary rocks now conforms to the contact of the granite.

The areas underlain by granitic rocks have a gently undulating surface. The granitic gneisses form long, continuous ridges which outline the trends of the gneissosity and reflect the fold pattern. Areas of gabbro form high, resistant ridges.

In most parts of the area the local relief is 250 feet or less with a maximum local relief of 700 feet along Aguanus river at the northern boundary and 500 feet along Nabisipi river north of Lake Galienne.

The area as a whole slopes gently to the south. Along the northern boundary, hill summits are at an elevation of 1,200 feet above sea level; at latitude $50^{o}30'$ N Nabisipi river is 200 feet and Aguanus river is 300 feet above sealevel.

Drainage

The drainage system in the area is not well developed. In most cases the lakes are joined by a short series of alls and rapids. This is particularly well illustrated by the Little Watshishu River system that drains Gallienne and Auger lakes, and the tributary of Nabisipi river that drains Michaud, Sylvestre, and Baies lakes.

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

1) Grand Watshishu river, which drains the area along the western boundary including Holt and Watshishy lakes.
2) Nabisipi river and its tributaries which drain the central portion of the area including Baies, Sylvestre and Michaud lakes.
3) Aguanus river which drains the area along the eastern boundary and a group of unnamed lakes in the north central part of the Aguanish area through a western tributary.

Besides these main rivers; several small streams, such as Petite Watshishu river, which drains Gallienne and Auger lakes, discharge independently into the Gulf.

Physiographie History of the Area

The Lake Michaud area is along the southeatern margin of the Canadian Shield. Numerous cycles of erosion have reduced the Laurentian

Upland to its present level, the history of peneplanation dating back to Precambrian time. In the Mingan area to the west the Precambrian peneplained surface is preserved beneath the overlying Paleozoic rocks. In the Lake Michaud area no consolidated rocks of post-Precambrian age were found. It is possible, however, that the area was covered by Paleozoic sediments which have since been eroded, leaving no trace of their presence. In the adjacent Pashashibou area, Blais (1955) has found limestone, probably of Ordovician age, filling fractures in the Precambrian rocks. Anticosti Island, lying within 20 miles of the coastal front of the present area, is underlain by relatively undeformed limestone formations of Ordovician and Silurian age at elevations of over 1,000 feet (Twenhofel, 1927), (Longley, 1950) (Bolton and Lee, 1960). As a large part of the Lake Michaud area is less than 1,000 feet above sealevel it is probable that parts of the area were covered by the same seas that deposited the Paleozoic rocks on Anticosti Island and the Mingan area.

In pliocene time an uplift of approximately 1,200 feet occurred and the rivers were rejuvenated (Cooke, 1930). The cycles of erosion that took place before the Quaternary glaciation largely shaped the basic features of the present physiography.

In the Pleistocene the Labrador ice sheet, estimated to have been more than 7,000 feet thick, advanced over the area from the north modifying the topography and causing a subsidence of the land owing to its great weight.

Following retreat of the ice the area was at least partly covered by the Champlain Sea which flooded the valleys and parts of the low-lying southern section while the region was deeply depressed. Stratified clays overlain by sand and minor amounts of gravel which may be of Champlain age were observed along Aguanus and Nabisipi rivers at an elevation of 450 feet above sealevel. Recent work on Anticosti Island, however, has indicated that surficial deposits of marine origin are present only as high as 250 feet above sealevel (Bolton and Lee, 1960).

After the retreat of the Pleistocene ice sheet and following the Champlain Sea stage, the area tended to return to its pre-Pleistocene level - a process that continues to the present time.

No reliable criteria are available for estimating the amount of subsidence due to the Pleistocene glaciation in this part of the Gulf of St. Lawrence. Cooke (1930) calculates it at 1,300 to 1,400 feet based on the present amount of uplift and drowning and the rise in sealevel following the melting of the Pleistocene ice sheets.

Glacial Geology

There is ample evidence throughout the Lake Michaud area that the region was once covered by continental glaciation. Glacial striae, polished surfaces and erratic boulders occur throughout the area. Outcrops are commonly well rounded and where the ice has moved parallel to the structural trends in the rock, flutes, due to differential erosion of softer bands and roche moutonnées have resulted.

The general direction of the ice movement was south. A plot of the direction of ice movement illustrated by glacial striae, flutes, crescentic gouges, and chatter marks shows that all the observations are between S.20° E. and S. 20°W. with a maximum between S. 10°E. and due south.

At several localities large grooves 20 to 30 feet long were observed in the rock walls of valleys, illustrating that the movement of the ice sheet was partly controlled by the topography.

Depositional features of glaciation are not numerous within the area. They consist of erratic boulders, boulder trains, unsorted till in the valleys, and a small esker on a sand plain south of Lake Michaud.

Unconsolidated deposits formed during the Champlain stage are fairly extensive in the southern part of the area. They are a prominent near the coast and consist of a parallel series of sand terraces (raised beaches) underlain by clay. They are gently arcuate in outline, are parallel to the present coastline, and extend from the mouth of Nabisipi river to the southeastern corner of the area.

Pleistocene glaciation modified the pre-existing drainage in certain parts of the area. The outlet of Watshishu lake formerly was at its southern end. A deposit of till more than 5 feet above the lake level has blocked the former drainage channel to the south and forced the lake to discharge into Holt lake through a new channel one mile to the north. A little water from Watshishu lake percolates through the till barrier, and there is a small stream 50 feet south of the till deposit in the much larger abandoned channel.

Sand deposits are rare except near the Coast. A flat plain of sand south of Michaud lake.has an area of approximately 1 3/4 square miles. It is underlain by clay which is well exposed along Nabisipi river and the small tributary that drains Michaud Lake.

A terrace of stratified sandy clay occupies the eastern shore of Michaud lake. It rises 30 feet above the lake level and 300 feet above sealevel. It may be a glacial feature or may have been developed during the Champlain Sea stage.

The small amount of unconsolidated material in the northern part of the area indicates that the glacial effect there was mainly erosive. The existence of a moderate pre-glacial relief is shown by numerous deep valleys whose present relief cannot be due to the small post-glacial streams that now occupy them. Glaciation stripped the unconsolidated material from the tops of hills, depositing it in the valleys, and where the structure of the underlying rock was parallel to the direction of ice movement the topography was accentuated.

The extensive pond-dotted muskeg and sand deposits of the coastal section were formed by the Champlain Sea reworking material that was largely of glacial origin.

GENERAL GEOLOGY

Two main geological units are represented in the Lake Michaud area first highly metamorphosed sedimentary gneisses and associated igneous rocks which form a "Grenville-type" folded, basement complex and second, quartzites, sedimentary schists, and conglomerates of the Wakeham Group which underlie much of the western part of the area and appear here and there throughout the rest of the area. Younger intrusive rocks including gabbro and granites are also common.

"GRENVILLE" GNEISSES

The Grenville-type sedimentary and granitic gneisses of the lower North Shore region have not been definitely correlated with Grenville assemblages in other parts of the Province of Quebec but there is a tendency to regard them as equivalent to the Grenville series.

In the present area this basement assemblage consists mainly of quartzo-feldspathic biotite gneisses and hornblende gneisses that more or less into granitic gneisses. It is probable that much metasedimentary material has been intimately granitized or contains a large proportion of granitic material of varied nature in the form of dikes, sills, narrow sheets, lenses, and irregular bodies. Thus, the general rule followed was to classify as metasedimentary only exposures that contained less than 25% of granitic material.

Paragneisses

Metasedimentary gneisses are the oldest rocks known in the area. They crop out along the coast, the lower part of Aguanus river, along parts of Nabisipi river, and form large irregular areas surrounding lakes Outardes, Quatres, and Sylvestre. Also, isolated exposures of paragneisses too small to be shown on the accompanying maps occur within granitic gneiss and gneissic granite in many parts of the area.

A distinct layering characterizes much of the paragneisses. Most of the layers are from a fraction of an inch to 4 feet thick, but bands up to 15 feet thick are common. A gneissic structure is usually well developed except in the hornblende-rich varieties which are locally massive.

Most of the foliation in the paragneisses is believed to be due to a gneissosity superimposed on an original sedimentary layering. Bedding, the most characteristic structure of theses rocks, commonly persists as a relict banding which may be accentuated through metamorphic differentiation. Gneissosity produced solely by metamorphic dif-

Table of Formations

Pleistocene and Recent		clay, sand, gravel, and erratic boulders
Great Unconformity		
Precambrian	Intrusive Rocks	Granite Porphyry
		Pegmatites
		Basic Dikes
		Massive Biotite Granite Gneissic Granite
		Schistose Gabbro Hornblende Gabbro Pyroxene Gabbro
	Wakeham Group	Gray Micaceous Quartzite Hematite-Rutile Quartzite White Quartzite Epidote Quartzite Conglomerate Quartz-Mica Schist Garnetiferous-Mica Schist Staurolite-Kyanite Schist
	Grenville-type Metasedimentary and Igneous Gneisses	Early Granite Porphyry (1) Augen Granite Gneiss Banded Granite Gneiss Metasedimentary Gneisses

(1) Age relationships uncertain

ferentiation, and which has resulted in a false - bedded appearance, may, in part, be responsible for these structures and may be more common than is generally suspected.

Ripple marks, crossbedding, and graded bedding were not observed in the paragneisses.

The margins of the paragneiss areas are usually transitional from a purely sedimentary gneiss into migmatites, augen gneisses, granitic gneisses, and finally into gneissic granite. Such a transition from a purely sedimentary rock affords strong evidence for a metasomatic origin for much of the mixed granitic gneisses and gneissic granite.

The most common type of paragneiss are:
quartz-biotite gneiss and schist;
quartz-feldspar-biotite gneiss;
quartz-feldspar-biotite-hornblende gneiss;
amphibolite of sedimentary origin.

Small lenses and highly contorted bands of crystalline limestone occur within the paragneiss in the southeast corner of the area. Three exposures of sillimanite-bearing schist that occur within gneissic granite may represent small remnants of Wakeman Group rocks.

Quartz-Biotite Gneiss and Schist

Quartz-biotite paragneisses are the most abundant rock type of the Grenville metasedimentaries. They occur along the coast and throughout the granitic gneisses. The rock varies from a foliated, light to medium gray quartzite to a black, highly foliated schist. Several occurrences of the more massive varieties of biotite gneiss resemble the gray micaceous quartzite of the Wakeham Group.

A variety of quartz-biotite gneiss that resembles the gray quartzite of the Wakeham Group occurs between the West Branch of Aguanus river and the main Aguanus. It is a medium-grained, almost massive variety of quartzite in which the faint foliation is produced by indistinct, schistose bands of biotite which are 1/32 inch thick and which alternate with quartzo-feldspathic bands containing minor amounts of biotite lying parallel to the foliation. The quartzo-feldspathic bands are up to 1/3 inch thick.

In thin-section, the quartzo-feldspathic bands consist of granulose, saussuritized oligoclase and quartz. Microline occurs as a replacement of plagioclase and is confined to two of the quartzo-feldspathic bands of the rock. Microline averages 1.27 mm and quartz 0.6 mm in diameter. An interesting feature of this rock and many of the other gneisses is the zoning between feldspar grain boundaries. Where potassium feldspar is in contact with plagioclase, narrow rims of clear albit surround the plagioclase. The albite rims are restricted to the plagioclase-potassium feldspar boundaries.

A sample of quartz-biotite gneiss consists of:

	per cent
quartz	50.6
plagioclase	25.6
microline	20.2
biotite chlorite	2.4
accessory minerals	1.2

Chlorite is an alteration of the reddish-brown biotite. Sphene occurs as rims around ilmenite, zircon, epidote and allanite.

Several exposures of biotite paragneiss along the lower sections of Aguanus river are coarse-grained, almost massive, impure varieties of quartzite. A faint foliation, visible in band specimens, has been produced by the parallel orientation of biotite which is not confined to schistose bands but is distributed evenly throughout the rock. Irregular porphyroblasts occur in a ½ inch band in several of the specimens.

A sample of biotite paragneiss consists of:

	per cent
quartz	45.2
oligoclase	50.0
biotite	4.4
garnet, zircon, rutile	0.4

The average grain size of the quartz, which shows undulose extinction, is 1.3 mm and of the plagioclase is 1.4 mm. Irregular-shaped porphyroblasts of garnet average 2 mm in diameter. The garnet contains small inclusions of quartz which average 0.09 mm in diameter and which may be an indication of the grain size of the rock before recrystallization.

With increasing biotite content the biotite gneiss becomes highly schistose. The biotite schist is fine to medium grained, very dark gray on the fresh surface and greenish black with a micaceous luster weathered surface. The rock consists of alternating biotite schist bands and fine-grained quartzo-feldspathic or coarse recrystallization bands.

The biotite schist consists of:

	per cent	
quartz	20.3	
plagioclase	25.2	
biotite	45.1	
chlorite	2.1	
accessory minerals	7.3	(pyrite, ilmenite, allanite, epidote, zircon).

The plagioclase, which has been partly saussuritized, consists of oligoclase. Pale green, pleochroic chlorite (pennine) occurs as an alteration of dark greenish-brown biotite.

Exposures of biotite paragneisses in the southeast corner of the area along the coast are similar to the more massive varieties of gneiss described above. They vary from varieties that are massive over widths of 6 inches or more to finely banded gneisses in which the banding is 1/20 inch thick. They consist of alternating bands of biotite-quartz-feldspar and quartz-feldspar.

In thin section the rock consists of saussuritized oligoclase, quartz, and reddish-brown biotite which alters to muscovite. Garnet is common in certain biotite-rich bands as porphyroblastic, euhedral crystals up to 1/5 inch in diameter. Ore minerals are, ilmenite, yellowish-brown rutile, and cubic pyrite which post-dates the schistosity.

Apatite and zircon are characteristic accessory minerals and allanite and epidote occur in minor amounts.

Quartz veins up to ¼ inch wide occur in one of the specimens. The veins are generally parallel to the schistosity but several cut the schistosity at 10^{o}. The exposure of this rock was cut by a pegmatite dike 5 feet wide.

Biotite paragneiss also occurs in the narrow band of metasedimentaries west of Nabisipi river between an area of gneissic granite and the large, composite gabbro sill that extends into the area from the south.

The rock is medium grained, pinkish buff, and weathers to a dark rust-brown. Parallel, discontinuous biotite is concentrated in bands up to 1/5 inch thick which alternate with quartzo-feldspathic bands up to 1/3 inch thick. In none of the biotite-rich bands is the biotite concentrated to such and extent that the rock is schistose. The banding is thought to represent a variation in sedimentation.

The average grain size of the rock is 0.3 mm; it is equigranular, and consists of oligoclase, quartz, and reddish brown biotite partly altered to chlorite. Accessory minerals are apatite, allanite, epidote, ilmenite, sphene and zircon. The epidote commonly contains cores of allanite. A small amount (less than 5%) of untwinned potassium feldspar was noted in the thin-section.

Quartzo-Feldspathic Paragneisses

Quartzo-feldspathic paragneisses occur throughout the area of Grenville rocks. They are similar to, and grade into, the biotite paragneisses. They are also found in narrow bands parallel to the granitic gneisses.

The quartzo-feldspathic paragneisses vary considerably in composition and texture. They range from fine - to medium-grained rocks resembling feldspathic-biotite quartzites, which may contain small porphyroblasts of pink feldspar, to coarse-grained granitic-appearing gneisses.

The varieties of quartzo-feldspathic paragneisses along the coast and in the southern part of the area that can be recognized as sedimentary rocks have been thoroughly recrystallized. Granitic and pegmatitic material occur a narrow lenses and bands parallel to the gneissosity.

A variety of the paragneiss occurring in gneissic granite is a medium-grained, medium gray rock that weathers rusty brown to 1/10 inch below the surface. It appears almost massive in hand specimen but seattered biotite crystals have a parallel orientation. It consits mainly of oligoclase, which has been partly saussuritized, quartz, and biotite. About 5% microline occurs replacing the plagioclase. Hornblende as poikiloblastic crystals forms 2% of the rock. An important accessory mineral is ilmenite which is rimmed by sphene. Sphene also occurs as subhedral, wedge-shaped grains. Other accessory minerals are epidote with a core of allanite, apatite, and zircon. The accessory minerals occur as narrow bands (relic bedding?). Biotite and hornblende show a faint parallel orientation. Albite occurs as fine rims at the boundaries between microline and oligoclase. Quartz has been recrystallized and strained.

The varieties in which the gneissosity is more pronounced consist of alternating quartz-plagioclase-biotite bands and quartz bands. Microcline, which may be a minor constituent or form more than 40% of the rock, occurs as small, oval-shaped porphyroblasts 1/10 - 1/5 inch long; it also occurs as a replacement of plagioclase along selective bands in the rock.

Fine-grained varieties in which biotite schist bands up to 1/10 inch alternate with quartz-feldspar-biotite bands up to 1 inch wide consist of:

	per cent
quartz	27.6
plagioclase	20.6
microline	42.2
biotite chlorite	5.9

ilmenite	0.6	
accessory minerals	3.0	(sphene, epidote, allanite, apatite).

Greenish brown biotite has been altered along the cleavage to chlorite. Sphene occurs as rims around ilmenite and as discrete grains. Microcline-microperthite forms large, irregular anhedral crystals replacing untwinned plagioclase. The plagioclase has rims of clear albite where it is in contact with microcline.

Other varieties consist of alternating fine - and medium - grained bands of quartz, saussuritized plagioclase, and potassium feldspar with parallel, discontinuous biotite occurring through the rock. Poikiloblastic hornblende occurs parallel to the foliation and is confined to one band. Ilmenite, rutile, epidote, and allanite are the accessory minerals.

A pinkish-gray rock that resembles a feldspathized, fine-grained quartzite occurs 2,000 feet west of Aguanus river at latitude 50°42.2'N. It is a finely banded rock in which the foliation consists of bands of biotite 1/32 inch thick. Coarsely crystalline quartz occurs as a network of veins parallel to the foliation. Several quartz veins also occur at varying angles to the gneissosity. The rock consists of:

	Per cent	
quartz	39.4	
plagioclase	37.8	
microcline	9.0	
muscovite	8.4	
biotite	1.2	
accessory minerals	4.2	(calcite, epidote, allanite, ilmenite, sphene)

The foliation, in thin-section, consists of alternating plagioclase-quartz-biotite bands, in which the average grain size of the quartz is 0.09 mm in diameter, and recrystallized quartz, which is highly strained and which averages 1.3 mm in diameter. Microcline replaces plagioclase in certain bands. Muscovite occurs as a post-foliation overgrowth; it forms poikiloblastic crystals at varying angles to the gneissosity.

A similar variety of paragneiss in which the biotite bands are more pronounced occurs, 1,000 feet north of Lake Rochette. It is a distinctly foliated rock consisting of fine-grained quartzo-feldspathic bands ½ inch thick alternating with biotite bands 1/32 inch thick. Incipient augens occur in several of the quartz-feldspar bands with pink potassium feldspar forming ovals up to 3/4 inch long and 1/3 inch in diameter, which distort the biotite schist bands. In thin-section, fresh microcline replaces saussuritized plagioclase in some of the quartz-plagioclase bands. Poikiloblastic hornblende occurs in two of the biotite bands. The accessory minerals occur in bands parallel to the gneissosity. The rock consists of:

	per cent
quartz	33.0
oligoclase	11.9
microcline	45.6
biotite	6.7
hornblende	1.6
accessory minerals	1.2 (muscovite, allanite, epidote, ilmenite, sphene, zircon, apatite.

<u>Hornblende Paragneisses</u>

Interbanded with the biotite-feldspathic paragneisses described above are several bands in which hornblende is in porphyroblastic crystals up to 1/5 inch long. The groundmass of this gneiss has a composition and texture similar to the other paragneisses.

The hornblende paragneisses occur along Nabisipi river at latitude $50^{\circ}34.6$N. in an area of feldspathic paragneisses, between lakes Quatres and Outardes in an area of gneissic granite, and on the shores of Lake Coin in an area of paragneisses.

The rock is medium grained, medium gray to pinkish gray on the fresh surface, and weathers to dull rust-brown. Hornblende occurs as distinct prismatic crystals in the plane of foliation as streaks up to ½ inch long and as stubby crystals which cut across but do not disrupt, the gneissosity.

The rock consists of fine-grained quartz and feldspar bands alternating with medium-grained quartz and microcline bands. Greenish brown biotite occurs as discontinuous crystals parallel to the gneissosity. Poikiloblastic hornblende occurs as prismatic crystals up to 2.55 mm long parallel to the gneissosity or as short, stubby crystals cutting across the gneissosity.

Oligoclase (An_{28}) forms irregular, anhedral crystals that have crystallized after the quartz. It normally contains small, rounded quartz grains and is untwinned. Alteration, which under high magnification is seen to consist of sericite, commonly occurs in patches in the center of the plagioclase; this indicates that there is a zoning in the plagioclase. The plagioclase, in several of the thin-sections examined, has an irregular porphyroblastic habit and encloses biotite as well as rounded quartz grains.

The potassium feldspar is microcline-microperthite and it replaces some of the plagioclase porphyroblasts. It also occurs in some of the rocks as small, clear, irregular grains in the quartz-plagioclase mosaic of the groundmass. Sphene occurs as rounded grains and rims around ilmenite. Allanite, with rims of yellowish-green epidote, is common to all the rocks examined. Apatite and zircon are the other accessory minerals.

Hornblende-biotite paragneiss in which the hornblende is a post-foliation growth and in which plagioclase prophyroblasts are well developed occurs on the shore of Lake Coin near the norther boundary of the area it is light pinkish gray and weathers rusty brown. Gneissosity is shown by parallel, discontinuous lenses and streaks of biotite schist. Hornblende occurs as euhedral, prismatic crystals concentrated in the biotite-rich zones; it has no preferred orientation but grows at all angles to the foliation. Subhedral and anhedral prophyroblasts of cream-colored feldspar occur as rounded areas up to 2/5 inch in diameter; these formed after the production of the gneissosity as the schistose bands are disturbed by the feldspar.

In thin-section, the rock consists of finely granulose bands of quartz and potassium feldspar which alternate with fine biotite schist bands. Plagioclase forms subhedral, porphyroblastic crystals up to 2.6mm long. The plagioclase has been partly altered to sericite and epidote. It formed in the quartz-feldspar bands and encloses small, rounded, quartz grains and biotite. Microcline has replaced some of the plagioclase porphyroblasts.

Sphene is an important accessory mineral and is concentrated in the biotite schist bands; it occurs as rims around ilmenite and as large anhedral grains up to 1.27mm. Epidote occurs as an alteration product of plagioclase and as crystals in the biotite schist bands. It commonly contains cores of allanite. Other accessory minerals are zircon apatite.

Hornblende occurs as euhedral, poikiloblastic crystals up to 2.4 mm long without preferred orientation and containing abundant inclusions of quartz, feldspar, zircon, and epidote.

Tourmaline-Hornblende Paragneiss

Quartzo-feldspathic paragneiss in which tourmaline and hornblende formed after the foliation, outcrops on the west shore of Lake Outardes in an area of mixed paragneisses. It is medium-grained, granitic in texture, light pinkish gray and weathers light buff-gray. The gneissosity is shown by alternating quartz-plagioclase bands and recrystallized quartz bands about 2.5 mm thick. The quartz in the recrystallized bands is strained and forms anhedral crystals up to 3mm across. Discontinuous biotite crystals are arranged parallel to the foliation. Fresh microcline has replaced the altered plagioclase and quartz along selected bands in the rock. Plagioclase (oligoclase) has been altered to a mixture of sericite and epidote minerals.

Deep green to greenish brown hornblende occurs as poikiloblastic crystals which enclose the earlier formed minerals. The hornblende crystals are usually arranged parallel to the gneissosity but also cut across it at varying angles.

Small prismatic crystals of black tourmaline (schorlite) without preferred orientation occur in bands of the gneiss. The schorlite is pleochroic from deep blue to buff and occurs as euhedral porphyroblasts up to 1 mm long. It forms spongy crystals with many inclusions of sphene and plagioclase.

Sphene, an important accessory mineral, occurs as euhedral, wedge-shaped crystals and as subhedral crystals which are scattered throughout the rock but with a higher concentration in the biotite-hornblende bands. Other accessory minerals are chlorite (an alteration of biotite), epidote, allanite, apatite, and zircon.

Crystalline Limestone

A little coarse, crystalline limestone is found on the coast 3¼ miles east of Michon. The limestone is associated with quartz-biotite paragneiss as lenses and bands distributed along bedding planes. The occurrences are clearly the remnants of limestone beds that were originally continuous but have now been squeezed and drawn out between the thick folded, quartz-biotite beds. The limestone beds and lenses show strong flow lines.

The rock weathers rusty brown with a pitted surface. It is pale pink and pale green on the fresh surface and has an ill-defined banding produced by alternating pink and green layers 1/5 to 1/4 inch wide. It consists predominantly of calcite which, in parts of the thin-sections examined, has bent twin lamellae. Calcite occurs in anhedral grains up to 3 mm in diameter. A colorless pyroxene-diopside ($Z/C= -40^{o}$) forms up to 10% of the rock and occurs as rounded and subhedral grains which altereded along fractures and margins to pale green pennine. Strained quartz forming less than 1% of the rock, occurs in one of the samples. Phlogopite and an opaque mineral which may be graphite form trace amounts in the rock.

Sillimanite Schist

Sillimanite schist was observed in two localities in the Aguanish part of the area. Two narrow bands of sillimanite schist occur interbanded with amphibolite 1,500 feet west of Aguanus river at latitude 50°27. 3N. Another is a narrow, highly sheared remnant in gneissic granite in the west-central part of the Aguanish area. These schists are near outcroppings of Wakeham sedimentary rocks and may be remnants of this group rather than part of the older paragneiss complex.

These exposures near Aguanus river are foliated biotite-quartz rocks that are highly weathered and friable. Pebble-like forms 3/4 x 1/2 inch occur in the plane of schistosity. In thin-section the pebble forms consist of areas of quartz and sillimanite in a fine-grained matrix of quartz, feldspars, and biotite. Sillimanite occurs as a felted mass of small prismatic crystals which grow around the quartz grains and as individual crystals in recrystallized quartz. Reddish brown biotite occurs parallel to the foliation and has been partly altered to chlorite. Lepidoblastic muscovite up to 4 mm long grows across the rounded quartz grains. The development of sillimanite is later than that of the muscovite as sillimanite cuts across the mica.

The second exposure of sillimanite schist is highly weathered but similar to the exposures near Aguanus river. It consists of a schistose, medium-grained, biotite-quartz-feldspar matrix containing oval-shaped areas 4 mm x 1.5 mm which consist of a felted mass of fine sillimanite crystals and recrystallized quartz. Muscovite has formed from deep, reddish brown biotite. The muscovite has been sheared and shows undulose extinction.

In the recrystallized sedimentary rock, which is believed to have been a conglomerate, plagioclase encloses rounded quartz grains of the original sediment which average 0.09 mm in diameter. Plagioclase also contains inclusions of biotite and of rounded zircons. The quartz in the pebbles also has been recrystallized. It contains inclusions of feldspar, sillimanite, and biotite, and average 1.3 mm in size perthitic. Microcline occurs as a replacement of plagioclase. Muscovite has replaced whole crystals of biotite or parts of the biotite along the cleavages.

A late deformation has fractured the rock. Shearing parallel to the schistosity has formed zones of microscopic milled material. Muscovite has been fractured with offset cleavages and biotite has been bent and fractured. The recrystallized quartz has also been strained and fractured. Planes of microscopic liquid-gas inclusions, occur in the quartz. Mixed gneisses or migmatites are common in the southern and northeastern parts of the Lake Michaud area. They commonly occur between paragneisses and gneissic granite but also occur as zones in evenly banded granitic gneiss and gneissic granite. They represent the transition from a rock which was sedimentary to a rock which has the appearance and composition of an igneous gneiss. Few well-defined zones of migmatite can be outlined.

The mixed gneisses are composed of a host rock in which the granitic material forms 25-75% of the volume. The introduced granitic material may be aplitic or pegmatitic bands with clearly defined margins that are continuous over long distances, or short lenses which feather out into the older gneiss. Portions of the mixed gneiss may also contain granitic material as irregular patches with no clearly-defined margins, or the granitic material may form phenocrysts of feldspar and quartz resulting in an augen gneiss.

The original character of the rock cannot always be determined. Much of the mixed gneiss has the appearance of an igneous granite; elsewhere the original rock was a sediment, such as an impure quartzite or biotite-hornblende-quartz-feldspar paragneiss.

Granite Gneiss

Classified under granitic gneisses are rocks of granitic composition but of doubtful origin. They are, however, older than some of the gneissic granite, which is observed cutting granite gneiss at Aguanish and in other parts of the area.

The granitic gneisses are medium-grained rocks that have a medium pinkish gray fresh surface and a buff to rusty weathered surface. The foliation is produced in the gneiss by parallel, discontinuous streaks of biotite or by parallel-oriented flakes of biotite distributed evenly throughout the rock. Biotite may also be concentrated in bands but not to such an extent that biotite schist is formed.

Most of the exposures are equigranular but in several localities quartz has recrystallized into large grains up to 1/5 inch across.

Varieties in which biotite is distributed evenly throughout the rock consist of:

	per cent	
quartz	38.1	31.8
plagioclase	27.3	28.2
microcline	26.3	34.0
biotite chlorite muscovite	6.9	5.4
accessory	1.4	0.6

The accessory minerals are apatite, zircon, allanite, epidote, ilmenite, and sphene.

The average grain size of the gneiss is 1.2 mm. The plagioclase is partly saussuritized oligoclase. The microcline which plagioclase, is perthitic locally.

The granite gneiss forming the second falls from the mouth of Aguanus river contains coarse-grained granite bands up to ¼ inch wide which have both sharp and diffuse contacts with the rest of the gneiss. The average grain size of the rock is 1.2 mm but in the coarser grained bands recrystallized quartz grains up to 10 mm occur. The recrystallized quartz contains small anhedral grains of plagioclase and microcline. Microcline-microperthite also occurs as a replacement of saussuritized plagioclase (An_{14}). Rims of clear albite occur at the microcline-plagioclase boundaries, and myrmekite is commonly formed in the plagioclase. The rock consists of:

	(1)	(2)
quartz	49.3	57.3
plagioclase	26.4	14.1
microcline	15.3	25.2

(1) normal pinkish gray granite gneiss.
(2) deep pink, coarse-grained bands.

	(1)	(2)
biotite		
chlorite	7.8	3.2
accessories	1.2	0.6 (allanite, epidote, zircon, sphene, apatite).

Many metasedimentary gneisses of quartzo-feldspathic composition have been evenly granitized. Banding is evident, however, and consists of alternating fine and medium-grained material. With increasing amounts of coarser grained granitic material in the gneiss the rock becomes a banded granitic gneiss.

The rock normally displays fine bands of quartz-feldspar and quartz-feldspar-biotite, which produce the gneissosity. The banding is usually less than 1/10 inch thick. Medium- to coarse-grained granite may form additional bands. Coarser grained granitic material also forms indistinct patches and lenses in which biotite crystals are parallel to the gneissosity of the rock.

In thin-section, the rock is observed to be completely granitic in composition and texture. Small rounded quartz grains and small biotite flakes are included in the large (up to 3.5 mm), anhedral plagioclase crystals. The plagioclase is oligoclase (An_{28}) and replaced by microcline. Accessory minerals are apatite, sphene, and zircon.

The quartz which is not included in plagioclase has been recrystallized into irregular grains up to 2.6 mm across. It has undulose extinction and contains liquid-gas inclusions which have no preferred orientation.

Banded Granite Gneiss

Granitic material, which varies in thickness from 1/10 inch to several feet, occurs locally massive sills which have sharp boundaries with the host component of the rock. In places, however, the granitic material, although having sharp boundaries, contains narrow schist folia which are parallel to the gneissosity of the rock. In places, also, the granitic material has diffuse, cross-cutting relationships to the paragneiss.

The host component of the rock consists of alternating fine- to medium-grained, quartz-biotite-feldspar bands, and quartz-feldspar bands. The bands are normally less than 1/20 inch thick. The rock has the appearance and composition of the biotite-feldspar-quartz paragneiss described above.

Evidence that the granitic component of the migmatite is at least in part replacive rather than intrusive is confirmed by a study of the thin-sections. The original rock is composed of quartz-biotite-oligoclase bands and biotite schist bands. Quartz occurs as rounded grains which average 0.1 mm in diameter and which are enclosed in large, anhedral, recrystallized grains of plagioclase averaging 7.5 mm across. Some of the quartz, also, has recrystallized into strained, irregular grains averaging 1.4 mm across. Microcline (in part perthitic) replaces the plagioclase (oligoclase). Small patches of altered plagioclase and rounded quartz grains remain in the microcline.

Banded granitic gneiss in which the granitic material has a replacive habit occurs in the southeast corner of the area. Here, the granitic material is coarse grained and occurs as a diffuse sill-like body which, however, cuts the older gneiss locally. In the granitic material biotite crystals and a narrow band of medium-grained, quartz-feldspar-biotite gneiss occur parallel to the gneissosity of the rock. The gneiss consists of quartz, microcline-microperthite, oligoclase, and biotite which is partly altered to chlorite. Accessory minerals are sphene (rims around ilmenite), rounded zircons, allanite, and apatite.

Augen Granite Gneiss

Augen granite gneiss forms a large part of the southern and eastern thirds of the Lake Michaud area. It occurs as large, irregular masses and as small bands included in gneissic granite.

Although some of the augen gneiss may be and augen facies of an intrusive granite, much of it is believed to represent the result of metasomatic processes in which porphyroblasts of feldspar have grown in a variety of original rocks. Also, much of it represents the transition from banded granitic gneiss to gneissic granite. Augen gneiss has also been formed by the development of porphyroblasts of feldspar and quartz in rocks of basic composition.

Augen gneiss occurs at the mouth of Aguanus river, in the Lake Gallienne granite, and in other parts of the gneissic and massive granite areas. At the mouth of Aguanus river there is a small escarpment of banded granite gneiss, described above. The banding is caused by stringers and lenses of pegmatitic material that parallel the foliation of a quartz-feldspathic-biotite gneiss. Near the top of the escarpment the banded granitic gneiss is in sharp contact with a coarse-grained gneissic granite, which gradually takes on an augen texture eastward across the strike.

The composition and texture of the augen gneisses may vary considerably. In the initial stages of the development of an augen structure in a gneiss believed to be originally sedimentary, small, lenticular-shaped areas of pink feldspar are produced. They are elongated in a direction parallel to the strongly developed gneissosity. The augens consist of medium-grained quartz, plagioclase (oligoclase), and microcline. Fine, schistose bands of biotite are wrapped around the augens, and in some augens relic schist bands are preserved. Pink feldspar also occurs in ill-defined lenticular patches.

The groundmass of the gneiss consists of fine bands of quartz, feldspar, and varying amounts of biotite. The augen-shaped areas are made up of coarser-grained recrystallized quartz, plagioclase, and microcline. Plagioclase in the augens and in the groundmass has recrystallized forming subhedral crystals that enclose small, rounded grains of quartz and sphene, which are possibly a relic feature of an earlier sedimentary fabric. Microcline has partly replaced the plagioclase in the augen areas and in selected bands of the groundmass.

A modal analysis of an augen gneiss shows the following composition:

	per cent
quartz	28.8
oligoclase	40.0
microcline	14.2
biotite	12.4
hornblende	2.2
accessory minerals	2.4 (sphene, ilmenite, allanite, epidote, zircon).

Hornblende occurs as stubby, poikiloblastic crystals enclosing rounded grains of quartz, plagioclase, and sphene. The inclusions are arranged in rows. The hornblende occurs at all angles to the gneissosity. Sphene forms subhedral, wedge-shaped grains and rims around ilmenite. Other specimens examined are similar but do not contain hornblende. Muscovite, where present, occurs as patches interstitial to quartz and feldspar, and is an alternation product of some of the feldspar.

In the irregular-shaped area of augen granite gneiss (intrusive?) south of Lake Rochette microcline forms a much larger part of the rock than in the paragneiss? described above. Coarse-grained granite forms ill-defined augen-shaped areas $1\frac{1}{4}$ x $\frac{1}{4}$ inch and also irregular bands. Potassium feldspar selectively replaces bands in the original gneiss.

The gneiss consists of:

	per cent
quartz	36.4
plagioclase	21.8
microcline	33.0
hornblende	3.8
biotite	4.8
accessory minerals	.2 (sphene, epidote, allanite, apatite, zircon)

In thin-section, parallel discontinuous biotite imparts a distinct foliation to the rock. Plagioclase forms anhedral saussuritized crystals that enclose small, rounded quartz grains up to 0.1 mm in diameter, and zircon. Perthitic microcline, replaces some of plagioclase. Patches of altered plagioclase remain in the fresh potassium feldspar. Anhedral plagioclase averages 1.0 mm in size and subhedral and anhedral microcline 1.5 mm long. Poikiloblastic hornblende contains inclusions of all the other minerals in the rock. Recrystallized and strained quartz forms elongated grains up 1.4 mm.

Bands of similar augen granite gneiss are found in gneissic granite in the southern part of the area and on the shore of Lake Sylvestre.

Porphyroblasts of medium-grained, recrystallized quartz with plagioclase and microcline occur in a finer grained strongly gneissic rock. The gneissosity of the rock is produced by bands of varying composition 1/10 inch to ½ inch thick. In several specimens the porphyroblasts form more than 50% of the rock and biotite schist remains as fine folia that are wrapped around the porphyroblasts. The porphyroblasts are almost continuous throughout the exposure and average ½ by 3/4 inch. In other specimens the quartz-feldspar augens form 15-20% of the rock and the gneissosity is pronounced.

No average composition of the augen gneiss can be estimated as there is such a variation in the proportion of the feldspars. An analysis of a specimen of augen gneiss that occurs in granite gneiss near Nabisipi river at latitude $50^{\circ}21'18"$N. Gives the following composition:

	per cent
quartz	24.7
plagioclase	48.0
microcline	17.2
biotite	3.5
hornblende	5.9
accessory minerals	0.7 (apatite, sphene, allanite, zircon).

The plagioclase, in which twinning is either poorly developed or absent, is oligoclase. Some of the plagioclase has recrystallized and contains quartz inclusions; it also encloses epidote in one specimen. Much of the plagioclase is saussuritized and has been replaced by microcline. Myrmekite has formed in, and rims of albite are common around, plagioclase grains.

Hornblende forms poikiloblastic crystals up to 1.4 mm long. Fine, recrystallized quartz, a fraction of a millimeter thick lies between hornblende and plagioclase and between biotite and plagioclase.

All the quartz that does not occur as inclusions has been recrystallized. It forms irregular, elongated, grains with a wide variation in size.

Much of the banded granitic gneiss surrounding Lake des Baies and the paragneisses surrounding Lake des Outardes contains bands parallel to the gneissosity in which pale to deep pink porphyroblasts of feldspar are formed. With increasing development of porphyroblasts in the gneiss the rock approaches the augen gneisses in composition and texture.

In the development of the porphyroblasts the initial stages are represented by the recrystallization and replacement of the groundmass by euhedral to subhedral plagioclase. The plagioclase is usually untwinned and is oligoclase (An_{27}). In one specimen, plagioclase largely altered to sericite contains patches of potassium feldspar as well as the usual quartz, biotite and zircon inclusions. Microcline replaces plagioclase and in one specimen forms a large porphyroblasts at least 20 mm in diameter, in which plagioclase remains as small patches.

Hornblende is common to all the rocks examined and may form up to 10% of the gneiss. It has formed late and occurs as poikiloblastic crystals which are short and subhedral or long (up to 3.7 mm) and euhedral.

Examination of thin-sections confirms field observations on the nature of the feldspars in the porphyroblasts. Pale pinkish-cream porphyroblasts consist largely of oligoclase; those that are salmon-pink consist largely of microcline with subordinate amounts of plagioclase and quartz.

Quartz that does not occur as inclusions in feldspars and hornblende is recrystallized. It usually is strained and fractured and may contain planes of liquid-gas inclusions that have no obvious preferred orientation.

THE WAKEHAM GROUP

Rocks of the Wakeham Group occupy most of the western part of the area. They also occur in the northeast corner and in the northern quarter of the southern (Aguanish) area. Mapping in adjacent areas by field parties of the Quebec Department of Natural Resources has shown that the group occurs on the North Shore near Baie Johan Beetz village and extends inland from the coast approximately 60 miles. The group is about 7-½ miles wide at the coast and more than, 40 miles wide at latitude $50^{\circ}40'$N.

Reconnaissance mapping by private mining companies and Quebec field parties has shown two additional areas of Wakeham rocks along Natashquan river 14 miles east of the Lake Michaud area. In all, the Wakeham Group covers an area of at least, 1,000 square miles.

In the present area, the Wakeham Group consists of a thick sequence of sedimentary rocks that have been intruded by gabbro sills and discordant bodies of gabbro. Quartzite is the predominant member of the group and includes such varieties as gray micaceous; white vitreous; hematite-rutile; epidote; calcic; and feldspathic. The purer varieties are usually thick bedded while the impure varieties are usually thin and, in a few localities, show crossbedding or ripple marks.

Interbedded with the quartzites are conglomerates, quartz-mica schist, garnet-mica schists, garnet-kyanite-staurolite schists, and cordierite schist.

Intrusive into the Wakeham Group are numerous bodies of massive to foliated gabbro which usually occur as sills but in a few localities are discordant. The sills range in thickness from 50 feet to more than 2,000 feet. Most of the gabbro is a hornblende variety but occasional thin-section have pyroxene, and it is thought that much of the gabbro was originally a pyroxene variety that has been uralitized.

Schists of the Waheham Group

Sedimentary schists of the Wakeham Group occur in a zone at least 2 miles wide which extends from the southern boundary of the western part of the area at longitude 62°22' W north-northwest through Lake Auger and along the western boundary of the Lake Gallienne granite stock. Limited exposures of sedimentary schist are found in other areas of Wakeham rocks in the area. No sharp limits to this zones of schist can be made as they are interbedded with, and grade into, gray micaceous quartzite, white quartzite, and conglomerates.

Geological mapping in adjacent areas and in the Lake Michaud area indicates that unless the sequence has been complicated by faulting, the schists are at the base of the group. The Wakeham Group as exposed in the area is part of the eastern limb of the major Wakeham syncline. Cross-bedding and ripple marks in the quartzites indicates that the series becomes progressively younger westward as the center of the syncline is approched and that the schist members of the group are older than the more massive varieties of quartzites. This does not imply, however, that there is any major break in sedimentation as there is a gradation from schists to massive quartzites and schists are interbedded with quartzites in the western part of the area.

As the schists are eroded more easily than massive quartzite they are found in the valleys, and it is probable that they occupy parts of the low drift-covered areas.

The schist of the Wakeham Group include a variety of quartz-mica types garnetiferous mica; conglomerate, kyanite-staurolite; and cordierite schist.

Micaceous Schists

Interbedded with the impure varieties of massive quartzite are numerous beds of quartz-mica schist. These have a maximum development in the main schist zone that trends north-northwest through Lake Auger, but also occur at the western margin of the area north of Lake Watshishn.

At the western margin of the area quartz-mica schist is interbedded with, and grades into, gray micaceous quartzite. It also forms the matrix of conglomerates exposed in the main schist belt. The schist in fine grained medium to light gray and has a pale gray weathered surface with a micaceous luster. An example consists of:

	per cent
quartz	56.0
microcline, plagioclase	11.6
muscovite, chlorite	28.0
accessory minerals	4.4 (magnetite, ilmenite, tourmaline, zircon, epidote-allanite)

The maximum size of the quartz is 0.09 mm. Muscovite and chlorite are in fine, schistose bands. Magnetite in octahedral crystals up to 0.63 mm across and tourmaline cut across the schistosity. Opaque minerals and epidote-allanite in bands that parallel the schistosity may be original beds. In two of the thin-sections examined, a secondary schistosity has been produced by a late growth of muscovite which cuts across the primary schistosity at 60^{o}.

A coarse-grained biotite-chlorite schist occurs 1 mile south of the Lake Gallienne granite near a zone of kyanite-staurolite-garnet schist. The rock weathers dark buff with a pronounced micaceous luster, and is greenish gray on the fresh surface. On the weathered surface radiating, greenish black chlorite crystals up to 2 inches long occur. These were probably and original amphibole, and were produced after the development of the schistosity. The present mineralogy of the rock, therefore, is the result of retrogressive metamorphism which followed the thermal metamorphism of a schistose rock:

	per cent
quartz	33.4
plagioclase	14.0
biotite	5.0
chlorite	20.6
epidote-allanite	11.2

accessory minerals 9.2 (Ilmenite, sphene, zircon)

Plagioclase has been altered to saussurite. Ore and zoned allanite-epidote occur in narrow bands parallel to the schistosity. Shearing at 55° to the primary schistosity has produced a secondary schistosity. Chlorite occurs in irregular patches. The rock is coarse grained with quartz occurring as recrystallized irregular grains up to 1.4 mm in size and showing pronounced undulose extinction.

Another variety of mica schist that has a complex history occurs 1,600 feet southeast of Lake Gallienne at latitude 50°40'N. It is a medium-grained, complexly folded rock that has a medium grayyish buff weathered surface and a dark gray to black, finely banded fresh surface where least deformed, the rock consists of alternating quartz, biotite, and ore bands. The maximum size of the quartz is 0.10 mm. The quartz has been recrystallized in several places and has a radiating structure. Greenish yellow, pleochroic epidote with cores of brown allanite occurs throughout.

The primary schistosity of the rock has been folded into tight, isoclinal folds. Strongly pleochroic, reddish brown to green tourmaline has formed parallel to the limbs and on the crests of the isoclinal folds. A secondary foliation has been produced by open folds which are at 90° to the isoclinal folds. This second deformation folded the tourmaline crystals. Green, pleochroic actinolite in prismatic crystals up to 1.3 mm long occur parallel to the secondary fold axes, as an overgrowth on biotite.

Apatite, an important accessory mineral, occurs as subhedral crystals up to 0.8 mm in size which cut across the limbs of the isoclinal folds. Its occurrence and form suggest that it is the result of pneumatolytic introduction of phosphate or phosphorous in volatile form probably in the same processes of paeumatolysis that formed tourmaline.

Garnet-Mica Schists

Garnet-mica schist is exposed throughout the Wakeham rocks in the western third of the map-area. Most occurrences are in the main schist belt but garnet-bearing schist (a $1\frac{1}{4}$ inch wide band) is found on the shores of Holt lake and $\frac{1}{4}$ mile east of Nabisipi river at latitude $50^{\circ}42.3'$N. in an isolated exposure.

The exposures of garnet-mica schist in the main schist area are of varying composition and texture. Several of the specimens are medium grained, gray, micaceous quartzites with a faint schistosity parallel to the bedding. They consist of:

	per cent
quartz	47.8
feldspar	12.6
garnet	4.4
biotite chlorite	16.6
muscovite	13.6
accessories	5.0 (opaque minerals, zircon, apatite, rutile, tourmaline).

The rows of inclusions of quartz and opaque minerals in the garnet porphyroblasts show that the garnet, was formed after the schistosity. In one specimen small micro folds have been produced at right angles to the primary schistosity, resulting in a secondary schistosity. Garnet porphyroblasts have been formed at the crests of the small folds. The primary schistosity is parallel to, and accentuated by, narrow bands of ore minerals which are believed to be a relic bedding structure.

Other specimens of garnet-mica schist in the main schist area are light to medium gray rocks, some of which exhibit a micaceous luster on the weathered surface. They are distinctly spotted by rounded, deep red, garnet porphyroblasts or round patches of biotite and chlorite; the biotite and chlorite are the result of retrogressive metamorphism of garnet porphyroblasts.

In thin-section the rock consists of alternating granulose quartz-biotite-feldspar and fine biotite schist bands. Garnet porphyroblasts form in the biotite schist. In some of the thin-section, inclusions in the garnet show that the porphyroblasts has been rotated. Reddish brown biotite occurs in the schistose bands and as poikiloblastic crystals that have the shape of former garnet porphyroblasts. Chlorite occurs as an alteration of biotite.

The composition of the schist is:

	per cent
quartz	40.0
feldspar	18.0
biotite chlorite	32.0
muscovite	5.4
accessory minerals	4.6 (garnet, apatite, zircon, opaque ore minerals, sphene, rutile)

Muscovite occurs as an alternation of feldspar. In one specimen bluish green amphibole occurs as a poikiloblastic over-growth on chlorite. Pale yellow-green, pleochroic epidote, some of which have a core of allanite, was observed in two of the sections. Where the epidote-allanite crystals occur in biotite, distinct pleochroic haloes are produced.

Garnet-Staurolite Schist

Surrounding the Lake Gallienne granite stock is a zone of garnet-staurolite schist. This is all within 1,600 feet of the granite-schist contact and is related to the intrusion of the granite. Most exposures are along the southern and western margins of the granite but there is one occurrence 1,000 feet north of the northeast corner of the granite mass. The rock is coarse grained and medium gray on the fresh surface. The westhered surface is light to medium gray and is spotted with large porphyroblasts of garnet and staurolite up to 3/5 inch in diameter. Quartz, which has been recrystallized, forms a network between the porphyroblasts, and is resistant to weathering.

In thin-section, the rock consists of euhedral porphyroblasts of garnet up to 7.7 mm in diameter and staurolite porphyroblasts up to 5.0 mm in diameter. Staurolite is distinctly pleochroic from almost colorless to golden yellow and contains quartz inclusions. In one thin-section the quartz inclusions occur as streaks up to 0.65 mm long. This streaking of the quartz inclusions was possibly caused by shearing in the rock prior to, or during, the formation of the staurolite porphyroblasts.

Feldspar, seen in two thin-section; consists of fresh oligoclase in one and of saussuritized plagioclase in the other. Biotite and chlorite are also prominent constituents of the schist. Chlorite occurs as an alteration of biotite and as an alteration of garnet along fractures. Muscovite is present in all the thin-sections as a late poikiloblastic growth on chlorite. Zoned epidote-allanite is a prominent accessory mineral in two of the thin-sections. Distinct pleochroic haloes are formed around the epidote minerals where they occur in biotite and chlorite. Apatite is another prominent accessory mineral. Rutile, sphene, and ilmenite are present is trace amounts. All the rocks were deformed after the formation of the porphyroblasts. Garnet and staurolite are fractured, and the quartz is brecciated and shows marked undulose extinction.

Kyanite Schist

Altered kyanite schists are found in a narrow zone that extends to the west and north-northwest from the two lakes immediately to the south of Lake Gallienne. This zone closely follows the lake and river system that borders the western and southern margins of the Lake Gallienne granite stock. Included in this zone are the garnet-staurolite schists described above and cordierite-bearing schists described below.

Altered kyanite crystals that have no preferred orientation are scattered throughout a fine-grained, micaceous schistose groundmass and give the rock a pronounced spotted appearance on the weathered surface. The zones containing kyanite are up to 30 feet thick. The kyanite crystals weather chalky white and are up to 6 inches long. In some of the kyanite schist, cruciform twins of altered staurolite up to 1 inch long occur.

In thin-section, kyanite (largely altered to sericite) and garnet porphyroblasts occur in a recrystallized medium-grained matrix of quartz, opaque minerals, epidote minerals, and apatite. Chlorite and muscovite are in poikiloblastic crystals overgrowing the groundmass. Kyanite occurs as bladed patches surrounded by sericite, which preserves the original porphyroblastic form of the kyanite. The epidote minerals consist of an allanite core rimmed by colorless epidote. The mineral is radioactive and produces distinct pleochroic halos where it occurs in chlorite. In some of the thin-sections the opaque ore minerals and epidote minerals occur in bands which may be a relic bedding feature. Staurolite was observed in one of the thin-sections in trace amounts. Characteristic accessory minerals are tourmaline, apatite, and zircon.

Cordierite Schist

Closely associated with the kyanite and staurolite schists are cordierite schists. Cordierite was observed in varieties of both the kyanite and staurolite schist described above and in fine-grained, quartz-mica-chlorite schist from the same areas.

Cordierite has been partly altered to sericite in all thin-sections examined; it is recognized mainly by its characteristic sector twinning. Possibly it has been more abundant, but having been altered to sericite it is now unrecognizable.

The fine-grained schistose varieties consist of:

	per cent
quartz	40
muscovite	20
altered plagioclase	15
chlorite	10
cordierite	5
ore minerals	5
zoned epidote-allanite	3
tourmaline, apatite	2

Tourmaline occurs as small prismatic crystals that cut across the schistosity. Later shear movements have fractured the tourmaline and micaceous minerals.

Quartzites of the Wakeham Group

Wakeham quartzites are widespread in the western part of the Lake Michaud area. They are generally younger than the schistose members of the group.

Gray Quartzite

Gray, micaceous quartzite is the main metasedimentary rock of the Wakeham Group area. It occurs in beds ½ inch to several feet thick and locally in large, massive exposures with no visible bedding. It is medium to dark gray and fine to medium grained. The weathered rock has a light to medium gray surface layer ½ inch thick which has resulted from the leaching of iron oxides; the oxides have been deposited as an iron-rich zone 1/10 inch thick, below the weathered surface layer.

The composition of the gray quartzite varies considerably. The average grain size of the quartz varies from specimen to specimen between 0.2 and 0.5 mm.

The composition of typical specimens is:

	per cent
quartz	50-75
feldspar	5-15
biotite	2-15
chlorite	0-5
accessory minerals	tr.-5

The accessory minerals include ilmenite, rutile, sphene, zircon, apatite, calcite, and tourmaline.

The quartzite has usually been recrystallized to such an extent that the original outline of the quartz grains is rarely apparent. Recrystallized quartz is highly strained. With increasing biotite content the gray quartzite grades into quartz-mica schist. One specimen contains a flattened pebble-like form 3.8 mm long.

Plagioclase and microcline were observed in all specimens examined. Sericite occurs throughout one of the specimens as irregular patches up to 1.10 mm in diameter, a feature which suggests that it is the result of alteration from potassium feldspar. Chlorite occurs in two of the thin-sections as an alteration of biotite.

The composition of an equigranular specimen in which sericite is an alteration of feldspar is:

	per cent
quartz	58.4
feldspar (unaltered)	6.4
sericite	17.8
biotite chlorite	10.4
accessory minerals	7.0 (tourmaline, zircon, rutile, ilmenite, sphene, calcite)

White Quartzite

White quartzite is widespread in the Wakeham Group. It is fine grained and white to light gray on both weathered and fresh surfaces. Weathering features are generally the same as in the gray quartzite. Texutres is variable owing to variations in original composition and in degree of recrystallization. In some thin-sections the texture is characterized by angular to sub-angular quartz distributed in a finer-grained matrix of quartz, feldspar, mica, and carbonate, whereas in the more recrystallized varieties the rock has a granoblastic texture of equigranular quartz with minor amounts of feldspar.

The composition of two typical specimens is:

	per cent
quartz	68.2; 69.0
feldspar	22.8; 16.2
calcite	- ; 5.2
actinolite	4.6; -

biotite chlorite muscovite	2.4; 6.4
accessory minerals (ilmenite, rutile, sphene)	2.0; 3.2(idem, plus apatite)

The feldspars consist of approximately equal amounts of plagioclase (albite) and microcline. The actinolite is pale green and pleochroic. It occurs as long, prismatic crystals that have a parallel orientation and impart a microscopic foliation to the rock.

Hematite-Rutile Quartzite

Hematite-rutile quartzite is less common than, and is interbedded with, the gray and white quartzites described above.

The rock is in thin beds, usually 1/20 inch in average thickness, consisting of inter-laminated white or gray quartzite and black layers. The finely bedded layers are in zones from a fraction of an inch to over 2 feet or more thick. Separating these zones are beds of gray or white quartzite 1½ inches to 10 feet thick. Crossbedding and ripple marks are common in the finely bedded layers. The hematite-rutile quartzites have a grayish-pink weathered surface and medium pink fresh surface, the pink being produced by fine reddish scales of iron oxide.

In thin-section, the black bands consist of hematite, rutile, ilmenite and, in some specimens, sphene. The ilmenite and rutile are in small sub-rounded grains averaging 0.3 mm in diameter. Rutile also occurs as microscopic, acicular crystals in grains of quartz. Sphene is found as rims around ilmenite and, in one specimen, as a narrow fracture filling. The rock shows varying degrees of recrystallization. One specimen consists of an aggregate of clastic quartz grains, surrounded by a felted mass of sericite. The sericite is a result of alteration of feldspar. In the recrystallized varieties the grain size of the quartz increases to 1.3 mm and parallel, discontinuous muscovite and quartz impart a microscopic foliation to the rock which is parallel to the bedding.

The composition of three specimens is given in the following table:

	(1)	(2)	(3)
quartz	91.8	91.8	68.4%
feldspar	31.8	-	-
microcline	-	-	12.2
biotite	-	-	1.6
muscovite	-	1.0	-
chlorite	-	6.0	-
biotite chlorite muscovite	2.1	-	-
sericite	-	-	10.6
ore minerals	4.3	1.2	7.2 (includes sphene)
zircon, tourmaline	-	tr.	tr.
amphibole	9.6	-	-

The amphibole is edenite-pale green, colorless, resembling actinolite in form.

Feldspathic Quartzite

Interbedded with the white quartzite and hematite-rutile quartzite are a few beds of feldspathic quartzite. They are medium to light pinkish gray, medium grained, and generally massive. Varieties consisting of alternating quartzo-feldspathic and micaceous bands appear massive on the fresh surface but have a finely banded, rough, weathered surface, which is produced by the deeper weathering of the micaceous bands. The banding produced on the weathered surface varies from 1/32 inch to 1/5 inch wide. The depth of weathering is approximately 2/5.

The composition of two feldspathic quartzites is:

	(1)	(2)
quartz	64.0	66.4%
plagioclase(albite)	-	21.6
plagioclase and microcline	24.4	-
biotite and muscovite	8.0	3.2(includes chlorite)
calcite	0.4	0.8
accessories(apatite, ore, tourmaline)	3.2	-
accessories(apatie, zircon, tourmaline, opaques)	-	8.0

Specimens that have a small amount of micaceous minerals are massive rocks consisting of a mosaic of equigranular quartz and feldspar averaging 0.3 mm in diameter, while specimens containing 8% or more of micas, although massive in the hand specimen are distinctly foliated in thin-section. Biotite, chlorite, and muscovite occur as parallel, discontinuous crystals or as narrow schistose bands parallel to the bedding. Plagioclase has been partly altered to saussurite and in several thin-sections microcline replaced plagioclase.

Calcareous Quartzite

Calcareous quartzite forms a large part of the Wakeham quartzites in adjacent areas, (Grenier, 1955) but is of very limited occurrence in the Lake Michaud area. It is interbedded with the gray and white quartzite and is a medium to dark pinkish gray rock that has a a light-gray, pitted, weathered surface. Calcite occurs as thin lenses and as irregular, interstitial grains in a quartz-feldspar mosaic. A typical specimen consists of:

	per cent
quartz	68.6
plagiocalse microcline	20.8
calcite	5.0
muscovite	3.2
ore minerals	2.4

The calcareous quartzite also contains a large proportion of pale green actinolite, with minor amounts of quartz and clinozoisite. The clinozoisite and amphibole have resulted from the metamorphism of an impure, silicious limestone.

Epidote Quartzite

Interbedded with the gray, white, and calcareous quartzites described above, and in the main area of Wakeham rocks, are numerous beds of epidote quartzite. Epidote quartzite is also found in two isolated exposures in an area of augen granite gneiss on the shore of Lake Vigneault. The high proportion of epidote in some of the rocks and the presence of small amounts of calcite indicate that the epidote quartzites are more highly metamorphosed equivalents of the calcareous quartzites.

The rocks are medium grained and vary from pale green to medium pinkish green to greenish gray. Several of the specimens consist of parallel lenses of granular quartz 1/10 inch thick by ½ inch long distributed in a finer-grained groundmass of quartz and epidote; other specimens are distinctly bedded.

The composition of two of the bedded varieties of epidote quartzite is:

	per cent		per cent
quartz	49.8	quartz	52.0
epidote	41.2	epidote, allanite	39.4
potassium feldspar	3.8	calcite	2.8
biotite chlorite muscovite	2.0	chlorite	0.4
ilmenite sphene	3.2	ilmenite sphene	5.4
tourmaline apatite	tr.		

The rocks have a granoblastic texture with quartz in grains from 0.2 mm to 0.6 mm in size; much of the quartz is strained. Ilmenite occurs in narrow bands which reflect the original bedding. The ilmenite is rimmed by sphene and commonly altered to leucoxene. Epidote is pale yellow-green, distinctly pleochroic, and arranged in bands. Allanite is common to many of the specimens of epidote quartzite and occurs as separate crystals or as overgrowths on epidote. Clinozoisite, a variety of epidote which is low in iron, is associated with allanite and epidote in some of the specimens.

Another variety of epidote quartzite contains approximately 10% pale green actinolite which occurs as parallel, discontinuous, prismatic crystals throughout the rock, but with a higher concentration in the epidote bands.

Muscovite, in varying amounts, is common in much of the epidote quartzite. It is a late growth which usually is arranged parallel to the bedding but in one specimen is at 30° to the bedding.

Feldspar is present in small amounts in all the thin-sections. It varies considerably in composition, occurring as fresh oligoclase, saussuritized plagioclase, fresh perthite which replaces plagioclase, and sericitized potassium feldspar. Chlorite occurs as an alteration of biotite and is present in most thin-sections.

Hornblende Quartzite

A variety of Wakeham quartzite in which hornblende is prominent is associated with kyanite schist south of Lake Gallienne and interbedded with white quartzite and quartz-mica schist along the northern boundary of the area at longitude 62°25'W.

The rock is coarse grained and distinctly bedded. The bedding consists of quartz-rich bands approximately 1/10 inch thick which alternate with beds up to 1-½ inches thick in which amphibole crystals up to 3/4 inch long occur. There is no preferred orientation of the amphibole either in outcrop or in thin-section.

In thin-section, the rock consists of a granoblastic aggregate of quartz with minor amounts of saussuritized plagioclase. Ilmenite and golden brown rutile are important accessory minerals and occur in narrow bands. Garnet porphyroblasts up to 0.6 mm in diameter are scattered throughout the rock.

The amphibole is a bluish green to green, pleochroic hornblende. It occurs as poikiloblastic crystals that enclose quartz, rutile, and ilmenite, and grow across the garnet porphyroblasts. Poikiloblastic chlorite is the result of retrogressive metamorphism of an earlier mineral; it is not an alteration of hornblende, which grows across the patches of chlorite. Epidote with a pale brown allanite core is scattered throughout the rock. Pronounced pleochroic halos surround the epidote-allanite where it occurs in chlorite.

Conglomerates

Most of the conglomerate occurs within the main schist area. Four exposures were observed on the shores of the lake immediately to the north of Lake Auger, and the same conglomerate horizon is exposed 1-3/4 miles north of the unnamed lake. Isolated exposures of conglomerate are found along the northern boundary of the area ½ mile east of Nabisipi river, on the shore of the small lake south of Lake Gallienne, and as a small bed 2 miles west of Nabisipi river, in the large, foliated, gabbro body. Two additional exposures of conglomerate-appearing rock, which are described with the gneisses, occur in the Aguanish part of the area as small schistose bands in gneissic granite.

The beds of conglomerate exposed on the lake north of Lake Auger are up to 10 feet thick. They are interbedded with gray micaceous quartzite and quartz-mica schist. The conglomerate consists of pebbles and cobbles of white quartzite ranging in size from 1/5 by 1/5 x 1/2 inch to 4 by 6 inches.

The matrix of the conglomerate usually appears massive in hand specimens but has a microscopic schistosity. It consists of fine-grained granulose quartz and schistose bands. Quartz biotite, muscovite and chlorite (as an alteration of biotite) are not dominant constituents. Perthitic feldspar occurs in one of the specimens and saussuritized plagioclase in another. Accessory minerals are zircon and opaque. Epidote occurs in two thin-sections. In a specimen from the northern boundary of the area east of Nabisipi river, a secondary schistosity at 90° to the primary foliation has been produced by the recrystallization of biotite.

The pebbles and cobbles of the conglomerate are flattened in the plane of foliation. They consist of the white, calcareous, and epidote varieties of quartzite.

INTRUSIVE ROCKS

Gabbros and Derived Rocks

General Statement

Massive and foliated gabbros form a large part of the rocks exposed in the area. In the northwestern third of the area they constitute almost a third of the section. Individual sills of gabbros in the Wakeham Group range from a few feet to more than a mile wide, and they vary greatly in length. The sill along the western shore of Holt lake extends to the St. Lawrence River - 18 miles south of the area (Blais, 1955; Cooper, 1957). This sill also continues 2 miles to the northwest of the area (Grenier, 1957) and beyond for an unknown distance in unmapped territory. Many of the sills are continuous throughout the map-area. Other sills, however, are less than ¼ mile long. Most of the gabbro bodies are concordant with the sedimentary rocks although several cut the bedding at a small angle.

Gabbro also occurs as a set of late dikes which vary in thickness from 3/4 inch to 40 feet, and which cut the Lake Gallienne granite stock and the older gabbro sills and the granite north of Coin lake.

Within the area of paragneisses and granitic gneisses massive and foliated gabbros form sills, dikes, and irregular bodies. Small dikes of gabbro cut earlier gabbro sills on the shores of Quatres and

Outardes lakes.

The composition and texture of the gabbros varies to such an extent within individual masses and from mass to mass that a rigid separation could not be attempted in the field on the scale of mapping. The main types are described here of mapping.

Olivine Gabbro

Fresh olivine gabbro was recognized at only one locality, one mile northwest of Lake Sylvestre. Where a small sill cuts augen gneiss and paragneisses. The olivine gabbro is similar in texture to the pyroxene gabbros and hornblende gabbros and it is possible that other exposures of the olivine gabbro exist in the area but have been mapped with altered varieties.

The olivine gabbro is massive, medium-grained, ophitic, dark brownish black, and light buff to dark rust weathering. It consists of:

	per cent
plagioclase	59.9
olivine	4.5
pyroxene	19.9
chlorite	5.5
biotite	7.7
accessory minerals	2.5 (ilmenite, zircon, apatite).

The olivine occurs as rounded grains and elongated up to 1.4 mm long anhedral crystals. It is surrounded by plates of pyroxene in kelyphitic rims consisting of an inner band of a colorless mineral (probably enstatite or hypersthene) and an outer rim of pale green, pleochroic chlorite. The olivine is biaxial negative. Numerous fractures in the olivine contain magnetite and ilmenite.

Pyroxene (augite) is lightly pleochroic from pale green to brownish purple and commonly has rims of colorless amphibole. It has been deformed and shows pronounced undulatory extinction. It occurs as subhedral crystals enclosing plagioclase. Much of it is altered along its margins to biotite or chlorite.

Reddish brown biotite occurs as small radiating crystals surrounding magnetite-ilmenite, as flakes up to 2.3 mm long which enclose patches of opaque ore minerals, and as pseudomorphs of pyroxene. It has been fractured and has undulatory extinction. Pale green chlorite occurs as small acicular crystals forming the outer margins of the kelyphitic rims which surround olivine. This chlorite represents a lower-grade alteration of amphibole. Chlorite has also formed as an alteration of biotite and as a patchy alteration of pyroxene.

The plagioclase (An 5-2) is in prismatic crystals up to 2.6 mm long (average 1.3 mm). It has a random orientation, and where in contact with pyroxene the boundaries are sharp but where in biotite or chlorite the boundaries are ragged, suggesting that the plagioclase has reacted with the pyroxene to form an amphibole which has been altered to mica or chlorite. The laths of plagioclase have undulose extinction and have been bent.

The opaque minerals, ilmenite and magnetite, occur as fracture fillings in the olivine and as large irregular patches up to 2.6 mm long. They are usually surrounded by rims of biotite and some have the form of pyroxene crystals. Apatite forms prismatic crystals a fraction of a mm thick and up to 1 mm long. Small zircons surrounded by dark pleochroic halos occur in the biotite.

A compact, pleochroic, yellow to brown mineral (bowlingite?) with high birefringence occurs as an alteration along fractures in olivine.

A mass of small colorless crystals (amphibole?) was observed as rims around biotite and as patches which have the outline of pyroxene crystals.

Hypersthene Gabbro

In hand specimen the hypersthene gabbros are similar to the olivine gabbro in texture and color. The ophitic texture is pronounced in both hand specimens and thin-sections. Crystal boundaries between the plagioclase and ferromagnesian minerals are not, however, as well defined as in the olivine gabbro. Plagioclase, which shows varying degrees of metamorphic clouding and has a pronounced undulatory extinction, ranges in composition from An_{30} to An_{39} with an average of An_{36} for the six thin-sections examined. The average length of the lath-sphaped crystals of plagioclase is 1.3 mm but crystals up to 7.0 mm occur. Some granulation and recrystallization of the plagioclase has occurred.

Hypersthene (pleochroic from pale green to pale pink) and augite have rims of deep green, pleochroic hornblende, or remain as patches in hornblende. The hornblende and pyroxenes enclose laths of plagioclase and retain the ophitic texture. Patches and small vermicular forms of hornblende occur within recrystallized plagioclase, and hornblende occurs as small ragged crystals that extend from the pyroxenes into the plagioclase.

Ilmenite forms black irregular patches within the hornblende. Much of is surrounded by a rim of deep reddish brown biotite. Ilmenite also occurs as dusty inclusions within hornblende and be distributed evenly throughout or occur as fine rows parallel to the hornblende cleavage.

Biotite occurs as patches within amphibole crystals or as distinct flakes that have the form of pyroxene. Apatite forms short irregular crystals, or prismatic crystals up to 1.27 mm long.

In the uralitization of the pyroxenes quartz is released and forms small vermicular and rounded grains within hornblende, or small irregular crystals between laths of plagioclase. Garnet may be present as a minor accessory mineral. It forms small subhedral and anhedral pale pink crystals up to 0.27 mm in diameter, and is believed have been produced by metamorphism.

With increasing alteration of the hypersthene gabbros the feldspar becomes more highly altered and more sodic in composition. The plagioclase, although retaining its lath-sphaped habit with a random orientation, partly recrystallizes into polygonal grains which enclose patches and small euthedral crystals of pyroxene and amphibole. The ferromagnesian minerals become more rugged in appearance.

Hypersthene and augite alter along their margins and fractures to hornblende, pale green actinolite, or colorless tremolite. The amphibole crystals project into the surrounding plagioclase. Quartz occurs as small anhedral grains between plagioclase crystals.

With further increase in metamorphism the pyroxenes and amphiboles lose their euhedral form and become granular, and, although the areas of ferromagnesian mineral retain the ophitic texture of the rock, the margins become ragged. Hornblende largely replaces the pyroxenes and projects into the plagioclase. Pale green serpentine (antigorite) occurs as an alteration of hypersthene. It surrounds the small rounded grains of pyroxene and fills fractures. Biotite increases in amount and has a tendency to form parallel orientated crystals.

The plagioclase becomes more highly sericitized and contains inclusions of hornblende and biotite and may be marginally altered to a more sodic plagioclase. The unorientated, lath-shaped form of the plagioclase persists but there is an increase in the amount of granular plagioclase. Commonly there is a later development of hornblende which forms prismatic crystals that are up to 1.3 mm long and which cut across the granular areas of earlier formed uralitic hornblende and biotite and the laths of feldspar.

This rock along the east shore of Vigneault lake consists of:

	per cent
plagioclase (An_{35})	32.7
hornblende	39.1
hypersthene augite	3.0
biotite	15.6
quartz	4.5
ilmenite	4.3
accessory minerals	0.8 (zircon, sphene, apatite)

Ilmenite forms irregular patches surrounded by hornblende and biotite. It also occurs as fine dusty rows along the cleavages in hornblende and has been produced by the uralitization of pyroxene.

Quartz and polygonal grains of plagioclase occur between prismatic crystals of plagioclase.

Hypersthene gabbro forms the falls at the mouth of Aguanus river and is well exposed along the western end of the falls. The rock is thought to represent a thermally metamorphosed variety of the uralitic gabbro described above. The source of thermal metamorphism was possibly from the intrusion of gneissic granite with augen facies that cuts banded granite gneiss along the east side of the mouth of the river.

In both the hand specimen and thin-section the ophitic texture is readily apparent. Laths of slightly clouded plagioclase (An_{48}) are enclosed in plates of pyroxene and granular masses of hornblende, biotite, and ore. There has been a certain amount of reaction between the plagioclase and the ferromagnesian minerals. Small prismatic crystals of dark green hornblende, colorless augite, pale green to pale pink hypersthene, and biotite occur within plagioclase crystals and along cleavages in the plagioclase. Areas of small polygonal and vermicular forms of hypersthene and augite occur as a corona structure in plagioclase surrounding augite and hornblende and as triangular patches between plagioclase laths. These areas are believed to represent recrystallized corona structures in a deuterically altered olivine or hypersthene gabbro.

The plagioclase occurs mainly as lath-shaped crystals up to 3.8 mm long (average 1.4 mm) which have a random orientation. Margins of the plagioclase are rarely straight and well defined as the ferromagnesian minerals project into the plagioclase and adjacent plagioclase crystals normally have reacted with each other producing a dentate boundary. Areas of polygonal-shaped untwinned plagioclase have been produced. The polygonal grains average 0.2 mm in diameter. The lath-shaped plagioclase has been strained, shows pronounced undulatory extinction, and contains patches which have been altered to sericite.

Corona structures in the areas of pyroxenes and amphiboles are still preserved. They consist of irregular patches of solid or dusty ilmenite which are surrounded by an inner rim of granular hypershene and/or augite and an outer rim of granular, deep green hornblende, or an inner core of biotite surrounding opaque minerals and an outer rim of hornblende. Other corona structures consist of granular, hypersthene and augite with no iron ore and an outer rim of hornblende. Ilmenite also occurs as patches with the form of pyroxene crystals.

Hornblende occurs as an alteration around the margins and along the cleavages and fractures in pyroxene - a feature of regional metamorphism in the amphibolite facies. An additional feature, however, that indicates the thermal metamorphism of the rock is the presence of small polygonal grains of hypersthene which occurs as an alteration of the augite. Part of the augite has a normal rim of hornblende and contains hornblende along the fractures, while the rest of the crystal is surrounded by pale green to pink, pleochroic hypersthene.

Accessory apatite occurs as short euhedral grains and as prismatic crystals up to 1 mm long.

Biotite occurs as an alteration of hornblende. It is pleochroic from yellow to yellow-brown. The biotite that occurs in the corona structures is a medium to dark reddish brown.

The ophitic texture of an altered hypersthene may be retained by the form and distribution of the mafic minerals and the plagioclase. Hypersthene occurs as small anhedral grains distributed in granular plagioclase. Some of the hornblende which replaces pyroxene has the form and distribution of the original pyroxenes. The granular plagioclase, also, is distributed in lath-shaped patches of the original ophitic gabbro. Reddish-brown biotite occurs in patches within the hornblende. The biotite may have a core of ilmenite and is commonly arranged in parallel flakes.

Large plates of deep green hornblende (up to 5.0 mm long) replaces original pyroxenes. The hornblende has been partly altered to chlorite and has a later development of hornblende which cuts the earlier variety.

Quartz forms polygonal grains which average 0.6 mm in diameter within the granular areas of plagioclase.

Hornblende Gabbro

Hornblende gabbros form a large part of the basic intrusives in the area. In many of the coarser-grained varieties the rock has an ophitic texture which may be seen in hand specimens. In some places the hornblende gabbros have yielded to shearing stresses and have become foliated gabbros (ortho-amphibolites) or schistose. No rigid line of demarcation can be drawn between the various types. The change from a massive gabbro, in which the ophitic texture is well preserved, to schists and hybrid rocks in which the ophitic texture is partly or completely destroyed may be gradual or it may be abrupt enough to be seen in a hand specimen. All stages of the alteration of the massive ophitic gabbro to a schistose variety have been traced under the microscope from specimens collected throughout the area.

Included in the following descriptions of hornblende gabbros are the basic dikes which cut the Lake Gallienne granite stock. They show similar composition and variations in texture as the older gabbros. It is possible also that some of the gabbros in the Grenville gneisses are of the same age as the late Lake Gallienne gabbro dikes as basic dikes were observed cutting gabbro sills in paragneisses and mixed granitic gneisses and granite along the shores of Coin lake.

In the hornblende gabbros in which a relic ophitic texture is still evident varying amounts of reaction took place between the plagioclase and amphibole. Grain boundaries are rarely straight and well defined but are usually serrated with amphibole crystals projecting into the laths of feldspar. The amphibole is usually normal hornblende which usually contains dusty inclusions of iron oxides which may be distributed evenly throughout the amphibole crystal or occur along cleavages and fractures. The iron oxides (ilmenite and magnetite) within amphibole are the result of complete uralitization of a pyroxene. The iron oxides vary considerably in form within a single thin section. Where the oxides occur as irregular patches and blebs up to 0.5 mm across they are normally surrounded by reddish-brown biotite, which may may be a radiating structure or be of random orientation.

The plagioclase of the hornblende gabbros when not completely saussuritized ranges from An_{28} to An_{37} with an average of An_{34}. All the plagioclase in the thin-sections examined shows some metamorphic clouding which usually increases as the ophitic texture is destroyed. The plagioclase in the least altered types is generally in lath-shaped crystals but a little occurs whith quartz as polygonal grains which are distributed in lath-shaped areas of former single crystals.

In the hornblende gabbros the ferromagnesian minerals consists usually of normal hornblende. In some thin-sections, however, amphiboles of varying composition are present. In the uralitization of the pyroxene gabbro, the ferromagnesian minerals have reacted with the plagioclase to produce a zoned amphibole with a pale to medium green hornblende core and dark green hornblende margins. Occassionaly, also, the margins of a normal hornblende may consist of a bluish green amphibole and in certain of the more highly altered varieties all the amphibole is bluish green.

Actinolite occurs in several of the thin-sections as an alteration of pyroxene. It occurs as long fibrous crystals which enclose biotite and unorientated laths of plagioclase.

In the more altered varieties of hornblende gabbro the ophitic texture may be preserved by unoriented plagioclase crystals which are surrounded by granular amphiboles or by the amphiboles which enclose lath-shaped areas of granular plagioclase.

With increasing alteration and stress the hornblende alters to biotite and chlorite or may recrystallize into poikiloblastic forms enclosing opaque ore minerals and plagioclase. The micaceous minerals assume a parallel orientation and the rock becomes a biotite amphibolite in texture and composition.

Placioclase recrystallizes into short irregular grains which enclose hornblende and the ophitic texture largely disappears. With recrystallization of the saussuritized plagioclase, epidote forms subhedral grains up to 0.27 mm long. Epidote may also occur as segregations filling small fractures in the rock. Zoisite crystals are roughly perpendicular to the walls of the fracture forming a comb structure.

Where stress has been a factor in the alteration of hornblende gabbro the rock tends to become equigranular although in parts of the thin-sections the prismatic crystal form of the plagioclase may persist. Also in the rock is an abundance of sphene which occurs in irregular patches up to 2.6 mm across, or in circular areas intergrown with hornblende. The sphene contains a large number of ilmenite inclusions.

Modal analyses of four thin-sections of hornblende gabbro follow:

	(1)	(2)	(3)	(4)
	per cent	per cent	per cent	per cent
plagioclase	(An_{28})29.40	(An_{37})31.22	(An_{28})29.40	An_{33}(15.0)
hornblende	63.1	62.33	67.0	60.5
biotite	tr.	2.86	tr.	4.7
sphene	4.45	2.93	-	-
quartz	1.45	-	1.10	6.1
ilmenite	0.80	0.06	0.90	12.2
accessories	0.80 (apatite zircon allanite)	0.60 (epidote)	tr. (apatite zircon chlorite)	1.5 (apatite epidote allanite)

(1) 1 mile west of Michaud lake in area of gneissic granite

(2) north shore of Coin lake; cutting massive granite

(3) 1 mile southwest of Sylvestre lake in area of gneissic granite

(4) 1800 feet east of Rochette lake in area of augen gneiss.

Pegmatitic Gabbro

Pegmatitic gabbros of the hornblende gabbro type are seattered throughout the area. Most of them cut granitic gneisses in the southern and eastern parts of the area but very coarse-grained gabbro sills occur in the Wakeham Group 300 feet east of Watshishu lake an altered pegmatitic gabbro is found on the western shore of Watshishu lake and near the eastern border of the main area of Wakeham sedimentary rocks.

A relic ophitic texture is apparent in the least altered varieties. Laths of white to cream plagioclase up to 1 inch long are enclosed in greenish black amphibole. The rock has a greenish black to rusty weathered surface and both fresh and weathered surfaces are spotted.

In thin-section, the plagioclase occassionally remains as prismatic crystals up to 1 cm long. It usually has been recrystallized into polygonal grains that are distributed in lath-shaped areas within the amphibole. The plagioclase in the least altered varieties is oligoclase which has been altered to sericite with minor amounts of epidote minerals. In the more altered varieties the plagioclase is albite almost completely altered to saussurite.

The ferromagnesian minerals consist mainly of deep green hornblende which has resulted from the complete uralitization of pyroxene. Ilmenite, which may be rimmed by sphene, occassionally has the form of pyroxene crystals or, more commonly, occurs as irregular black areas. Ilmenite also frequently forms narrow blebs and patches which are in the amphiboles and follow the cleavage of former pyroxenes.

In the pegmatitic gabbro at the western boundary of the area on the shore of Watshishu lake, the amphibole has been completely altered to pale green chlorite with a minor amount of biotite. The biotite and chlorite occur in patches and as small crystals within altered, lath-shaped crystals of plagioclase.

The pegmatitic gabbro within the main Wakeham Group area contains considerable calcite, but there is only a minor amount in the pegmatitic gabbro from the areas of gneisses. The calcite forms irregular crystals within hornblende and euhedral crystals that may partly or almost completely replace plagioclase. The calcite-rich pegmatitic gabbros have a deeply-pitted weathered surface.

In the least altered of the hornblende pegmatitic gabbros quartz occurs as small irregular grains within the amphibole; in the more recrystallized and altered varieties quartz and plagioclase form equigranular areas.

Apatite and zircon are accessory minerals common to all the pegmatitic gabbros. Allanite occurs in some of the specimens that contain epidote. A few crystals of dark blue to buff, pleochroic tourmaline (schorlite) occur in the pegmatitic gabbro along the western boundary of the area.

Amphibolite

Amphibolites occur throughout the area and form major rock units in the Grenville-type gneisses. Most have evolved from gabbroic rocks but amphibolites which are interbanded with paragneisses may represent metamorphosed impure, calcareous beds. However, such bands do not show any mineralogical orientation from the types derived from gabbro.

The amphibolites are foliated rocks consisting essentialy of hornblende and plagioclase. Foliation is not evident in varieties that contain little or no mica although in thin-section there is usually a preferred orientation of hornblende. Segregation layers and lenses are present in some of the amphibolite.

In thin-sections that are free of biotite the hornblende is strongly colored. It occurs as subhedral prisms with ragged crystal boundaries and contains inclusions of ilmenite, plagioclase, and apatite. The plagioclase has been recrystallized to equant, anhedral grains and altered to saussurite. Chlorite occurs in hornblende where the rock has been fractured. A deep yellowish green to colorless, pleochroic epidote occurs as fracture fillings. There is a slight preferred orientation of the amphibole.

In amphibolites that contain a small amount of biotite the texture is similar. Biotite, however, shows a pronounced parallelism. Quartz, which is absent in the biotite-free variety, occurs as small rounded grains within the hornblende. Plagioclase, which has not been completely saussuritized, shows twin lamellae and is andesine. The rock consists of plagioclase - 48.0%, hornblende - 41.6%, quartz - 2.4%, reddish-brown biotite - 5.6%, ilmenite - 1.6%, and apatite - 0.8%.

Sphene occurs as wedge-shaped crystals in the biotite amphibolites and epidote may be present as deep yellow prisms. Garnet is not a common accessory mineral but above the third falls (from the mouth) of Aguanus river fractured euhedral garnets up to ½ inch in diameter occur within a highly foliated biotite amphibolite. No garnet was observed in the thin-section. This foliated amphibolite consists of plagioclase (An 29), 39.6%; hornblende, 24.8%; biotite 26.6%; quartz 2.4%; ilmenite and sphene, 6.2%; apatite and zircon, 0.4%.

Amphibolites from the southern part of the area have the following compositions:

	(1)	(2)	(3)
plagioclase	An36 50%	oligoclase 29%	An30 58.5%
quartz	1.2	1.4	-
chlorite	-	-	3.6
hornblende	22.4	41.0	26.3
biotite	26.0	21.4	-
ilmenite	-	-	2.8
accessoiries	0.4 (ilmenite sphene zircon allanite apatite)	2.8 (ilmenite apatite zircon)	2.8 (epidote zoisite apatite zircon)

(1) Isolated exposure in gneissic granite

(2) Dike 10 feet wide cutting granite gneiss

(3) Sill 11 feet thick in gneissic granite.

Epidote Amphibolite

Epidote amphibolite occurs as sills within the sedimentary rocks of the Wakeham Group and within the granitic gneisses and epidote forms prismatic crystals and anhedral grains up to 0.6 mm. long. Although some of the epidote has been formed by the saussuritization of plagioclase much of it is thought to have been formed by the metamorphism of an original calcareous sediment or the epidotization of a basic intrusive rock.

In only one of the thin-sections examined is there a suggestion of an ophitic texture. This rock occurs within sedimentary Wakeham schists southeast of Auger lake. It is medium grained, dark gray, that weathers dark rust. On the fresh surface lath-shaped feldspar-epidote patches up to 1/5 inch long are distributed in a random pattern throughout a dark gray amphibole groundmass. In thin-section, the lath-shaped areas consist of saussuritized plagioclase which has been partly or completely replaced by a colorless to yellow, highly pleochroic epidote.

The hornblende occurs as prismatic crystals with ragged margins and as small prismatic crystals within plagioclase. The plagioclase also contains inclusions of ilmenite, many of which are surrounded by rims of sphene.

Epidote amphibolite occurs near the southern boundary of the northwestern third of the area, within the large foliated gabbro sill that extends into the area from the south. It is dark greenish black, medium-grained, foliated, and has a pitted, rusty weathered surface. Epidote is distributed throughout the rock and is concentrated into epidote-rich bands 1 inch thick that parallel the foliation of the rock.

In thin-section, the foliation is seen to consist of a parallel arrangement of prismatic crystals of amphibole up to 2.6 mm long. The rest of the rock consists mainly of equal amounts of granular saussuritized plagioclase and a deep greenish yellow, pleochroic epidote. The epidote is in rounded and subhedral grains with a few prismatic crystals that parallel the foliation. Irregular grains of ilmenite, ilmenite with coronas of sphene, and wedge-shaped sphene occur in narrow bands that parallel the foliation.

Epidote amphibolite, in which the amphibole has been completely altered to chlorite, occurs up Aguanus river between the third and fourth falls as part of an exposure of hornblende gabbro. This amphibolite is a massive, medium-grained, dark greenish black rock in hand specimen, but in thin-section a tendency of the chlorite to assume a preferred orientation is observed. The chlorite is pennine (anomalous blue briefringence). It occurs a prismatic crystals with ragged ends and replaces an amphibole. In parts of the thin-section its forms radiating crystals with a center of quartz of ilmenite and sphene.

Quartz, forming approximately 20% of the rock, occurs as anhedral crystals that average 1.2 mm in diameter. It has been fractured and recrystallized and has a pronounced undulatory extinction. In parts of the thin-section the quartz has been recrystallized along fractures and cleavages in the chlorite, and occassionally it has recrystallized in radial forms.

Epidote minerals are enclosed within the quartz and chlorite and consist of yellow, pleochroic epidote and colorless clinozoisite. They form prismatic crystals that average 0.25 mm long.

Opaque patches consisting of a mixture of ilmenite, rutile and sphene are scattered through the rock. Cloudy untwinned plagioclase (oligoclase) forms about 5% of the rock. Apatite is an accessory mineral.

Granitic Intrusive Rocks

Gneissic Granite with Augen Facies

Gneissic granite is extensively developed in the eastern and southern thirds of the Lake Michaud area. With its associated augen facies, which is best displayed along the coast at Aguanish and Michon villages, it forms the most common rock unit in the southern third of the area. Gneissic granite also forms moderate-sized bodies surrounding Lake Quatres.

The gneissic granite is medium grained and has a well developed gneissosity consisting of alternating, granulose, quartz-feldspar bands and fine seams and streaks of biotite. It generally is medium pinkish gray to salmon pink.

The thin-sections of gneissic granite show that there is a considerable variation in the proportion of minerals present and in the grain size. The following composition is given by a thin-section of pinkish gray gneissic granite grading into augen granite at Aguanish village.

	per cent
oligoclase	31.7
potash feldspar	32.2
quartz	32.0
biotite chlorite	1.8
hornblende	0.4
ilmenite, sphene, zircon, allanite	1.9

Plagioclase occurs as euhedral and subhedral crystals which average 1.0 mm long. The potash feldspar is microcline with a small amount of microperthite, and forms subhedral and anhedral crystals averaging 2.2 mm long. It encloses small rounded crystals of quartz and plagioclase. Myrmekite is common in the plagioclase. The plagioclase has been more highly saussuritized in the centers of the crystals and along fractures. Clear sodic feldspar rims the plagioclase. The quartz is in irregular grains which enclose small crystals of microcline, plagioclase, and biotite. Dark brown biotite partly altered to chlorite, forms a narrow band. Some of the biotite has formed poikiloblastic crystals up to 2.6 mm long which enclose quartz and feldspar grains. Ilmenite forms a network of fine seams at quartz and feldspar grain boundaries, and also occurs as rounded grains which are rimmed by sphene.

In many places the gneissic granite has an augen texture, and this displays considerable variation in texture and mineralogical composition. In thin-section, the augen are up to 13 mm long and consist largely of microcline which contains irregular patches of highly saussuritized plagioclase and irregular areas of quartz. Some of the plagioclase and irregular areas of quartz. Some of the plagioclase has not been replaced by microcline and contains small prismatic crystals of epidote.

The groundmass of the augen granite consists of medium-grained quartz saussuritized plagioclase, and a little biotite and chlorite. The micaceous and epidote minerals form small lenses and patches which curve around the porphyroblasts. Much of the epidote has cores of allanite.

The composition of a specimen of augen granite as determined by modal analysis is:

	per cent
plagioclase	32.0
microcline	47.1
quartz	18.9
biotite	0.1
pennine	1.3
epidote, allanite ilmenite, sphene, zircon.	0.6

Much of the gneissic granite in the southern third of the area contains hornblende. A modal analysis of a typical specimen along Aguanus river at latitude 50°21.8'N. shows a hornblende content of 6.4%.

Augen gneissic granite from the northern part of the area contains up to 15% chlorite (pennine), which is associated with epidote and hornblende. The chlorite and epidote probably have resulted from the alteration of the hornblende, as in other rocks of the area.

Microperthite Granite

A medium-to coarse-grained granite characterized by abundant microperthite occurs in the southeast corner of the area. Two additional bodies of microperthite 1,000 and 1,500 feet thick respectively, granite, are found along the coast east of Michon. A narrow body occurs within banded granite gneiss on the north shore of Gal lake.

All the microperthite granites are concordant with the foliation of the surrounding paragneisses, amphibolites, and granitic gneisses. Contacts between the granite and the older rocks are largely gradational, but on an island in the southeast corner of the area granitic material increases in a basic rock across a width of 10 feet up to a sharp contact between the microperthite granite and the older granite gneiss. Also within the microperthite granite, are bands of quartz-biotite paragneiss up to 100 feet wide. Contacts between granite and paragneiss may be gradational or sharp.

The microperthite granite varies considerably in texture both within individual masses and from mass to mass. In the small stock in the southeast corner of the area the rock varies from a massive, coarse-grained granite to a gneissic, salmon-pink granite. Also present within this stock is a slightly foliated, light gray granite. Both the gray and pink varieties contain a little fluorite in the form of small anhedral crystals which are interstitial to the other minerals.

In thin-section the quartz and microperthite form irregular anhedral grains. Quartz occurs as strained grains up to 2.7 mm in diameter. The microperthite encloses quartz and plagioclase grains. It forms crystals up to 6 mm in diameter. Plagioclase generally is in anhedral grains but a few prismatic crystals up to 5.0 mm long occur. The plagioclase is albite-oligocalse (An 10). Both fresh and saussuritized plagioclase occur within the same thin-section.

The intergrown plagioclase contained within the potassium feldspar occurs as narrow lenticles or small, oval blebs which are evenly distributed throughout the microcline. Clear rims of sodic plagioclase surround the microperthite in one thin-section and abundant myrmekite occurs in the plagioclase of an other. Much of the microperthite shows a metamorphic clouding.

Reddish brown biotite is common to both the pink and the gray rocks. In the pink gneissic variety it occurs as parallel, discontinuous flakes which are concentrated in bands with the quartz and feldspars. The biotite has been slightly altered to chlorite along the cleavages. In the gray variety the biotite is distributed evenly throughout the thin-section.

Accessory minerals include topaz, fluorite, allanite, ilmenite and zircon.

A modal analysis of gray microperthite granite from the southeast corner of the area gives the following composition:

	per cent
plagioclase	9.1
microperthite	47.9
quartz	38.3
biotite	4.2
zircon, fluorite, topaz, opaques	0.5

Diorite Gneiss

In the coastal section of the area near the southeast corner diorite gneiss occurs along the western edge of a paragneiss band which is enclosed in gneissic granite. The contact between diorite gneiss and gneissic granite is gradational; that between diorite gneiss and paragneiss is not exposed. The diorite gneiss is exposed over a width of 250 feet but its length is unknown.

The rock is medium grained, black with pink feldspar crystals, and weathers dark rust. Foliation is faint although in thin-section there is a parallel arrangement of euhedral and subhedral hornblende crystals which form approximately 35% of the rock.

Plagioclase (oligoclase) is in subhedral crystals 0.6 to 2.3 mm long that have been slightly altered to saussurite and form 40% of the rock. Microperthite (25% fo the rock) is in anhedral crystals that average 1.6 mm in diameter. It encloses small rounded grains of plagioclase. The accessory minerals are apatite, allanite, epidote, zircon and pyrite. A small amount of quartz is present in the thin-section as small veinlets between hornblende and plagioclase and as a myrmekitic growth in plagioclase. Chlorite occurs as a patchy alteration along cleavages and fractures in the hornblende.

Early Granite Porphyry

Foliated, leucocratic gneiss believed to be recrystallized ryholite occurs interbanded with hornblende and biotite paragneiss at the following localities: 1,500 feet west of the Nabisipi river -lat. 50°34.6'N; on the western shore of the Nabisipi river -lat.50°35.5'N; on the western and eastern shores of Coin lake and immediately to the east of the lake. An isolated exposure within an area of gneissic granite lies between Outardes and Quatres lakes.

The rocks are light gray and weather medium to dark buff. In the least altered specimens (shores of Coin lake) phenocrysts of quartz and feldspar up to 1/10 inch in diameter are distributed in a fine-grained quartzo-feldspathic groundmass. Streaks and lenses of mafic minerals a fraction of a millimeter thick occur throughout the rock and are believed to represent an original flow structure.

In thin-section, feldspar phenocrysts are subrounded to subangular in form and range from 1 mm to 2.6 mm in diameter. The feldspar phenocrysts are largely microcline-microperthite with a small amount of highly saussuritized plagioclase. Quartz forms lenticular recrystallized areas 1.1 to 3.0 mm long and 0.15 to 0.6 mm in diameter. Individual grains of quartz within the lenticular patches are subangular and average 0.2 mm in diameter or form elongated crystals up to 1.3 mm long. All the quartz is strained and has undulatory extinction. In the recrystallization of the lenticules the quartz has recrystallized with the quartz of the groundmass so that the margins of the lenticles are irregular.

Discontinuous streaks, consisting largely of greenish brown biotite with a little pale yellowish green, pleochroic epidote (some of which contains cores of allanite), wrap around the feldspar phenocrystas and the quartz lenticles. Most of the biotite is in flakes which average 0.1 mm long but some of it forms poikiloblastic crystals up to 1.3 mm long. In the least altered rhyolite several poikiloblastic crystals of fluish green hornblende occur within the streaks of biotite. Minor accessory minerals include ilmenite, sphene, zircon, and apatite.

In the more altered rocks of this type some of the phenocrysts have been recrystallized into an equigranular aggregate carrying small inclusions of biotite and hornblende. Plagioclase (oligoclase) has been saussuritized. Epidote has been produced in the saussuritization of the plagioclase. It also occurs in areas of biotite in the groundmass where it may contain a core of allanite. Sphene, an important accessory mineral, forms rounded grains up to 0.3 mm in diameter, and as well as rims around the opaque minerals. Other accessory minerals are apatite and zircon. With increasing alteration, the grain size of the groundmass increases and the phenocrysts become granulated.

Massive Granite

Granite that is massive and has cross-cutting relationships forms small elongated and oval bodies in the eastern and southern parts of the area. The individual masses are rarely exposed over an area greater than 2 square miles. Dikes of massive granite cut the older granitic gneisses, gabbros, and paragneisses. The massive granite south of Lake Michaud grades into coarse-grained pegmatitic granite. The massive granite in the southern part of the area is a facies of gneissic granite and augen granite.

The massive granites are medium grained and vary from light pink to a deep pink. Although the composition of particular specimens shows a considerable range, the average modal composition of a number of massives granites is that of adamellite (quartz monzonite):

	per cent
plagioclase	37.35
potash feldspar	35.55
quartz	27.77
mafic minerals	1.69
accessory minerals	0.64

The plagioclase of the massive granite varies from albite oligoclase to basic oligoclase (An_{28}). It generally shows some saussuritization. Potash feldspar is fresh perthitic microcline and commonly.

The mafic minerals of the granites consists mainly of biotite which has been partly altered to chlorite (pennine) and muscovite. Two thin-sections contain hornblende partly altered to chlorite and biotite. The accessory minerals are opaque iron ores, rutile, zircon, apatite, and allanite.

Pink biotite granite occupies an area of approximately 30 square miles surrounding Lake Gallienne in the northwestern part of the area. A sill of silimar granite 8,000 feet long and 400 feet wide cuts the quartzites and schists of the Wakeham Group 5,500 feet southwest of the main mass. The granite contains xenoliths of quartzites, sedimentary schists and gabbro. The Lake Gallienne granite is cut by a series of later gabbro dikes ranging in thickness from 1½ feet to 100 or more feet.

The granite is medium to dark pink and westhers light pink to dark rust. It is medium to coarse grained and varies from a massive rock to one with ill-defined gneissosity (produced by the segregation of biotite) to one in which the gneissosity is pronounced. Locally the granite is porphyritic with feldspar phenocrysts up to 3/4 inch in diameter.

Late Granite Porphyry

A thin sill of dark pink granite porphyry cuts the large, foliated gabbro sill that extends into the area from the south. It is approximately 2 miles west of Nabisipi river between latitudes $50^{o}32.4'$ N. and $50^{o}35.0'$N. Granite porphyry is also exposed 5½ miles to the north and probably represents an extension of the same sill. The granite porphyry cuts quartzites, sedimentary schists, gabbros, and gneisses and is believed to be one of the youngest intrusive rocks of the area.

Pink and white phenocrysts of feldspar and glassy phenocrysts of quartz range in size from sub-microscopic to 1/5 inch long. The phenocrysts are usually oval. The groundmass of the porphyry is medium to dark gray and individual crystals cannot be recognized in the hand specimen. Most samples show a foliation which is thought to be original flow structure modified and accentuated by a later schistosity which has been superimposed parallel to the original foliation.

In thin-section the groundmass in seen to consist of an equigranular mosaic of feldspar and quartz in which the grains average 0.05 mm in diameter. Greenish brown biotite is an important constituent of the groundmass. It occurs as narrow bands and lenticles that curve around the phenocrysts or are scattered throughout the groundmass. Sphene, ilmenite, zircon, and apatite are accessory minerals common to all the thin-sections.

Pegmatite

There is abundant evidence in the area of two ages of pegmatites, which are believed to have been largely produced during the migmatization of rocks in the eastern and southern parts of the area, occur as narrow bands and lenses which are generally parallel to the foliation of the gneisses, although cross-cutting pegmatites are common. Much of the older pegmatite is believed to be of the replacement type. The bands and lenses of pegmatitic material may have sharp contacts with the older gneisses but when traced along the strike they feather out into the surrounding gneisses in many cases. Also, the pegmatite may pinch and swell along strike.

The later pegmatites cut across the older pegmatites and the other rocks. They also occur as narrow sills in the late granite and may form large lenticular bodies parallel to the trends of the older rocks. The late, massive to slightly foliated granite grades in a few places from medium-grained into a coarse-grained pegmatitic granite.

An examination of both the field occurrences and thin-sections of the pegmatites shows a considerable variation in the proportions of quartz and feldspars. They vary from coarse-grained, massive rocks, in which microcline may form euhedral crystals up to 2/5 inch long, to very coarse-grained rocks with feldspar crystals up to 2 or more inches long.

Muscovite occurs in the thin-sections as an alteration along fractures in the feldspars, and along cleavages and margins of biotite.

A pegmatite dike 3 feet wide that occurs along the eastern side of the southern bay of Baies lake contains beryl crystals up to 9/10 inch across and 3 inches long. The beryl crystals occur over a length of 100 feet, but are not numerous. This same pegmatite contains a few flakes of molybdenite and rare garnet. Molybdenite also occurs sparingly within the pegmatitic granites south of Lake Michaud. The molybdenite forms hexagonal plates up to 1 inch in diameter. Euhedral garnets are common in the older pegmatites along the coast. They occur both within the pegmatite and as concentrations in the pagmatite-paragneiss margins. Magnetite is also common in the pegmatites.

Aplite

Bands of aplitic granite form a prominent part of the banded granitic gneisses. The linear persistence of the aplitic element is variable. Some are continuous over long distances while others lens out or break up into a number of thin filaments within a short distance. The aplite occurring within the granitic gneisses is believed to be (as are the early pegmatites) partly of replacement origin and to have been formed during the migmatization of the older rocks. Aplite also occurs as narrow sills and dikes cutting the gneissic and massive granite.

Many of the replacive aplites have an ill-defined foliation shown by the parallel orientation of biotite flakes, which are distributed evenly throughout the rock and not confined to schistose bands. The average grain size of the quartz and feldspar grains is 0.55 mm.

A thin-section study of the various aplites shows a similar composition but a variation in the proportions of minerals present.

The plagioclase (An_{11}) has been slightly altered to saussurite. The potassium feldspar is microcline with a small amount of perthite. Clear albite rims formed on the oligoclase at oligoclase-microcline grain boundaries. Some of the microcline contains small rounded grains of quartz and plagioclase. The biotite has been altered to chlorite and rutile. Muscovite, where present occurs as an alteration of biotite and feldspar. Calcite is a product of saussuritization.

STRUCTURAL GEOLOGY

Folds

The Lake Michaud area is on the eastern limb of the major 'Wakeham Lake Syncline', which extends inland from the Gulf of St.Lawrence approximately 50 miles.

The interpretation of the structures of the area underlain by metasedimentaries of the Wakeham Group and the associated gabbro sills is based on the distribution and orientation of the various rock types. Cross bedding and ripple marks in the quartzites indicate that the rocks become progressively younger as the western boundary of the area is approached. However, parts of the Wakeham Group may be repeated by folding and, thus, no reliable estimate of the total thickness of the group would be warranted.

Structures in the eastern and southern parts of the area, which is underlain mainly by metasedimentary and granitic gneisses, are more complex. Interpretation of structures in the gneisses is based largely on foliation and the distribution of the various rock types.

At least three periods of folding are represented in the area.

The earliest folding trends east-west and involves the gneisses and parts of the Wakeham Group along with associated gabbros. The large anticline that curves around Lake Quatres and the anticline around the southern part of Lake Gallienne are representative of the early folding.

The early folding was followed by the intrusion of the Lake Gallienne and at least some of the other granite bodies. The intrusion of the Lake Gallienne granite displaced the east-west folds and produced contact metamorphic effects that are well displayed in the sedimentary schists south and west of Lake Gallienne.

The second phase of folding produced the most dominant structural features of the area. North-northwest to north trending folds involved the gneisses, the Wakeham Group, the gabbro sills, and the stocks.

Accompanying or closely following the main second phase of folding was the intrusion of basic dikes, which are best displayed in the Lake Gallienne granite. The basic dikes were emplaced mainly along longitudinal joints in the granite.

A late phase of folding on east-west trending axes presumably involved all the rocks of the area. The folds in granite north and south of Lake Michaud and in parts of the area underlain by sedimentary rocks and gabbros were produced by this late deformation.

Faults

No major fault zones have been recognized in the area. Faults that trend northeast were observed north of Lake Gallienne and west of Lake Mardi-Gras. A fault which appears to be present in the adjacent Pashashibou area (Blais, 1955), separating the Wakeham Group and the gneisses, is not recognized in the present area, where structural trends in the Wakeham rocks and the gneisses are parallel.

Joints

Stereographic plots of the joints from different parts of the area and from different rock types show two main sets which appear to be related to the second phase of folding.

The system of jointing in the sedimentary rocks, gabbros, and the Lake Gallienne granite in the western part of the area shows a longitudinal set with a maximum concentration at N. 10^{o}W. to north and a set of cross joints at N. 80^{o}E. to east.

The system of jointing in the gneisses and gabbros from the eastern part of the area is more complex but shows maximum concentrations that are related to the pattern in the west described above. Jointing in the granitic and metasedimentary gneisses consists of a set with a maximum concentration between north and N. 15^{o} E. and a set of cross joints with a concentration between east amd E. 15^{o} S. The jointing in the gabbros from this section consists of a set at N. 20^{o} W. and a set with a concentration between E. 20^{o} N. and E. 10^{o} S.

The system of jointing in the southern area consists of a set with a concentration between N. 5^{o}E. and N. 15^{o}E. and a set at E. 5^{o}S. to E. 15^{o}S.

Schistosity

The micaceous sedimentary rocks of the Wakeham Group have a well developed schistosity. These rocks are most common in a broad band of Wakeham rocks that trends north-northwest through Lake Auger. Micaceous schists are also interbedded with quartzites throughout the Wakeham Group. In all cases the schistosity is parallel to the bedding of the adjacent quartzites. South of Lake Auger there are several exposures in which a secondary schistosity has been produced by the growth of poikiloblastic muscovite and/or biotite. The secondary schistosity is 15^{o} to 50^{o} off the strike of the primary schistosity.

The gabbros of the area may be massive or foliated. In places shearing has been intense and the gabbro has been converted to an amphibolite or biotite schist. The trend of foliation in the gabbros is parallel to the enclosing metasedimentary rocks. In the western part of the area there is a broad transition from massive gabbros along the western boundary to schistose gabbros as the gneisses to the east are approached.

ECONOMIC GEOLOGY

Beryl

Beryl crystals up to 9/10 - inch in diameter and 3 inches in length were found in a pegmatite dike on the eastern side of the southern bay of Lake Baies. The beryl is present over a width of 3 feet and a length of 100 feet but is not abundant.

Molybdenite

Several flakes of molybdenite up to 2 inches across occur in the oval mass of pegmatitic granite southeast of Lake Michaud. Small flakes of molybdenite occur with beryl in the pegmatite dike mentioned above.

Iron Ores

Narrow 1/10 inch thick or less bands of iron ores occur in the Wakeham rocks. Small lenses of magnetic iron ore were found in the pegmatites along the coast.

Sulfides

Very small concentrations of chalcopyrite occur as veins in a few exposures of gabbro.

Disseminated pyrite occurs as small, well formed cubes in Wakeham schists and in the paragneisses along the coast. Pyrite also occurs as small veinlets in some of the gabbros.

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