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CANIMITI RIVER AREA, PONTIAC COUNTY

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Department of Mines

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GEOLOGICAL SURVEYS BRANCH

I. W. JONES, Chief

GEOLOGICAL REPORT 52

CANIMITI RIVER AREA

PONTIAC COUNTY

by

N. B. Gillies

Ministère des Richesses naturelles du Québec
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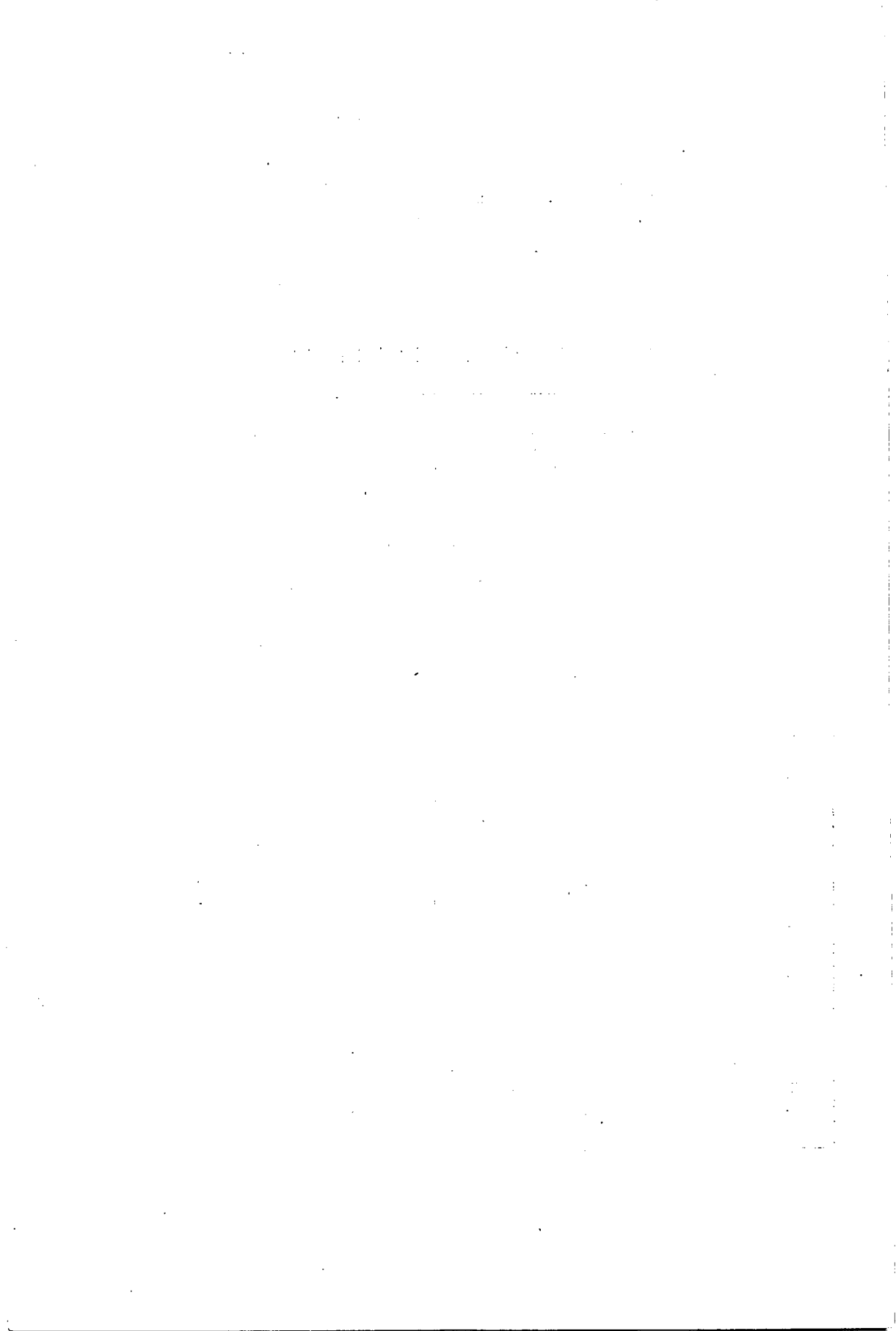


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CANIMITI RIVER AREA

PONTIAC COUNTY

by N.B. Gillies

INTRODUCTION

General Statement

The Canadian Shield is underlain predominantly by rocks of Precambrian age and contains numerous belts and isolated masses of volcanic and sedimentary origin (greenstones) in which many of the gold and base metal deposits of Canada are found. The 'greenstones' are, however, only a small part of the rocks of the Shield; large areas are gneisses and schists believed to have been formed from ancient sedimentary, volcanic, and plutonic rocks by metamorphism.

The close geographical relationship between the greenstones and many orebodies has caused the prospector to neglect or to pass hastily over the gneisses, schists, and granitic rocks, in the search for new areas of greenstone; and geological investigation has tended to be concentrated on areas of immediate economic importance. A natural result of this neglect of the complex gneisses and granites has been the development of a 'feeling' that these rocks are barren, except for such minerals as mica, feldspar, apatite, and molybdenite. Little is known about the contact zones between the Keewatin-Temiscamian volcanic and sedimentary rocks and the surrounding gneisses. No one knows whether the ore deposits stop at the contact zones; but in this respect it is of interest to note that the zinc-lead deposits of Calumet Island, Quebec, the brucite deposits of Farm Point, Quebec, the lead deposits of the Kingdon mine, Ontario, the lead-zinc deposits of Montauban, Quebec, and the zinc-lead deposits of Flin Flon, Manitoba, do not occur in 'greenstones', but are associated with Grenville-type metamorphic schists, gneisses, limestones, and quartzites.

Purpose of the Survey

The area investigated lies between the Keewatin-Temiscamian sedimentary and volcanic rocks mapped by Lowther (1936)^{*} in 1935, and the area mapped by Wahl and Osborne (1950) in 1946, containing only granites, gneisses, and schists. It was hoped that the mapping in the present, intervening area might shed some light on the ages, and on the

^{*}Year numbers within brackets refer to bibliography at end of report.

origin, of the granites and gneisses, and, possibly give some clue to the relative ages of the Keewatin-Temiscamian rocks and the Grenville rocks. It was also desired to examine the possibilities for the occurrence of metallic or other mineralization of economic interest in the area.

Extent and Location of Area

The Canimiti River area, about 200 square miles in extent, was mapped by the writer in the field season of 1947. Lying between latitudes 47°30' and 47°45' North and longitudes 77°00' and 77°15' West, it is in the northern part of Pontiac county, covering a part of the Senneterre-Mont Laurier Hunting and Fishing Reserve (La Vérendrye Park). The southeastern part of Fréville township and the southwestern part of Champron occupy a three-mile-wide strip across the northern part of the area, whose northern boundary is approximately 44 miles south of Senneterre, on the northern transcontinental line of the Canadian National Railways.

Means of Access

Highway No. 58 from Mont Laurier to Senneterre and Val d'Or passes diagonally across the southwestern part of the area. It crosses the southern boundary at a point 66 miles from Val d'Or and leaves the western boundary at 53.3 miles from that town.

A daily bus service connects the towns of Noranda, Val d'Or, and Senneterre with the cities of Montreal and Hull.

Aeroplanes on pontoons can be chartered at either Val d'Or or Senneterre for trips into those parts of the region remote from the main water routes.

Travel Within the Area

Ottawa, Chochocouane, and Canimiti rivers afford excellent canoe routes. There are numerous rapids in the two last named rivers, and in two places on Chochocouane river there are falls with drops of between 15 and 20 feet, but in most places portages have been provided and few are more than 300 yards long. Throughout its course within the map-area, Ottawa river is navigable for canoes except at one place near the mouth of Blind river.

In those parts of the area removed from the main rivers, travel by canoe is difficult because the streams are shallow, have numerous small rapids, and are often blocked with 'windfalls'; portages, where formerly provided, have long since grown over. Canoes may be

launched directly from either the Ottawa or Chochocouane River bridges of highway No. 58 for trips into the south and central parts of the area.

A good bush road, maintained by the Canadian International Pulp and Paper Company, joins the highway 46 miles from Val d'Or and extends eastward across most of the area, about a mile and a half from the northern boundary.

Field Work

The mapping was carried out by means of pace-and-compass traverses, spaced at half-mile intervals. Base-maps, on the scale of two inches to the mile, and aerial photographs, enabled the traverses to be planned, checked, and tied-in to topographic features. All exposures on lake shores were examined wherever possible. Highway 58 has consecutive mileage signs, which give the distance from the town of Val d'Or, and these provided useful ties for the recording of roadside exposures.

Previous Work

In 1887 Robert Bell (1889) examined the route from Témiscamingue lake to Grand Lake Victoria by way of Kipawa lake and Dumoine river. He explored the headwaters of Ottawa river, then crossed the divide into the Gatineau River drainage basin, and returned by this river to Ottawa. Later (Bell 1896), he re-visited Grand Lake Victoria, passing northward from there to explore Bell river.

Between 1907 and 1912, M.E. Wilson reported on many sections of northwestern Quebec, including the Kipawa-Grand Lake Victoria region. These investigations are described in a memoir (Wilson 1918) published by the Geological Survey of Canada. It contains the first comprehensive study of the complex gneisses in this region.

Other previous work in the region includes an investigation of the complex gneisses in the Foch area by L.V. Bell (1933); a reconnaissance survey of the Upper Gatineau region by J.A. Retty (1934); mapping of the Villebon-Denain area by G.K. Lowther (1936); a reconnaissance of the Mont Laurier-Senneterre highway by E. Aubert de la Rüe (1941); and a study of the complex gneisses of the Cawatose area by W.G. Wahl and F. Fitz Osborne (1950).

G.W.H. Norman and collaborators made detailed maps of the Keewatin-Temiscamian volcanic and sedimentary rocks along their contact with the complex gneisses in Haig and Pershing townships (Norman and Dawson 1947; Norman and Tiphane 1947). M. Tiphane and K.R. Dawson continued this work in 1947, carrying the mapping farther southwest (Tiphane and Dawson 1950).

Acknowledgments

The writer acknowledges the assistance received during the field season from Messrs. James and Paul Blondin, game wardens for the Senneterre-Mont Laurier Hunting and Fishing Reserve (La Vérendrye Park), from Mr. Fred Durocher of the Ottawa River Forestry Protective Association, and from the members of the Quebec Department of Lands and Forests stationed at Murdock Camp.

He wishes to express his appreciation to W. Dennen, J. Béland, G. Migué, F. Paquette, and G. Troughon, all members of his party, for the manner in which they carried out their various duties.

DESCRIPTION OF THE AREA

Climate

The climate is rigorous, with short but hot summers during which there is a moderate rainfall. Even in summers, however, the nights are frequently cool, and heavy summer frosts are not unknown. The winters are long and cold, with abundant snowfall.

Drainage

The area is within the St-Lawrence River drainage basin but close to the Hudson Bay divide. It is drained by Ottawa river (of which Soulier lake and Dozois lake are parts) and its tributaries, Chocho-couane and Canimiti rivers.

Inhabitants

There are temporary settlements, known as Murdock Camp and Paré Camp, at the Chocho-couane River crossing of highway No. 58. The inhabitants are employees of local road construction and lumber companies and, in all, probably number less than 200 persons at any time. The settlements are served by one general store in which provisions may be purchased, but there is no regular accommodation for tourists. One or two families of Indians have an encampment on the bank of the river.

The Quebec Department of Lands and Forests maintains a district office here for the supervision of woods' operations, and the Ottawa River Forestry Protective Association has a district headquarters where Ottawa river crosses the highway.

The nearest tourist accommodation is at Dorval Lodge, eight miles south of Ottawa river along the highway, and outside the map-area.

Timber

There are large tracts of spruce, and smaller stands of white pine, red pine, and jack-pine. The northern two-thirds of the area is under lease to the Canadian International Pulp and Paper Company, and the southern part is leased or owned by the C. and G. Dent Lumber Company, whose mill, with a capacity of six million board feet per year, is on Corbell (Canica) lake at the mouth of Camatose river, about 16 miles south of the map-area along route No. 58.

At some time within the past forty years, much of the forest along and adjacent to the eastern boundary of the area was destroyed by fires and the country over which these passed is now covered with a heavy growth of white and yellow birch, poplar, and mountain maple.

The spruce in the area is healthy and relatively free from blight, but much of the white pine has a trunk rot, and many fine, large trees are broken off near the base and completely rotted away inside.

A noteworthy example of natural reforestation by white pine may be seen along the southern boundary of the map-area, between the east and west arms of Soulier lake, in the Dent Lumber Company limits.

Agricultural Possibilities

The area is not suitable for farming as the only lowlands are underlain by sandy soils or moisture-retaining clays, and, moreover, there is danger of destructive summer frosts.

Fish and Game

The map-area is within the Mont Laurier-Senneterre provincial game reserve where hunting is prohibited, although fishing is allowed in season. The rivers, streams, and lakes are plentifully stocked with fish amongst which are Great Northern pike, whitefish, and pickerel or doré; no trout were seen but many of the lakes and streams in the eastern half of the area, with their rocky or sandy basins and clear water, are suited for these fish.

Bear are numerous and at times a great nuisance to campers, since they are readily attracted by unburied refuse, or food not properly cached.

Beaver are present in fair number and probably one-fifth of the small lakes in the area owe their existence to beaver dams. One dam observed is at least 125 feet long and, at the centre of the stream, is retaining about five feet of water.

Moose are not plentiful and unless given more protection they will gradually disappear. In this connection it should be mentioned that the game wardens have carried out their duties with the utmost diligence.

Fox and muskrat were occasionally seen in various parts of the area.

Partridge are exceptionally plentiful.

Power

Neither along Chochocouane nor Canimiti river are there sites capable of providing more than a few thousand horse-power. At the present time, a large concrete storage dam is being constructed by the Quebec Hydro-Electric Commission^x at the 'narrows' on Dozois (Big Birch) lake, about three miles west of the present area. This dam, when closed, will raise the water in Ottawa river and its tributaries in the area from the 1,105-foot level to 1,135 feet, and thus portions of the southern part of the area will become flooded (see map in pocket).

GEOMORPHOLOGY

Topography

The maximum relief so far recorded within the area is 658 feet and is between the Kanimitti geodetic station (elevation 1,763 feet) — which is one mile east of the south tip of Gremlin lake, in the west-central part of the sheet — and Ottawa river at its junction with Chochocouane river (elevation 1,105 feet). The average relief is 200 feet, but in a few localities, such as west and southwest of Elbow lake and along the eastern boundary of the map-area, some hills are from 350 to 400 feet above the adjacent valleys.

In general, the surface is one of contrasting elevations and depressions, with many small, but few extensive, lowlands. Many of

^xThe dam was completed in 1948.

the hills have pronounced elongation, with trend north or northeasterly. These trends are reflected in the courses of streams and lakes but are more pronounced in some parts of the area than in others. Whether elongated or not, many of the hills have steep north- to west-facing scarps rising above valleys containing either lakes or streams. In contrast, the back slopes of these hills are less steep and have few rock exposures (see Plates I and II).

The most extensive lowlands are east of Chochocouane river, in the central and southern parts of the area. These are sand-plains covered by young jack-pine. Spruce muskegs are best developed along the northern reaches of Canimiti and Chochocouane rivers and along the south bank of Ottawa river west of the highway.

Explanation of Topography

A view from one of the higher ridges shows numerous hills dotting the country, most of them approximately equal in elevation. This roughly accordant level probably represents the 'Laurentian peneplain', and Cooke (1930) states that "it had been a peneplain which was elevated high above the sea during Pliocene time", and that "the uplift was attended by faulting in places" (see Plates III-A and III-B).

The many elongated hills of the area with steep north- to west-facing scarps are undoubtedly a reflection of underlying rock structures. The scarps are in many cases composed of gneisses, whose strike is parallel to, or nearly parallel to, the long axis of the hills, and which dip in the direction of the more gentle back slopes. At the bases of some scarps, gneisses with pseudo-slickensided surfaces were found, which may indicate that some of the valleys and the adjacent hills are the result of erosion along faults. Lowther (1936), in the northern part of the area mapped by him, found that similar scarps are transverse to the strike of the bedding. This is suggestive of their fault origin in that area. Supporting this is the fact that the cores of some hills, in particular the higher ones, are sill-like bodies of massive or nearly massive acidic igneous rocks.

Wilson (1918) believes the linear valleys of the region are the result of faulting which occurred after Silurian and before Pleistocene time. Despite this, serious consideration should be given to the possibility that some of the valleys may be the result of differential erosion on limestones or garnet gneisses, or even on greenstones. These rocks would surely be more easily eroded by stream and ice action than the ridges that are cored by resistant igneous rocks.

In addition to the regularly oriented hills, there are irregular or rounded hills, which appear to be principally in places

where faults or prominent joints do not coincide with the strike of the gneisses.

Other 'irregular' hills are developed on homogeneous rocks, such as the syenites which underlie part of the southeast corner of the map-area. Here the hills are relatively low, well rounded by glaciation, and the predominant structures determining their shape appear to have been jointing and fracturing.

The absence of glacial stoss and lee slopes on any of the hills of the area can only be explained by the attitudes of the structures of the rocks. It is thought that the ubiquitous layering of the rocks probably acted as reinforcing and gave them a resistance which prevented their breaking along joint planes. This would tend to prevent the formation of the lee forms, whereas the gneissic structure, with its northeasterly strikes and southerly dips, would present a strong front to the ice movement from the north, and so decrease the tendency for the ice to carve stoss slopes.

To a large extent, the trends of rivers, streams, and lakes are parallel to the strike of the gneisses, as may be confirmed by a glance at the accompanying map. But Tombbah, Gabbro, and Des Montagnes lakes, Ottawa river west of the highway, and the two narrow lakes east of Elbow lake, have trends that are nearly east-west, disrupting the general northeasterly grain of the area. These lakes show a marked coincidence in trend with the strikes of the known or suspected faults of the area.

Two miles south of the northern boundary of the map-area and a similar distance east of the Fréville-Champrodon township-line there is a fold-shaped hill that apparently is formed on an individual garnetiferous formation. The outline of the hill is shown on the accompanying map, but the garnetiferous rocks are indicated only in those places where exposures were observed.

Pleistocene

During Pleistocene time, the area was covered by ice, as evidenced by the large erratics and striated rock surfaces to be seen on a few of the higher hills. Few good striae were observed, but those seen indicated an ice movement due south or between that and S.10°W.

Whether Ottawa and Chochocouane rivers existed in their present channels in pre-late-glacial times is not known, but they occupy the broadest valleys in the area. Much morainic material was deposited in their valleys and, as a result, both rivers, in places upstream from natural barriers such as rapids, have aggraded their beds and built natural levees behind which there are small lakes and swamps.

Fluvioglacial deposits are found as a small sand-plain in the northeast corner of the area along the Canadian International Pulp and Paper Company road, and in a much larger one in the central part of the map-area east of Chochocouane river. Between Soulier and Tombbah lakes the country is strewn with much morainic material, and an esker starts just above the main fork of Cultus creek and extends south into a district containing many erratics and a few small sand-plains.

Local deposits of morainic material are found throughout the area. These may consist of relatively well stratified sands and gravels, with marked cross-bedding, or of poorly sorted sands and gravels through which are scattered many large erratics. The cross-bedding shows no consistent attitude, indicating that the deposits were formed by currents moving in diverse directions. The gravels, in some places, form thin lenses and are possibly the result of some temporary torrential current issuing from a stagnant ice front. The large boulders appear to be more numerous in the less well stratified deposits of finer grained material, and these are generally thought to have been formed by ice-rafting in ice-dammed lakes.

GEOLOGY

Introduction

The rocks of the area are fine- to medium-grained gneisses and granulites^x of metamorphic origin, which have been liberally injected and 'soaked' by igneous material, which now forms stocks, dykes, or possibly sills, and thin, closely-spaced parallel layers, of dioritic to pegmatitic composition. Where intrusions of this nature have been numerous, the rocks are 'composite', that is, they have both metamorphic and igneous characteristics. The intense regional metamorphism has destroyed or modified original structures such as bedding, and has so altered the rocks that their former mineralogical compositions are not known, and determination of their original chemical character is difficult, since it is impossible to say what material has been added or abstracted during metamorphism and intrusion.

Many methods have been employed to ascertain whether a gneiss was derived from a sedimentary rock, but to date the only universally accepted proof is that based on the presence of primary features such as bedding, cross-bedding, and conglomeratic structures.

^xThe term refers to their granular appearance, and has no implication of origin or composition.

It was decided, after considering the high grade of metamorphism prevailing in the rocks of the area, that the only feasible method of classification is on a purely mineralogical basis, i.e., by the minerals identified in the hand-specimen. Thus a gneiss would be called a "biotite-garnet-feldspar-quartz gneiss" if it contained all those minerals.

In the mapping, garnet, biotite, hornblende, and pyroxene were used as index minerals. As it was found that garnet was present in some essentially biotite- and pyroxene-bearing gneisses, the name 'garnet gneiss' was restricted to those types containing five per cent or more garnet, and less than five per cent hypersthene.

In the region south of this, Wahl and Osborne have used a different method of classifying the gneisses. Many rocks called 'garnet gneiss' by them have less than five per cent garnet. The difference in usage of the term was made necessary by differences of the rocks in the two regions. The apparent discrepancies of the maps where they join is thus explained.

In the map that accompanies this report, areas underlain principally by rocks in which the same index mineral predominates are coloured similarly, but this does not preclude the occurrence within any such area of small amounts of rocks containing other index minerals.

Everywhere within the area, schistosity and foliation of the gneisses were found to be parallel to each other. Their attitudes are indicated on the accompanying map by conventional strike and dip symbols. No slates, phyllites, or schists were seen in the area, nor was bedding definitely recognized, although it is thought that some of the gneisses represent bedded rocks.

Regional Geology

Lowther (1936) and Tiphane and Dawson (1950) mapped the area to the north and northwest of the Canimiti River area, and have shown that there, in the northwest half of the area, Temiscamian-Keewatin-type volcanic and sedimentary rocks, many of which are altered to amphibolites, have been intruded by hornblende syenite and muscovite- or biotite-bearing pegmatites. The southeast part of the area mapped by them contains only biotite and garnet gneisses which are a continuation of those found in the present area. Tiphane considers the boundary between the gneisses and the Keewatin-Temiscamian rocks to be a fault zone which must extend diagonally in a northeasterly direction across the area mapped by him.

Wahl and Osborne (1950) mapped the Cawatose area, which adjoins the Canimiti River area on the south. The rocks there are predominantly biotite, biotite-garnet, and biotite-hornblende paragneisses, along with biotite- and hornblende-bearing granite orthogneisses. In addition there is a large quartz syenite intrusive which extends across the northern boundary into the southeast corner of the present area. The occurrence of a small exposure of Grenville-type limestones and quartzites in the Cawatose area is significant in that it shows that metamorphosed sedimentary rocks, some of which may be of Grenville age, are present in the region.

Retty (1934) carried out a reconnaissance survey of a region east of the present map-area and reported biotite and garnet gneisses, granites, and granodiorites, with a few small patches of Grenville-type limestones and quartzites.

The geology of the Canimiti River area is in marked contrast to that of the areas mentioned above. No Grenville-type limestones, quartzites, or sillimanite gneisses are found in the area, and only a few small exposures of orthogneiss. No actual volcanic or sedimentary rocks were seen - though they possibly are to be found west of the northern boundary of the area - but some of the gneisses and granulites may be their metamorphic equivalents. On the other hand, composite or hybrid gneisses are numerous and are characterized by small amounts of a 'sandin-dine-anorthoclase' mineral. Hypersthene, which has hitherto not been reported in the rocks of the surrounding areas, is ubiquitous throughout the area.

All the principal structures mapped in the region, except in the area examined by Wahl and Osborne, strike in a northeasterly direction. This strike is approximately that of the fault that has been postulated between the Keewatin-Temiscamian rocks and the gneisses.

General Geology of the Map-Area

Among the rocks in the area are biotite, biotite-garnet, and hypersthene gneisses and granulites which are thought to have been formed by metamorphism of sedimentary and volcanic rocks. Some of the gneisses are composite rocks, that is, they were formed by igneous injections into, and metasomatism of, paragneisses. Such gneisses have characteristics of both igneous and metamorphic rocks.

Metamorphism has been of such a grade that schists were not formed. Granoblastic textures with slightly oriented fabrics are the rule. Differential movement in restricted zones has resulted in the formation of 'plated gneisses' or 'flaser pegmatites', which are

thought to be the equivalent of the rocks found in shear zones in regions of lower grade metamorphism. Banding caused by igneous injection or original compositional differences in the rocks is prevalent throughout the area. Evidence of faults has been observed only in two places. One fault zone is filled by a 'flaser pegmatite', proving beyond doubt that such rocks owe their structure to movement.

Hypersthene granulites are well represented in the area, particularly along the eastern boundary, between Des Montagnes and Tombah lakes. Where exposed in the southwestern corner of the area they are strongly gneissic and contain some mafic inclusions and zones of garnet gneiss.

Garnet gneisses are ubiquitous but are particularly common in localities to the west of Chochocouane river. They grade into or are intermixed with both hypersthene and biotite gneisses and granulites.

The main occurrences of biotite gneiss are east of Chochocouane river, where lenses between one and two miles wide form a belt which extends from the central part of the southern boundary diagonally northeastward up to and beyond Des Montagnes lake. Another prominent occurrence is near the southeast corner of the area, near Blind river. These gneisses are much injected by igneous material and within their area of outcrop there are numerous small exposures of pink flaser or augen gneiss. The rock commonly contains garnet, but in minor amount (less than 5 per cent).

Composite gneisses, which are found in the northern part of the area, have medium- to coarse-grained igneous texture and a composition approximately that of quartz diorite. They grade into finer grained and often definitely layered rocks rich in hypersthene and garnet. The layering is in part the result of pegmatitic and migmatitic injections along planes of schistosity, and in part due to original variations in composition from layer to layer (see Plate IV-B).

A short distance beyond the western boundary of the area at its northwest corner there are some small exposures of 'greenstones' which has been intruded by red quartz diorite and syenitic pegmatite. It is thought that some 'greenstone' has been incorporated into the composite rocks in the vicinity of Composite lake.

The earliest intrusive rocks in the area are apparently white to grey quartz diorite and associated grey to pale pink pegmatoid and pegmatitic sills and dykes. These form no large masses but are abundant throughout the entire area.

Massive igneous rocks -- hypersthene gabbro, quartz diorite, and quartz syenite -- form the largest individual intrusive bodies in the area. These rocks are cut only by their associated syenitic and granitic pegmatites. Tiphane (1950) considers the syenites of the area mapped by him to be post-Temiscamian, and because there is a similarity in composition and in the trend of the long axis of these intrusive bodies in his area and in the present area, the syenite and associated intrusives of this area, also, may tentatively be assigned a post-Temiscamian age.

Several small exposures of a medium-grained, green, massive rock in the vicinity of Gabbro lake may be either hornblende gabbro or amphibolite.

One coarse-grained granitic dyke that cuts the composite gneisses is unlike any rock seen elsewhere in the area, but a similar dyke occurs outside the northwest boundary on the highway near MacLaurin lake, where it intrudes amphibolitic and garnetiferous gneisses.

A few basic dykes were seen in the area. Some of these have been only weakly altered by metamorphism, but little is known about their associations or origin.

Table of Formations

GENOZOIC	Quaternary	Pleistocene	Sand and gravel
Great unconformity			
PRECAMBRIAN		<u>Post-Temiscamian (?)</u>	
		Basic dykes Younger intermediate and acidic intrusives Hypersthene and hornblende gabbros (amphibolite?)	
		Intrusive contact - Folding and faulting (?)	
	Archaean	<u>Gneiss Complex: Paragneisses and orthogneisses</u> Greenstones: Altered sedimentary rocks (outside, west of, the map-area) Composite gneisses: Hypersthene-bearing gneisses, hypersthene-garnet bearing gneisses, medium-grained gneisses with many mafic-rich layers Older intermediate and acidic intrusives: Quartz diorite orthogneiss, quartz diorite, associated pegmatites Biotite gneiss Garnetiferous gneisses Hypersthene gneisses and granulites Hypersthene-augite-amphibole rocks in layers or lenses - including some later ultrabasic intrusives	

PETROLOGY

Hypersthene-Augite-Amphibole Rocks in Layers or Lenses

A surprising feature of the Canimiti River area is the abundance of rocks containing augite and hypersthene. Wahl and Osborne (1950) found no rocks of this type in the area adjoining on the south. At some localities, the hypersthene in the hypersthene-bearing rock is in large crystals; at others it is in small grains and may be associated with an almost colourless augite or a pale-green, apparently hedenbergitic, pyroxene. A garnet, which is a deeper pink in thin section than that found in most of the paragneisses, is common, particularly in varieties of the rock containing feldspar. For purposes of this report,

the finer grained types with abundant feldspar are termed 'hypersthene gneiss' or 'hypersthene granulite'.

There is uncertainty concerning the origin of the hypersthene-bearing layers and lenses and the granulites. The rocks appear to conform to the structure of adjacent garnetiferous gneisses that are considered to be of sedimentary origin. In some localities there even appears to be a gradation into the paragneisses. However, the chemical analysis of a typical specimen of the pyroxene-bearing rock shows that it was once a peridotite, that is, an intrusive rock. The rock has been so altered by deformation and metasomatism that the original igneous nature was not recognized, either in the field or in thin section.

On the other hand, it has long been recognized that hypersthene can occur in paragneisses, so that a hypersthene-bearing paragneiss is to be expected. The analysis of a garnetiferous gneiss given on a later page (analysis II, p.21) shows that, in chemical composition, the rock is unlike any igneous rock and is probably of ultimate sedimentary origin, although the composition may have been modified by igneous action or metasomatism.

The suggestion is here offered that the hypersthene-augite rocks and some of the granulites are part of a sill-sedimentary complex, possibly with some dykes. Volcanic rocks, which may have given rise to some of the more massive pyroxene gneisses and granulites, may have been associated with the sedimentary rocks. The complex was folded and then intruded by igneous rocks, whose emanations produced changes that tended to obscure the simple relationships.

Support is lent to such a contention when it is recalled that, in the Abitibi region, basic and ultrabasic rocks are known to intrude the Keewatin- and Temiscamian-type rocks and to have been emplaced before the granites of the region.

The heavy cover of vegetation in the present region makes it difficult to trace the structure of the complex, which appears to be a somewhat local feature, for Wahl and Osborne did not record anything like it in the area to the south.

Description

The hypersthene and augite rocks of these layers and lenses are dark green, massive, medium- or coarse-grained rocks, consisting essentially of hypersthene, augite, and amphibole in various proportions. Some varieties contain biotite, sericite, chlorite, and carbonates.

Occurrence

One variety, which crops out on the east bank of Canimiti river about three miles above its junction with Chochocouane river, contains large (up to 1 1/2-inch) porphyroblasts of hypersthene in a medium-grained groundmass of hypersthene, augite, and amphibole. It is a layer or lens about 125 feet thick, but otherwise of unknown extent. At the centre of the mass the rock is coarse, but the grain size decreases toward the only visible contact with the gneisses. Near the contact, the porphyroblasts disappear and amphibole is the predominant mineral. These rocks appear to grade over short distances into the gneisses at the contact, which strike N.60°E. and dip 50°S.E. Locally, for example along shear zones, rocks of this type have been converted to chlorite schist.

Many bands or lenses of basic rock were found in the granulites or pyroxene gneisses south of the Nose lakes in the southwest corner of the area. They are of two types: in one, the rock is brown to dark brown, medium-grained, and composed essentially of a dark brown hornblende with lesser amounts of augite or hypersthene or both; in the other it is green to dark green, fine- to medium-grained, and contains hypersthene, augite, hornblende, biotite, plagioclase, and accessory quartz. The layers or lenses are rarely more than a few inches thick. The second type is the more common and has been found also as small elliptical masses in the granulites. In all the observed exposures, these bands are parallel to the gneissic structure of the enclosing rocks.

Also in the area south of the Nose lakes is an exposure of coarse, reddish, hypersthene-bearing pegmatite which contains numerous irregular but rounded inclusions of a green, fine- to medium-grained hypersthene-bearing rock, similar to those found in the granulites.

A dark brown, medium-grained rock containing mica, hornblende, and pyroxene forms a ten-foot layer or lens that crosses highway 58 about 400 yards north of Gabbro lake. The foliation strikes N.5°E. and dips 50°E. On the south side of this lens the rocks are garnetiferous, whereas on the north side the first few exposures are granulites with numerous hypersthene-bearing layers which are roughly parallel to the structure of the enclosing rocks, but in places have a disrupted or brecciated appearance.

Petrography

In thin sections most of these rocks are seen to be medium- to coarse-grained crystalloblastic aggregates. Some varieties show faint foliation, and many of the coarser-grained varieties are poikiloblastic. Hypersthene, augite, amphibole, and in some varieties biotite, are essential minerals. Olivine, carbonates, quartz, and plagioclase are in minor amounts. However, the carbonates and olivine

are found only in the coarser grained varieties, and plagioclase ($An_{32}-An_{40}$) may be an essential mineral.

The hypersthene (bronzite) is in very large crystals (up to 30mm.) which frequently enclose the other minerals. The augite and olivine are much corroded. The amphibole, which in at least some varieties is actinolite, is the result of metamorphism of the rock.

Following is the result of an analysis of a specimen of this rock taken from an exposure in the bay on the east side of Canimiti river at the head of the rapids four miles from where that stream joins Chochocouane river. The rock was originally a peridotite, variety websterite, composed of olivine, augite, and hypersthene, but relics only of these minerals persist, their place having been taken by a very pale green secondary amphibole. The presence of chromium leaves no doubt that the rock is of igneous origin.

Altered Websterite. East Side Canimiti River
Four Miles Above Junction with Chochocouane River

(Analysts: C. Tousignant and

H. Boileau, Quebec Department of Mines)

SiO ₂	45.79	K ₂ O	0.22
TiO ₂	0.36	H ₂ O ⁺	1.55
Al ₂ O ₃	6.97	H ₂ O ⁻	0.09
Fe ₂ O ₃	0.77	P ₂ O ₅	0.003
FeO	9.74	CO ₂	1.90
MnO	0.18	Cr ₂ O ₃	0.37
MgO	26.75	NiO	0.14
CaO	4.39	S	0.40
Na ₂ O	0.54		
		100.163	

Hypersthene Gneisses and Granulites

Description

These are fine- to medium-grained rocks, green to rusty-brown, depending upon whether they are fresh or weathered. They are composed of hypersthene, plagioclase, quartz, biotite, and, in some varieties, garnet. The term 'granulite' is used with reference to their granular appearance and without implication of composition or origin.

Occurrence

Southeast of the Nose lakes, in the southwest section of the area, there are many foliated granulites containing conformable hypersthene-rich layers or inclusions. The strikes of the gneissic structure are diverse in this locality and appear to indicate folding such as is observed in normal sedimentary or volcanic formations. A good example is to be seen east of the small lake at latitude $47^{\circ}33'N$. and longitude $77^{\circ}11'30''W$.; here the axis of a closed fold about thirty feet in cross-section trends $N.43^{\circ}E$. and plunges 30° and is overturned to the southeast. The rock has a banded appearance as the result of very slight differences in mineral composition between successive layers of pale green to green granulite, and also because of the presence of one narrow, dark hypersthene band conformably folded with the others.

Hypersthene granulites underlie many of the high hills south of Des Montagnes lake, along the eastern boundary of the area. These rocks are relatively massive, but in places they contain layers of garnetiferous rocks and are cut by coarse-grained pegmatite dykes, some of which are three to four feet thick. Thin sections of the granulites from this vicinity show plagioclase, An_{38} (60%), hypersthene (15%), quartz (15%), and biotite (10%). Accessories are garnet, magnetite or ilmenite, and sulphides.

Along the east side of Canimiti river above its junction with Chochocouane river, hills with prominent west-facing scarps are composed essentially of massive granulites and garnetiferous gneiss. A thin section prepared from a representative specimen showed that garnet and hypersthene each form about 15 per cent of the rock.

Exposures of hypersthene- and garnet-bearing gneisses are numerous in the north and northwest parts of the map-area, but the more massive, unfoliated types are absent. The gneisses here are more intimately injected by igneous material than are those described above, so much so that in places they are seen to grade into coarsely granoblastic and apparently igneous rocks, which are referred to in this report as 'composite gneisses'. Marked layering is seen in many places and appears to have resulted from thin igneous injections along parallel planes, and from compositional differences in the original rock (see Plate IV-B).

Petrography

These are fine- to medium-grained, granoblastic rocks. In actual exposures and hand specimens the foliation is usually quite evident, but it is not very apparent in thin sections. Essential constituents are plagioclase ($An_{32}-An_{40}$), hypersthene, quartz, and biotite;

in addition, some of the thin sections examined have a large amount of garnet. Accessories are garnet, magnetite and/or ilmenite, sulphides, and, in some sections, apatite.

Following is the result of an analysis of a specimen taken from the body of granulite that crosses highway 58 near Beak lake, which is three and a half miles southeast from the point where the highway crosses the western boundary of the area. As will be noted, Al_2O_3 (15.42%) is much in excess of combined CaO, Na_2O , K_2O (7.77%). Assuming that its composition was not highly modified during metamorphism, this suggests that the rock is a paragneiss, that is, it is derived from a sedimentary rock that had been weathered to such an extent that the feldspar it contained had been largely decomposed.

Granulite. Highway 58, near Beak lake

(Analysts: H. Boileau and

J. Gagnon, Quebec Department of Mines)

SiO ₂	66.24	Na ₂ O	3.19
TiO ₂	0.61	K ₂ O	1.43
Al ₂ O ₃	15.42	H ₂ O+	0.43
Fe ₂ O ₃	0.76	H ₂ O-	0.08
FeO	5.40	P ₂ O ₅	0.08
MnO	0.09	CO ₂	Nil
MgO	3.21	S	0.26
CaO	3.15		100.35

Garnetiferous Gneisses

Description

These are fine- to coarse-grained rocks, grey-green to green on fresh surfaces, with light yellow-brown weathering. In some exposures they are massive, but generally they are foliated or banded as a result of igneous injection. The minerals recognizable in hand specimen are pink to red garnet, feldspar, quartz, and biotite. Only those rocks containing garnet in excess of 5 per cent and negligible hypersthene (less than 5 per cent) are included in this group.

Occurrence

South of the old highway bridge over Ottawa river, many exposures of these rocks show banding, which has resulted from igneous injection along closely-spaced parallel planes in the original rock. The strike of the gneissic structure is variable, but generally northeasterly. The dip is southeasterly, at a low angle in exposures a few hundred yards south of the bridge but steepening as Ottawa river, to

the north, is approached. The material injected into the gneisses is quartz diorite, and it constitutes 70 per cent of some exposures. Thin sections of these rocks show plagioclase, An_{34} (50%), garnet (15%), quartz (25%), and biotite (10%).

A green, foliated, fine- to medium-grained garnet gneiss is exposed along the highway 1,000 feet north of the old highway bridge over Ottawa river. The layering caused by igneous injection is much less apparent here than in the exposures described in the previous paragraph, but the rock has a strongly plated aspect, very suggestive of some argillaceous rocks (see Plate IV-A). In thin section this rock is seen to contain plagioclase (50%), quartz (10%), garnet (15%), and biotite (25%). North of but adjacent to this garnet gneiss is an exposure of relatively massive, green, hypersthene granulite with little injection layering. This rock contains plagioclase, An_{30} (50%), hypersthene (15%), quartz (10%), biotite (20%), and garnet (5%). The presence of garnet-bearing and hypersthene-bearing rocks in adjacent exposures is of interest and will be discussed later, in the section on the origin of the rocks.

Layering of a different type is to be seen in the narrow zone of garnetiferous rocks indicated on the accompanying map at the western end of Tombbah lake. The layers here are one to two feet thick and somewhat contorted; granitic material alternates with green layers consisting of biotite, plagioclase, quartz, and abundant red garnet. In another garnet zone at the eastern end of the lake, the rock contains 40 per cent garnet. A thin section of the gneiss of this latter zone was found to contain plagioclase, An_{31} (45%), garnet (15%), quartz (15%), and biotite (20%), with accessory microperthite, sanidine or anorthoclase, magnetite, and sulphides. (The low content of garnet in the thin section is the result of its loss during grinding).

A grey-green, massive, buff-weathering variety of garnet gneiss is found throughout the north-central and central parts of the area, west of Canimiti river. The layering is not conspicuous and is restricted to the occasional thin acidic stringer, in and alongside of which grains of garnet may be numerous. In the massive rock away from the injected material, garnet may be plentiful, but the crystals are small and are easily overlooked. In some occurrences, these rocks give the appearance of having been 'soaked' by acidic material. The strikes of the garnetiferous rocks northeast of Gabbro lake indicate the presence of a large fold, which is cut by one of the two known faults in the area.

Petrography

Seen under the microscope, these rocks are fine- to medium-grained and granoblastic, with porphyroblasts of garnet; gneissic structures are inconspicuous or absent. The essential minerals are plagioclase, garnet, biotite, and quartz; common accessories include magnetite and sulphides, and very minor hypersthene, apatite, and zircon. The zircon occurs as inclusions in biotite and is surrounded by pleochroic haloes. Alteration is not common, but one thin section of a specimen from east of Chochocouane river shows distortion of biotite metacrysts and contains some chlorite, epidote, sericite, and carbonates.

Analysis of a specimen taken from the band of this formation that crosses the Canadian International Pulp and Paper Company road four miles west of the east margin of the map-area gave the result shown in Column I of the accompanying table. The excess of alumina over combined alkalis and lime suggests that the rock is a paragneiss. Analysis II is of a gneiss containing garnet, augite, hornblende, and iron oxide, which is included in gabbro that intrudes the mass of garnet-quartz-plagioclase gneiss a mile south of the southern end of the boundary between Fréville and Champrodon townships. The gneiss may be a dyke but more probably it is a paragneiss, included in and modified by trans- fusion of material from the gabbro. That some material was added from the gabbro is suggested by the high tenor of titanium dioxide.

	<u>I</u>	<u>II</u>
SiO ₂	63.50	49.78
TiO ₂	0.66	2.96
Al ₂ O ₃	17.32	13.44
Fe ₂ O ₃	1.06	4.94
FeO	5.40	12.99
MnO	0.09	0.24
MgO	3.68	3.85
CaO	2.64	7.27
Na ₂ O	3.21	2.16
K ₂ O	1.85	1.30
H ₂ O+	0.21	0.56
H ₂ O-	0.05	0.10
P ₂ O ₅	0.05	0.27
CO ₂	Nil	Nil
S	<u>0.22</u>	<u>0.02</u>
	99.94	99.88

I.-Garnetiferous gneiss. C.I.P. and P. Company road four miles west of east boundary of area.

II.-Gneiss included in gabbro. One mile south of boundary between Fréville and Champrodon townships.

Analysts: H. Boileau and J. Gagnon, Quebec Department of Mines.

Biotite Gneisses

Description

These are fine- to medium-grained, grey-green to green rocks. They are gneissose to sub-schistose as seen in most hand specimens, but in some occurrences they are relatively massive. Biotite, feldspar, and quartz are the common minerals, and in the typical rock biotite predominates over the others, though all gradations may be found between rocks rich in biotite, and granitic rocks in which feldspar and quartz are the chief minerals. Garnet is commonly present, but only those gneisses with less than 5 per cent garnet or hypersthene are called biotite gneisses in this report.

Occurrence

These rocks are mainly confined to the southeast corner of the map-area and to a belt one to two miles wide that extends from the central part of the south boundary, northeastward to and beyond Des Montagnes lake.

The fine-grained sub-schistose variety is best developed on the south shores of Des Montagnes lake and is almost identical with varieties found in the Villebon-Demain map-area (Lowther, 1936); elsewhere, as in the vicinity of Blind River, the biotite is usually in relatively large flakes, though often not plentiful and not evenly distributed. Much igneous material has been injected in lit-par-lit fashion. These injections include quartz dioritic to granitic rocks and lenses of 'pink granite pegmatite'. Parallel layering, in which coarse biotite layers alternate with others composed of quartz and feldspar, is seen in places.

Between Cultus creek and Chochocouane river there are numerous exposures that show other varieties of biotite gneiss; these vary, with increasing quantities of injected material, from greenish, medium-grained, sub-schistose, biotite rocks, to lenses of granite or pegmatite, with a little biotite. A thin section of a typical biotite gneiss from this area has biotite (30%), quartz (8%), plagioclase, An_{33} (62%), and accessory garnet and magnetite.

Petrography

Examination of a number of thin sections of these biotite gneisses showed them to be fine- to medium-grained rocks with a texture that varies from granoblastic to gneissose. The essential minerals are plagioclase (An_{30} - An_{33}), biotite, and quartz. Garnet, apatite, magnetite, and sulphides are the common accessories.



Profile of a typical elongated ridge . The steep slope of the ridge faces west .
Highway No. 58, mileage 52 .



A typical lake of the area . Note steep rock ridge which forms southeast shore of lake .
Highway No. 58, mileage 55.5.

Plate III



A- Looking northeast along valley of Chochocouane river.
Note rough accordance of summits of hills on the horizon.
Taken from hill west of Paré Camp.



B- Looking southwest toward valley of Canimiti river.
Taken from ridge on $77^{\circ} 05'$ meridian in Champronon township.

Plate IV



A- Green garnet gneiss with injected layers. Banded appearance is very suggestive of impure arenaceous or slaty rocks. Exposure is on abandoned part of highway No. 58, 1,000 feet north of Ottawa river.



B- Close-up or composite gneiss. Note injection layering and that caused by compositional differences.

Older Intermediate and Acidic Intrusives

Introduction

Throughout the area there are small lenses and many closely-spaced, thin, sill-like injections ranging in composition from granite to quartz diorite; some have associated pegmatitic facies. Large intrusive masses are not found, but the abundance of these early acidic injections into the gneisses is such that in places the rock assemblage may be termed 'composite'.

Quartz Diorite Orthogneiss, Quartz Diorite, and Associated Pegmatites

Description

These early intrusives are medium- to coarse-grained, white to grey, granitoid rocks, composed of feldspar and quartz, with or without biotite and hornblende. Some are highly contorted and foliated, others are massive.

The early pegmatitic facies are grey and are slightly coarser grained and contain more quartz than the granitic facies. Biotite is in minor amount.

The late pegmatites are pink and are much coarser grained and have less quartz than the early ones.

Occurrence

Quartz diorite orthogneiss has been found only on the islands in the eastern part of Tombbah lake. Here it is much contorted and contains hornblende inclusions in all stages of digestion.

Quartz diorite was seen in a vertical exposure near the north abutment of the new highway bridge over Ottawa river. In the lowest part of the section it is a white, massive, medium- to coarse-grained rock, but half way up, with an increase in biotite, it could be termed an orthogneiss and at the top it is a biotite paragneiss.

The pegmatoid and pegmatitic lit-par-lit injections of quartz diorite into the paragneisses are only slightly coarser in grain and more quartzose than the quartz diorite in this occurrence.

Pink pegmatites cut the white varieties of the quartz diorite and are therefore younger. Retty (1932) reported a similar

relationship between the pink and white pegmatites in the Lake Ostaboning map-area. Thin sections show these rocks to contain orthoclase, microcline, microperthite, plagioclase, and quartz.

Pink pegmatites having 'eye-like' feldspar (augen gneiss), and sheared-looking, plated varieties (flaser gneiss), occur throughout the area, both parallel to and cutting the regional foliation.

Petrography

These rocks are invariably hypidiomorphic, granular, and of medium to coarse grain, excepting the flaser gneisses which have a marked flow texture. The early varieties contain only quartz and plagioclase, with, locally, biotite or hornblende as a contamination product.

The early white to grey pegmatites contain antiperthite, microperthite, plagioclase (An_{30}), and quartz, with accessory biotite, garnet, and a 'sanidine-anorthoclase' mineral. This last is optically negative with $2V$ between 10° and 30° , has a very low birefringence, and a refractive index lower than that of Canada balsam. The crystals are usually glass-clear, but they contain small inclusions of twinned plagioclase, An_{36} . It is worthy of mention that the grains in which inclusions are most abundant have the largest optic angle.

The pink pegmatites differ from the above in their higher content of potash feldspars and the presence of microcline.

Composite or Hybrid Rocks

Description

It is difficult to offer a simple description for these rocks. They are grey-green to dark green, medium- to coarse-grained, and massive, with definite layers of the mafic minerals; or they are fine- to medium-grained, and layered as a result of igneous injection or of original heterogeneity. They may contain hypersthene, or hypersthene and garnet, and such varieties may grade into coarse-grained rocks which in all respects appear to be of igneous origin.

Occurrence

The northern parts of the map-area appear to have more complex rocks than the other sections, and many composite gneisses are to be seen in the exposures along the Canadian International Pulp and Paper Company road. The coarser-grained varieties, which are invariably found near the tops of small hills, consist of reddish to green

feldspar, pink to mauve quartz, biotite, coarse dark pyroxene, and garnet.

In thin section they are seen to contain microperthite (5-10%) and/or orthoclase, plagioclase, $An_{27}-An_{33}$ (50-60%), biotite (5-15%), quartz (10-20%), garnet (0-10%), and hypersthene (0-5%); magnetite, sulphides, and anorthoclase, with or without sanidine, are present as accessories. The quartz, which has a mauve tint, commonly occurs in small stringers which contain, in places, a few specks of sulphide. These coarse-grained rocks can be seen to grade into medium-grained, light brown, foliated varieties, which have injection layers and contain either garnet or hypersthene, or both.

Three-quarters of a mile east of Composite lake, along the road, a composite hypersthene-bearing rock of medium grain has layers that appear to be, in part, the result of the injection of pegmatitic material, and in part inherited from the original rock (see Plate IV-B). The variation in grain size and colour cannot be directly attributed to alteration by the intruding pegmatites; it could, of course, have resulted from selective pneumatolytic action, but for such action to have taken place would argue for an original compositional layering in the rocks. Some layers contain garnet, others both garnet and hypersthene, and, in addition, there is the occasional dark, pyroxene-hornblende inclusion that contains pyrrhotite in sufficient quantity to deflect a compass needle. In thin section, these gneisses are seen to contain plagioclase ($An_{27}-An_{30}$), antiperthite, hypersthene, biotite, garnet, and quartz.

South of Composite lake, the exposures along the road are of a medium- to coarse-grained, green to dark green rock, in many respects similar to the coarse textured rocks described previously, but here dark mafic bands are so numerous that in places they constitute 70 per cent of an exposure. These rocks form steep scarps on the east side of the creek that drains Composite lake at its southwest end (just west of the map-area), and are intruded in lit-par-lit fashion by material of quartz diorite composition. The foliation and banding strike north and dip 50° to 60° east. In two small exposures of 'greenstone' on the west side of the creek, also, the foliation has this attitude, and one of them is much injected by quartz diorite material similar to that intruding the rock on the east side of the creek. The concentration of the mafic minerals into layers in the rock on the east side of the creek and the proximity of the 'greenstone' suggest the possibility that the mafic bands are assimilated or metamorphosed 'greenstone'. The composite rocks from this vicinity contain plagioclase ($An_{32}-An_{35}$), hypersthene, biotite, quartz, and accessory augite, hornblende, apatite, magnetite or ilmenite, and sulphides.

Petrography

The coarse-grained composite rocks are granoblastic and consist of plagioclase (An_{27} - An_{35}), quartz, hypersthene, garnet, biotite, and orthoclase or microperthite. Plagioclase and quartz are present in all the thin sections examined. Augite, hornblende, apatite, 'sanidine-anorthoclase', zircon, magnetite and/or ilmenite, and sulphides are accessory minerals.

The mafic layers which are so common in the rocks around Composite lake are composed of fine-grained aggregates of biotite, hypersthene, augite, quartz, plagioclase, and garnet, in a coarser-grained plagioclase-quartz aggregate, and are identical in many respects with the layered composite hypersthene-garnet gneisses that are found farther along the road, southeast of Composite lake.

Some grains of orthoclase are seen in thin sections of these rocks, but the potassic feldspar is found more often as antiperthitic inclusions in the plagioclase, and is either the result of exsolution or of replacement along fractures or twinning planes.

The 'sanidine-anorthoclase' has presumably replaced plagioclase since it embays and contains inclusions of the latter that appear to have been in process of solution at the time of consolidation of the rock.

The occurrence of opalescent to mauve quartz in the rocks in this vicinity is worthy of mention, since it is similar to that found in the albitic intrusives of the Bourlamaque area.

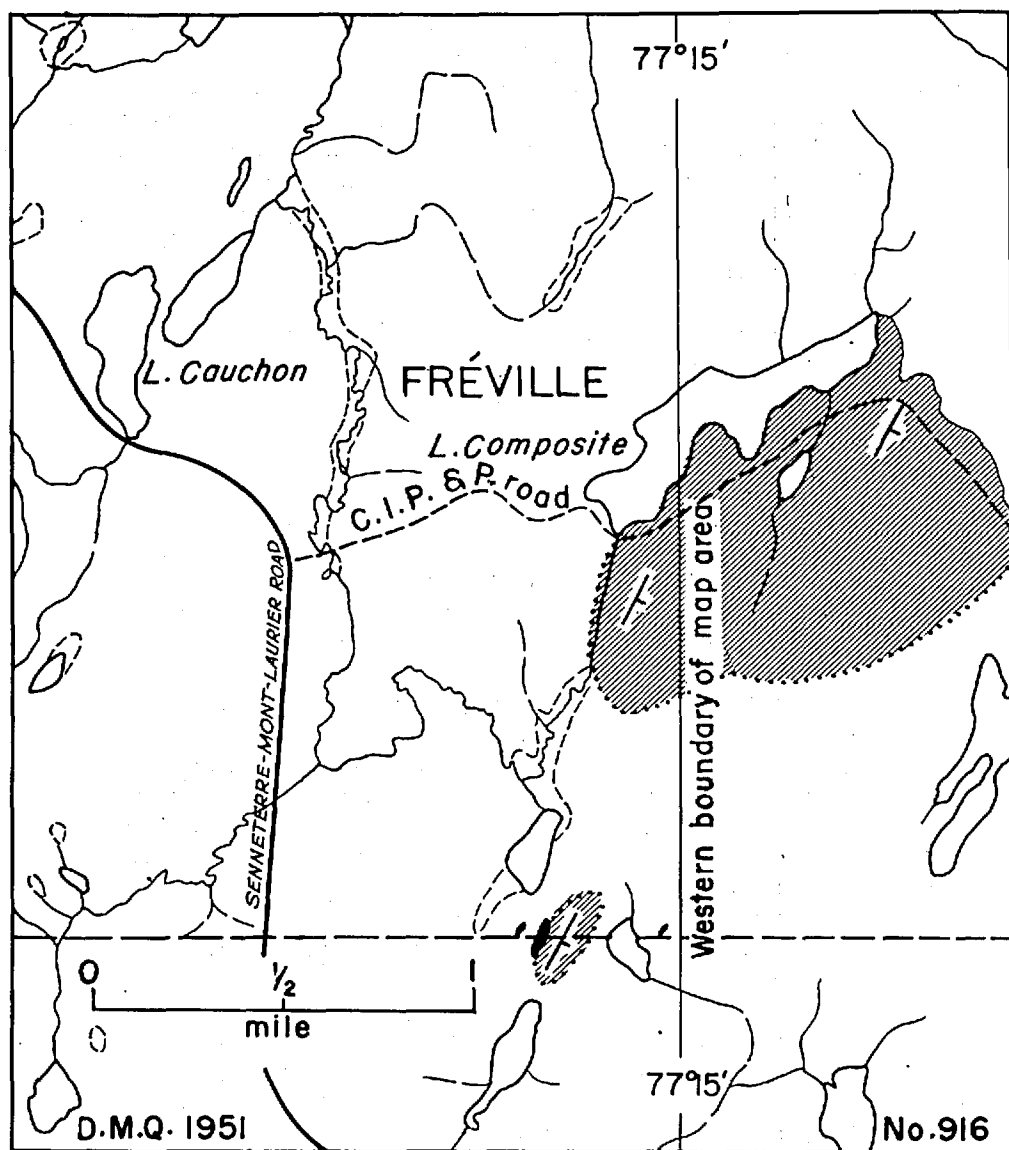
Granite Dyke (Pegmatitic)

Description

This is a coarse-grained mottled grey and green rock containing coarse, light grey feldspar, dark green pyroxene, rose quartz, and biotite. The feldspar grains are large but of consistent size (10 to 20mm.) and make up 70 per cent of the rock. The mafic minerals and quartz are in smaller grains than, and interstitial to, the feldspars.

Occurrence

Only one dyke of this type was seen within the area, on the Canadian International Pulp and Paper Company road, about two miles east of Composite lake. It is about five feet thick and cuts coarse-grained gneisses which strike $N.15^{\circ}W.$ and dip northeast, whereas the dyke strikes $N.10^{\circ}E.$ and is vertical.



■ Greenstone ▨ Composite Gneiss / Strike and dip of Foliation

FIG. 1

SKETCH TO SHOW GREENSTONE EXPOSURES NEAR
CANIMITI RIVER MAP AREA

Greenstone-type Rocks

It was stated in the introduction to this report that one of the objects of the investigation was to determine if possible the relationship of the gneisses to the rocks of the Keewatin-Temiscamian sub-province. The latter rocks are characteristically altered to greenstone types, that is, to metamorphic rocks that are finely schistose and characterized by chlorite, hornblende, epidote, and related minerals. They are thus much less highly altered than the gneisses that in many places have been converted to rocks of igneous aspect. No rocks that belong to the greenstone type were found in the area mapped, although some were encountered only half a mile beyond its western boundary. Because of the importance of the problem of their relationship to the gneisses, a description of the greenstone-type rocks and their occurrence is included in this report.

Occurrence

The most important of the exposures referred to is 4,000 feet east of the highway and on the southern boundary of Fréville township; it is on the side of a steep west-facing ridge, which rises some 250 feet above the adjacent valley. Greenstones form small ledges which protrude through a talus slope; these were traced along the strike (N.5°E.) for about 200 feet but may extend farther. The width of the zone could not be determined because of the talus. The rocks break with a sub-schistose fracture that has a chloritic and slickensided appearance, and in some occurrences they are very finely layered. At one place they are intruded by a coarse-grained, rusty-brown, hypersthene-bearing pegmatite similar to those associated with the quartz syenite intrusives of the present area, but elsewhere no contacts with other rocks were seen. There are no exposures below the greenstones, but lying above and separated from them by some 30 feet of talus there are large exposures of medium- to coarse-grained composite gneisses, the foliation of which is conformable to that of the greenstones.

On the far side of the valley, about 800 feet west of the ridge, there is exposed, at the margin of the muskeg that covers the valley floor, a small body of green rock which contains some injected igneous material or porphyroblasts. The rock is foliated, with strike north and dip east, but whether it is a metamorphosed diorite or a greenstone was not ascertained. The finding of this exposure suggests the possibility that greenstones may underlie the muskeg in the valley.

A few hundred yards south along, and on the west bank of, the stream flowing from the southwestern end of Composite lake, there is an exposure of greenstone measuring about 25 feet by 15 feet. It

is a fine-grained, massive rock with only a weak foliation, which strikes N.15°E. and dips 45°E. Under the microscope it is seen to be similar in all respects to the rocks previously described, and to contain small porphyroblasts of garnet (10%) set in a very fine-grained groundmass of plagioclase (An₂₈), quartz, biotite, muscovite or sericite, and small amounts of carbonates and chlorite. The texture is strongly directional and sweeps around the garnet porphyroblasts. A much smaller exposure only 100 feet north of here shows a strongly foliated green rock which has been injected by thin sills of acidic igneous material. The foliation strikes N.10°E. and dips 40°E., thus conforming to the attitude of other formations in the vicinity. On the eastern side of the stream valley, steep scarps of composite gneisses contain many mafic layers having strikes between due north and N.15°E., and dips to the east of 40° to 55°.

The presence, on the opposite side of the stream valley from the greenstones, of many mafic bands in the composite gneisses, and their injected and plated appearance, could readily be explained by the injection and modification of the greenstones by granite, in much the same manner as the biotite and garnet gneisses were modified, and as a result of which they would grade into coarse-grained composite rocks. As bearing on this suggestion, it should be pointed out that the composite gneisses in this vicinity are at the southern end of a diorite stock and are believed to have formed as a result of its intrusion.

Petrography

In the thin sections examined, these rocks all have a fine grain and a strongly schistose structure which passes around the metacrysts of garnet. They consist of plagioclase (An₂₈), garnet, quartz, biotite, muscovite, and sericite, with accessory carbonates, chlorite, magnetite, and sulphides.

An analysis of the greenstone, reproduced below, shows that the tenor of lime is lower, and that of magnesia higher, than in a normal andesite. Furthermore, the 'norm' does not correspond with that of any known rock of igneous origin. The probability is that the greenstone is derived from a rock of sedimentary origin, probably of greywacke type, as is indicated by the low molal excess of alumina over combined lime, soda, and potash.

Greenstone, South Boundary of Fréville Township,

4,000 Feet East of Highway 58

(Analysts: H. Boileau and J. Gagnon,

Quebec Department of Mines)

SiO ₂	59.81	Na ₂ O	3.88
TiO ₂	0.69	K ₂ O	1.83
Al ₂ O ₃	17.06	H ₂ O+	1.78
Fe ₂ O ₃	1.54	H ₂ O-	0.09
FeO	4.97	P ₂ O ₅	0.18
MnO	0.08	CO ₂	0.38
MgO	4.12	S	<u>0.30</u>
CaO	3.23		99.94

Late Intrusives (Post-Temiscamian?)

Hornblende Gabbro (Amphibolite ?)

Description

These medium-grained massive rocks are mottled green and grey and contain feldspar, hornblende, and some garnet. Some specimens show a parallel arrangement of the inequant crystals.

Occurrence

These rocks are exposed in several localities, but best in the vicinity of Gabbro lake, near the western boundary of the map-sheet.

Petrography

The rocks are medium-grained, granoblastic, and consist of plagioclase, An₄₅ (50%), brown hornblende (40%), and garnet (10%), with very minor accessory magnetite.

The feldspar grains are subhedral to anhedral and are not at all altered. They display good albite and pericline twinning and, rarely, Baveno twinning. The garnet, in small euhedral to subhedral crystals, occurs within and around clusters of hornblende.

In thin section, the rock has more the appearance of an amphibolite than a gabbro.

Hypersthene Gabbro

These are massive, mottled green and grey, granitoid rocks, composed of pyroxene, feldspar, and minor amounts of garnet.

Occurrence

West of Canimiti river, about four miles above its junction with Chochocouane river, there are numerous exposures of these rocks; the largest seen is about 400 feet by 200 feet. Vertical joints that strike S.55°E., and a discontinuous linear arrangement of the crystals in a N.75°E. direction, are the only observed structures. In one place a garnetiferous layer is included in the gabbro. It is probably an inclusion of highly modified paragneiss (see analysis II, on a previous page), but it may be a dyke.

Petrography

These are medium-grained, hypidiomorphic, granular rocks, containing plagioclase, An₄₅₋₅₀ (40%), hypersthene (15%), hornblende (10%), augite (25%), and garnet (10%). Biotite, zircon, and magnetite or ilmenite are accessory.

Quartz Diorite (Red)

This is a medium-grained, pink to reddish, granitoid rock, composed of pink to red feldspar and quartz, with only minor amounts of mafic minerals, chiefly biotite.

Occurrence

East of Numance lake, which is in the northwest corner of the area, there is a large north-south trending ridge that apparently has a core of reddish quartz diorite. Its western flank is steep, and many of the scarps expose interlayered quartz diorite and pyroxene-bearing gneisses; the strike of the layers is between due north and N.10°E., their dip is 60° to 70° east. Above the line of scarps the rock is massive quartz diorite, and injection banding is rarely seen. On its eastern side, the diorite body is in contact with foliated pyroxene-bearing gneisses and granulites that contain a few small lenses of 'hypersthene-augite-hornblende' rock, similar to that previously described in this report.

Only three exposures were found between the base of the ridge and Numance lake. In one of these the rock is foliated quartz diorite; in the other two it is a massive, medium- to coarse-grained pyroxene-hornblende rock that has some acidic bands and appears to grade into quartz diorite. The strikes and dips of their foliation are conformable to those of the other rocks in this locality.

Petrography

The rock is hypidiomorphic, medium-grained, and granular, and consists of plagioclase, An₃₀ (80%) and quartz (15%). Hypersthene was the only accessory mineral noted in the thin sections examined, but biotite also may be seen in some hand specimens.

Hornblende Syenites, Quartz Syenites

Description

These are medium- to coarse-grained granitoid rocks, mottled in pink and green. They consist of mauve feldspar, dark brown hornblende, and quartz, in varying proportions. Some facies contain abundant hornblende, and in some quartz is a very minor constituent.

Occurrence

There are two large stocks and a number of smaller exposures of syenite in the southeastern and eastern parts of the area. The largest is on the south boundary, between the arms of Soulier lake; it extends southwestward into the area mapped by Wahl and Osborne (1950).

In plan, this stock is elliptical, with a northeasterly trend. Including that part which protrudes into the area to the south, it is about five miles long and from one to two miles wide. Exposures of this body were seen in several places along the southern boundary of the area, but farther north none were found and it was only possible to map its probable extent by recording the relative abundance of syenitic erratics and those of gneiss.

There are two distinctive facies in this intrusive. One, the more common, is a mottled pink and green rock; the other has a rich pink colour, contains no hornblende, and is composed of feldspar with 10 to 15 per cent quartz. This latter type is inequigranular and contains some large phenocrysts of mauve feldspar.

Although the intrusive is generally massive, there is a tendency for the marginal zones to have the appearance of a well banded hornblendic gneiss. This may be the result of contamination, of shearing, or of lit-par-lit injections of syenite into the adjacent rocks. The strikes of these foliated zones conform to the long axis of the intrusive. Near the mouth of Blind river, the lineation trends S.45°E. and plunges 55° southeast, whereas within the main mass it trends N.60°-80°E. and plunges 10° to 25° eastward.

The other large syenite mass is in the east-central part of the area, north of Tombbah lake; it also is elongated, being two miles long by one mile wide, with its longer axis trending in a northeasterly direction. In appearance, the rock is similar to that described above, but is intruded by many very coarse-grained, reddish-brown pegmatite dykes, as well as by a few fine-grained aplitic dykes which in places form selvages around the coarser pegmatites before branching off as individual dykes. In thin section, the aplite is seen to consist of microcline (50%), quartz (40%), and plagioclase, An_{30} (10%).

At the southern end of this body and just west of Tombbah lake, a medium-grained reddish pegmatite, containing magnetite, intrudes a mafic facies of the quartz syenite. Half a mile south of here, there is an exposure of mafic syenite that grades into the normal hornblende-bearing variety. This, in places, is markedly foliated and resembles the marginal hornblende gneisses found elsewhere in association with the other intrusives of this group. No sharp contacts between these syenite intrusives and the gneisses were seen, but marginal zones containing what appear to be hybrid rocks occur.

Petrography

The hornblende syenites at the southern boundary of the area are hypidiomorphic-granular, medium- to coarse-grained rocks, composed essentially of micropertthite (45%), microcline (20%), plagioclase, $An_{10}-An_{15}$ and $An_{25}-An_{30}$ (25%), quartz (5%), and hornblende (5%). Accessories are augite, magnetite, and sulphides.

Quartz Diorite, Hornblende Syenite, and Quartz Syenite Pegmatites

Description

These are coarse- to very-coarse-grained, pink to reddish-brown rocks. Minerals to be seen in hand specimen are mauve to reddish feldspar, hypersthene and/or hornblende, and, in some varieties, mauve or opalescent quartz. Magnetite is present, but in small amount.

Occurrence

On highway 58, within a few hundred yards of the western boundary of the area, is a small exposure of pink to reddish pegmatite, composed entirely of reddish to mauve feldspar, and thin sills of similar rock may be seen intruding the hypersthene-bearing rock in the vicinity. Under the microscope, this pegmatite is seen to consist

of microperthitic feldspar, with only accessory zircon, apatite, and plagioclase.

Coarse, reddish to brown hypersthene- and/or hornblende-bearing pegmatites intrude the hornblende syenite stock on the south-east boundary of the area and also that north of Tombbah lake. No thin sections were made of these rocks, but their very coarse, mauve feldspar is undoubtedly orthoclase. Coarse-grained reddish pegmatite containing disseminated magnetite is exposed also at the western end of Tombbah lake. A noteworthy feature is the frequent occurrence of these pegmatites in the more mafic and banded facies of the syenites.

A reddish-brown to dark brown, coarse-grained pegmatite intrudes the 'greenstones' that lie at the southern boundary of Fréville township.

Half a mile outside the western boundary of the map-area, along highway 58, an exposure of medium- to coarse-grained dark green rock contains green feldspar and dark brown pyroxene and/or hornblende. The coarser facies are pegmatitic in appearance. Similar rock is exposed at short distances to the north and south. In thin section the rock is seen to be composed of orthoclase (15%), antiperthite plagioclase, An_{27} (75%), and quartz (10%). Accessory minerals are hypersthene and biotite, which in hand specimen are much more prominent than in the thin sections examined.

Petrography

Under the microscope the textures of these rocks are seen to be hypidiomorphic-granular to inequigranular. Plagioclase (An_{27} - An_{33}) is the commonest mineral, and is moderately closely twinned and little altered. Microperthite, antiperthite, and quartz are present in most varieties of the rock, but mafic minerals are found only in minor amounts.

Basic Dykes

Basic dykes are not numerous in the area, but many of the inclusions or bands found in the granulites and gneisses may be metamorphosed and disrupted dykes or sills.

Metagabbro

Only a few small, sill-like bodies of metagabbro were seen. The rock is dark green, medium-grained, and rusty-weathering. Thin sections show it to consist of hypersthene and hornblende, with accessory feldspar and quartz.

Metadiabase

This is a massive, dark green, medium-grained rock, with a marked ophitic texture in some exposures, and to the eye consists of feldspar and pyroxene in about equal amounts.

A dyke of this rock some six to eight feet thick was seen on Soulier island, in the northwest arm of Soulier lake. It crosses the narrows between the island and the mainland and extends for some 300 yards along the north shore. The strike is between N.50°W. and N.60°W. and the dip is vertical.

Augite-bearing Dykes

Four or five augite-bearing dykes cut the banded hypersthene-garnet gneisses that are exposed along the long rapids on Chocouane river, three-quarters of a mile south of its junction with Canimiti river. They are from two to six feet thick and strike between due north and N.70°E., with dip southeast. They are dark green, fine-grained rocks in which pyroxene and feldspar are the only recognizable minerals in hand specimens. There is a slight increase in grain size toward the centre of the dykes, but no strong chilling along their margins. Foliation is negligible or absent.

Other Basic Dykes

A fine- to medium-grained, brittle, dark green dyke was seen on the Canadian International Pulp and Paper Company road just east of the 77°05' meridian; it appears to strike N.10°E. and to have a vertical dip. Near the only observable contact the rock becomes finer grained and breaks with a subconchoidal fracture. The width of the dyke could not be determined but the exposed width is about 15 feet.

STRUCTURAL GEOLOGY

General Introduction

Metamorphism resulting from elevated temperature and movement has obliterated any former distinctive features of the paragneisses and orthogneisses of the area, leaving a uniformity of appearance that in many places is broken only by slight diversity in colour, grain size, and mineralogical composition. These differences may be a consequence of former contrasting rock types, but they could be the result of alteration produced in the rocks during metamorphism. There appear to be transition zones from one metamorphic rock type to another; these could be contacts that have been obliterated by diffusion at high temperatures, or they could mark bedding in former sedi-

mentary rocks. As a result, no distinctive rock types were found that might throw light on the structural disposition of the original rocks.

Foliation, Schistosity, and Banding

The term 'schistosity' is used in this report to imply a parallelism of the larger dimensions of the platy or tabular minerals such as micas and feldspars, without their segregation into streaks, whereas the terms 'layering' or 'banding' (foliation) are used with the implication of segregation into well defined lenses or sill-like masses of distinctive compositions. Gneisses commonly show both schistosity and layering, which are together called 'gneissic structure'.

In any particular exposure of these gneisses, the schistosity and the layering or banding have identical strike and dip. A marked regional northeasterly strike of the gneissic structure, with consistent dips east or southeast, is apparent. Locally, the gneissic structure indicates folds, such as the one northeast of Gabbro lake, where, in this instance, a fault cuts the fold roughly parallel to its axis. Nose and Beak lakes are believed to occupy basins formed by differential erosion of folded layered rocks. In the same locality, minor folds in faintly layered and un-injected granulites plunge parallel to the axial line of the folds outlined by the lakes, as previously described. It is realized that there is no reason why massive rocks could not be rendered schistose and injected along the schistosity, and at a later date folded; but it is very difficult to visualize layers of such consistent thicknesses and compositions forming in a manner other than by that of sedimentary deposition. Occurrence, conformable to the foliation, of thin layers or lenses rich in mafic minerals are best explained as relics of original beds. Finally, the schistosity seen in one exposure along the old highway near Ottawa river resembles that of a slate rather than that of an igneous rock (see Plate IV-A).

Faults

Numerous faults or fault zones are indicated by the occurrence of 'augen' and 'flaser' gneisses at the bases of hills or in their steep scarps, but only two were found along which movement could be proved. One of these is a broad faulted zone on Canimiti river about a mile northwest of its junction with the Chochocouane; it strikes N.40°E. and dips 60° southeast. In the same vicinity the aeroplane photographs show an apparently truncated north-trending ridge, and this may indicate the presence of other fault zones. The other fault is two miles northeast of Gabbro lake, where the garnet gneisses are cut by a pink 'flaser' gneiss. Here there has been considerable movement,

which has caused a richly garnetiferous rock to be brought against one of low garnet content.

Thrust Faulting (?)

There is some evidence of thrust faulting in the area, possibly along a northeast-striking fault or faults.

Folding

Observations of the strikes of the foliation and banding indicate folding. Where folding has been assumed, however, precise determination of the structure is not possible owing to the fact that nowhere in the area was bedding definitely recognized. The largest assumed fold is northeast of Gabbro lake and extends northeastward for some ten miles.

Joints

The joints in the area are vertical and strike between N.30°W. and N.40°W. They are not injected by igneous material and so were probably formed after the close of igneous activity.

GEOLOGICAL HISTORY AND CORRELATION

As will be evident from what has been said in the foregoing pages, the geology of the map-area is complex. Few formations may be traced any considerable distance, and metamorphism has destroyed many of the structures of the rocks that might have served to clarify the structural geology and throw light on the origin of the rocks.

The oldest rocks of the area contain layers and lenses that, as shown by the analysis on page 17, were once ultrabasic rocks belonging to the pyroxenite group. The ultrabasic rocks are much metamorphosed and were folded with the surrounding formations. Their presence suggests that certain dykes or sills of intermediate or basic composition, whose distinctive characteristics have been destroyed, may also be correlated with these oldest intrusives.

The presence of layered structures in the gneisses indicates that they are, at least in part, of sedimentary origin. This possibility is supported by the analyses given on pages 19 and 21. Furthermore, the presence within the gneisses of the region west of the map-area of 'greenstones' derived from sedimentary rocks suggests that, in at least some measure, the gneisses of the present area must have formed from such greenstones. Lowther (1936) has described Temiscamian-type sedimentary

schists grading into garnetiferous gneisses in the Villebon-Denain area. The gneisses there are in many respects similar to those that are so abundant in the area described in this report. Wahl and Osborne (1950) found limestone and quartzite of Grenville type intercalated with paragneisses in the Cawatose map-area, which is adjacent on the south to the present area. Taken by themselves, the items of evidence cited in this paragraph are inconclusive, but collectively they strongly support the hypothesis that many of the gneisses are of sedimentary origin. The absence of sillimanite, cyanite, and related minerals, indicative of a high tenor of alumina, suggests that the original sediments were not the result of a thorough weathering of the source terrane. In the Grenville region, the alumina content of the rocks is sufficiently high to show that the source of the sediments was in a region with relatively deep and mature weathering.

At some time after their formation, the paragneisses were intruded by ultrabasic, and probably by basic, rocks which were probably emplaced as sills. Still later, the rocks were folded and at the same time injected by igneous material, commonly in lit-par-lit fashion. The resulting metasomatism and injection gave the present characteristics to the gneisses. The presence of the greenstones in the gneisses suggests that most of the metamorphism was induced by a rise in temperature caused by igneous rocks rather than by deep burial. In the typical Grenville region, the alteration is the result of deep burial, for it is uniformly high grade over great areas. After the folding and injection was completed, the area was apparently stable and probably being eroded; then there was another period of igneous intrusion in which the quartz syenites and related rocks were introduced.

The history outlined in the preceding paragraphs is compatible with the suggestion that the paragneisses of the Canimite River area are equivalent to the schists of the Keewatin-Temiscamian region to the north, but they have been altered by the injection of much material from a magmatic source. However, the general structural relationships of the Keewatin-Temiscamian sub-province and the Grenville sub-province do not obviously fit such an interpretation. These relationships are seen on the map of Southern Quebec (Geol. Surv. Can. Map 703A). The formations of the Keewatin-Temiscamian belt trend east to terminate against a northeast line, southeast of which gneisses, with many granites, are found. This latter region is considered part of the Grenville sub-province, but the limestones, sillimanite-garnet gneisses, and quartzites that are characteristic of the southern part of the sub-province do not occur there in force. In the Grenville region in Quebec, from Gatineau river on the west to Saguenay river on the east, the formations trend a few degrees east or west of north.

Northward from there, this trend continues until, near the northeast-trending line of separation of the two sub-provinces, the trend swings to the northeast.

Norman (1936) postulated a fault to account for the relationship of the Grenville and the Keewatin-Temiscamian sub-provinces. Although he gave no absolute evidence for the presence of a fault and expressed no opinion as to its attitude, he suggested later (Norman, 1940) that the rocks of the Grenville sub-province were thrust over the probable Proterozoic rocks near Mistassini lake. Since then, the probability of an overthrusting of the Grenville on the Keewatin-Temiscamian rocks has been accepted by many geologists, although little additional evidence concerning the postulated fault has been presented.

The apparent abruptness of the changes of trends of the formations in the two sub-provinces lends support to the belief that there is such a fault. The fact that the rocks on the northwest side are considerably less metamorphosed than those on the southeast is also suggestive of a fault. However, the data are inadequate to show whether the fault was normal or reverse. Observed normal or reverse faults along the contact may be local, and the exact character of the transition zone or contact for much of its length in the Province of Quebec has not been determined by detailed geological mapping. However, it is to be noted that a normal fault, whereby the belt of Keewatin-Temiscamian rocks would be brought down relative to the rocks of the Grenville sub-province, is as effective in explaining the relationship as a reverse fault. The northern edge of the St-Lawrence Lowlands is marked by normal faults that cut across the south-trending structures in the Grenville rocks. A similar but older series of faults may bound the Grenville sub-province on the north.

Major overthrust faults have a tendency to have traces parallel to the fold axes of the folded structures. The postulated overthrust fault would cut both the east-striking folds of the Keewatin-Temiscamian belt and the north-striking folds of the Grenville region in Quebec.

It is a commonplace that large overthrust faults are likely to be long-travelled, that is, the overriding slice has been brought a long way forward. This means that the correlation of units on two sides of a reverse fault of this type is likely to be hazardous because there may have been a change of facies in the two loci of formation of the original rocks. On the other hand, with a normal fault the distance between the original sites of deposition would not necessarily be great, and the possibility of tracing one formation across the break would be greater than if the fault were an overthrust.

It is unlikely that the actual fault surface will be seen in the vicinity of the Canimiti River area for, if such a fault zone exists, it has been the locus of igneous injections. The material of the ubiquitous lit-par-lit injections probably was formed during folding and probably with the faulting. It would tend to mask any fault that antedated it.

The north-trending folds that are characteristic of much of the Grenville region in Quebec swing northeast as the Temiscamian-Keewatin sub-province is approached. Although much territory remains geologically unmapped, the examination of such published maps as are available suggests that the north-trending folds are older than the northeast structures.

Correlation of the formations of the Canimiti River area must be based on the facts and inferences outlined in preceding sections of this report. The inclusions of greenstone-type metasedimentary rock in the gneisses suggest that some of the gneisses are derived from rocks such as occur in Villebon and Denain townships and were mapped by Lowther (1936) as Temiscamian and Keewatin. Ultrabasic rocks are more abundant in the Keewatin-Temiscamian sub-province than in the Grenville region, and it has been shown that the metamorphic equivalents of ultrabasic rocks occur in the Canimiti River area. These, therefore, probably belong to the region to the north.

The position in the transition zone of the contact between the rocks of the Grenville division and those of the Keewatin-Temiscamian division is not clear. If the limestone and quartzite on the east shore of Canica (Corbell) lake in the Cawatose map-area be considered certainly Grenville, the change must take place in the northern part of that area or within the Canimiti River map-area. Unfortunately, no actual limit could be found or inferred from the mapping. No direct evidence of the age of the Grenville rocks could be obtained. Based on considerations of lithology alone, the Grenville sediments could be equivalent to the Archaean sedimentary rocks of the Keewatin-Temiscamian sub-province if only a slight facies change were admitted.

It is possible to infer something of the age of the fault or faults if it or they exist. The granitic material which forms the abundant lit-par-lit injections would obscure the fault itself. The injections are older than the bodies of pink quartz diorite and pink quartz syenite in the area, and these are similar to 'post-Temiscamian' intrusives in the Keewatin-Temiscamian belt, which are older than the Huronian rocks (at least the Cobalt series). It is reasonable to infer that the fault and the injections are pre-Huronian and

probably Archaean. If such faults have cut the Grenville, the Grenville also must be Archaean. The fact that faulting, if any, in the Canimiti River area is Archaean would not eliminate the possibility of later fault movements along similar northeast-striking faults in other localities.

The earliest intrusives are the grey quartz diorites; they form no rock bodies of large size, but core the ridges and make up the lit-par-lit sills or stringers found in the paragneisses. The gabbros, hornblende syenites, and their associated pegmatites intrude the other rocks as large stocks in a manner conformable to the regional trend and to that of similar syenite and granite stocks in the area to the north that was mapped by Tiphane (1950), where the relationships show the latter rocks to be of post-Temiscamian age. Because of this, the late intrusives of the Canimiti River area are tentatively considered to be of that age.

Folding and thrust faulting were probably accompanied by the intrusion of the early grey quartz diorites, since the proven faults in the area cut folds whereas early pink pegmatites are cut by and fill faults, showing that faulting was probably continuous toward the end stages of early igneous intrusion.

The northeasterly trend of the gneiss complex cuts across the east-west trend of the Keewatin-Temiscamian volcanic and sedimentary belt to the north, which is believed to have been folded in post-Temiscamian times, and in view of this it is probable that the folding and faulting in the Canimiti River area happened at a later date. Mawdsley and Norman (1935, pp.51-57) found that the northeast-striking faults in the Chibougamau area cut off sulphide zones, and also displace Huronian sediments; this, however, only dates the last known movement along these faults, which might have originated in early post-Temiscamian times.

Dynamic metamorphism undoubtedly occurred in the early stages of folding, but its effects were obliterated by the high grade of thermal metamorphism that accompanied the intrusion of the early grey quartz diorite. At a later date, the hornblende syenites and their associated intrusives probably played an important, but much less spectacular, part in the metamorphism of the rocks in restricted parts of the area.

ECONOMIC GEOLOGY

In many parts of the area, the rocks are traversed by quartz veins, but all of those observed are narrow. They rarely contain sulphides, and only a few of those assayed were found to contain even a 'trace' of gold. One of the samples assayed was from a small pyrite-bearing quartz-pegmatite vein near the metadiabase dyke on the mainland at the 'narrows' north of Soulier island. The assay returned a 'trace' of gold.

The thickest quartz vein seen in the area is on the new section of the highway several hundred feet northwest of the bridge over Chococouane river. It is three feet thick, and consists of white quartz with coarse 'books' of biotite along its margins. The vein is in biotite gneiss and not far distant there are exposures of composite rocks which resemble quartz diorite. The strike is N.50°E., conformable with that of the other rocks in that vicinity.

Disseminated sulphides, chiefly pyrrhotite, are found in sugary-looking 'granitized' gneisses in many places throughout the area, but the concentrations of sulphides seen are low and of no economic importance. However, similar rocks a short distance above the mouth of Canimiti river contain pyrrhotite in amount sufficient to deflect a compass needle.

The fault zone on Canimiti river, shown on the accompanying map, is in acidic gneisses which enclose fragments of small, basic dykes. Both rocks contain fine disseminated sulphides, with by far the greater concentrations (one to two per cent) in the dyke fragments, but assays gave only 'traces' of nickel and silver.

On the Canadian International Pulp and Paper Company road, 1,500 feet east of the boundary between Fréville and Champron townships, a quartz-sulphide-graphite zone two to four feet thick is exposed in a greenish acidic-looking rock enclosed in the composite gneisses. The strike is northeasterly. The sulphides - chiefly pyrrhotite - are not abundant, and an analysis gave only 'traces' of silver, lead, and nickel. About 3,500 feet east of here along the road, a very narrow rusty-weathering zone in the composite gneisses contains one to two per cent of graphite and possibly some sulphides. On the same road, west of Canimiti river, the composite gneisses are traversed in places by thin stringers of mauve to opalescent quartz which occasionally carries specks of sulphides. One fracture was seen to have a thin filling of quartz and moderate amounts of sulphides.

The pegmatites in the area are not commonly mineralized, but magnetite was seen in some of those at the eastern end of Tombbah lake.

The area is not considered favourable for gold, but base metal deposits may be present and the fault zone on Canimiti river is worthy of notice. The valleys between many of the ridges in the north-west half of the area may contain shear zones, and relics of 'greenstones' which could be mineralized; but in most places these possibilities can be investigated only by geophysical methods or by diamond drilling because of the absence of exposures.

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