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SAVANE RIVER AREA, MISTASSINI TERRITORY

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GEOLOGICAL EXPLORATION SERVICE

SAVANE RIVER AREA

Mistassini Territory,
Roberval and Chicoutimi Counties

GEOLOGICAL REPORT – 146

E. H. CHOWN

1971

G. R. – 146

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ILLUSTRATION

INTRODUCTION

Location

The Savane River area is bounded by latitudes 51° and 52° North and longitudes 71° and 73° West, and covers about 6,000 square miles. It comprises the west half of map 22 M (Plétipi Lake) and the east half of map 32 P (Lac Baudeau) of the National Topographic Series, both at the 1:250,000 scale. Roughly two thirds of the area is in Mistassini territory, but the eastern portion includes northern parts of Roberval and Chicoutimi counties. The southern limit of the area is 160 miles north of Lake St-Jean. The northeastern ends of Lakes Mistassini and Albanel project into the southwestern corner.

Access

The area is most easily reached by flying. Its center is located about 160 miles northeast of Chibougamau, 175 miles west of Gagnon, and 150 miles west-northwest of Manicouagan-5; all three places have aircraft bases. A landing strip at Albanel Minerals Ltd. property near Lake Albanel can accomodate bimotor wheeled aircraft. A road from Chibougamau to Lake Albanel, built by the Quebec Department of Natural Resources, provides a land (and water) route to the southwest corner of the area. Some Indian trappers still enter the area by conventional canoe routes - from Mistassini Post (near the south end of Lake Mistassini) via Lakes Mistassini and Albanel and Témiscamie river and its tributaries; from Pointe-Bleue (an Indian reserve on the west shore of Lake St-Jean) by ascending Péribonca river.

Canoe travel within the area is relatively easy in the south and east sectors, where rivers and lakes are navigable, but is very difficult in the north and west parts.

Physiography and Drainage

The area between Témiscamie and Péribonca rivers is characterized by a range of rounded hills with 400 to 1,000 feet of local relief, interspersed with fairly large, interconnected lakes. The more rugged hills lie west of the height-of-land separating the Lake Mistassini - Rupert River drainage basin from the Lake St-Jean - Saguenay River basin. Within the map-area, the divide marks the boundary between Mistassini territory and Roberval county. The forementioned range fades out northward in a moraine- and swamp-covered plain which continues both to the southeast, where it is broken by hills east of Benoit lake, and to the northeast, where it ends at the foothills of the Otish mountains. West of Témiscamie river, the land slopes gently up to the Tichégami Mountains block in the northwest, the highest part of the area - about 2,750 feet above sea-level. Just north of Lake Mistassini, the Takwa Mountain block interrupts this plain. Broad, flat-topped hills near Indicateur lake rise to almost the same elevation as the Tichégami mountains to the west.

The southeastern third of the area drains to Lake St-Jean, (and thence to the Saint-Laurent), by the two branches of Péribonca river and their tributaries, Savane and Grande Loutre rivers. The central third of the area drains to Lake Mistassini via the Témiscamie river system, and the northwestern third drains to Lake Mistassini by the Pépeshquasati, Tocqueco and other smaller rivers, or into Eastmain river by its tributary, the Tichégami. All these waters eventually flow into James Bay.

Field Work and Explanatory Note

The eastern half of the area, covering close to 3,000 square miles, was mapped during the summer of 1965 by a 12-man party consisting of 5 geologists, 6 students and canoemen, and a cook. The group worked as 3 two-man, and 1 four-man, field parties operating from fly-camps throughout the area. After each fly-camp, the subparty would return to a base at Bussy lake to plot results and for reprovisioning. Traverses were planned carefully, using air photos and aeromagnetic maps, to covers areas of promising outcrop. Largely drift- amd swamp-covered tracts were not traversed on the ground. Important outcrops in such terrain were visited by aircraft, where possible, at the end of the season. Traverses were closely spaced in the north, east, and southwest, where more intricate geology warranted it. In the rest of the area, the traverses were widely spaced. In the west half of the area, only 600 square miles were mapped in the southeast corner. The other four fifths of that half had been previously mapped for the Department, at a scale of 1 mile to the inch, by several geologists, intermittently during the period 1947-60. The results of their work appear in: Bérard (1965), Chown (1960a, 1960b), Hashimoto (1960), Neale (1965), Neilson (1966), and Wahl (1953). The present map includes a compilation of their mapping at a scale of 1 inch to 4 miles. Readers are referred to the above publications for a more exhaustive treatment of the lithology particularly that of the basement rocks of the Superior province and of the younger Mistassini Group strata. The Grenville and the Otish Group rocks, which are not discussed thoroughly in previous publications, are described more fully in this report, although is must by emphasized that all the work herein reported is based on reconnaissance only.

Acknowledgements

Besides the earlier work within the map-area (referred to above), previous work, in adjoining areas, includes: Eade (1966), to the north; Chown (1964, 1965), and Chown and Hashimoto (1965), to the east; Chown (1962), to the west; and Neilson (1953) and Laurin (1966, 1967), to the south.

The writer wishes to thank Paul-J. Conlon and Gérard Woussen, senior assistants; Andrew Spykerman, special assistant courtesy the Colombo plan; and G.B. Knox, student assistant; who were responsible for much of the mapping. Jean-Guy Pageau, student assistant; J.A.H. Fortier, Robert Lemieux, Lawrence Neeposh, Sam Neeposh and Gilles Pouliot, canoemen; and F.X. Lapointe, cook; all worked very hard under sometimes unpleasant conditions to assist in finishing the field work on schedule. Their help is gratefully acknowledged.

Merril Island Mining Corporation Ltd. made available to the author a detailed geological map of its Holton Lake claims enabling a revision of the geology in that sector. The cooperation of the company is much appreciated. Société Minière de Québec (SOQUEM) brought to the writer's attention several important outcrops in the largely drift-covered northeast corner of the area.

GENERAL GEOLOGY

Summary

The consolidated rocks of the area are all Precambrian in age, and embrace parts of two major tectonic provinces of the Canadian Shield - the Superior and the Grenville.

The complex of steeply dipping basement rocks, trending east to southeast, that underlie the northwestern part of the area belongs to the Superior province. This complex includes quartz-plagioclase-biotite gneiss; metavolcanic rocks, ranging in metamorphism from greenstones to amphibolites, and metamorphosed ultrabasic rocks; all with parallel structural trends. Massive and gneissic granite bodies, locally porphyritic, have intruded the metamorphic rocks and have converted much of the gneiss to migmatite. A small swarm of quartz-feldspar porphyry dikes cuts the granite and earlier rocks near the confluence of Pépeshquasati and Holton rivers.

The southeastern half of the area is underlain by metamorphic and intrusive rocks belonging to the Grenville province. These rocks have a dominant southeast trend, which is cut off by a later northeast trend, in a tectonic zone 5 to 10 miles wide along the contact with rocks of the Superior province. Metamorphic rocks of the Grenville sequence include a broad range of quartzofeldspathic gneisses, as well as amphibolites and metamorphosed ultrabasic rocks. Parts of two anorthosite masses are present in the Grenville, one occurring along the western border of that province, the other east of Savane river, along the east boundary of the map-area. Permissive gneissic granitic intrusions occur locally. Within the northeast-trending tectonic zone are a series of massive, granite bodies. A group of syenitic, intrusive masses occurs near the south border of the area.

A group of younger rocks overlies the Superior complex, and may also overlie the Grenville. It comprises Late Precambrian sedimentary rocks of two contemporaneous groups - the Mistassini and Otish Groups. Finally, a series of basic sills and dikes, the Otish Mountains intrusives, intrude both sedimentary groups.

Large parts of the area are heavily mantled with glacial deposits, chiefly till and moraine. Eskers, trending south to southwest, are very prominent.

Table of Formations

CENOZOIC		Recent and Pleistocene	River, lake and swamp deposits Till, sand and gravel
		Unconformity	
PRECAMBRIAN	LATE PRECAMBRIAN	Otish Mountains Gabbro (Coom Lake Gabbro)	Gabbro, diabase, uralitic gabbro
			intrusive contact
		Otish Group	Upper Division Lac Indicateur Formation Témiscamie Formation
		Mistassini Group	Upper Albanel Formation Lower Albanel Formation Chéno Formation Papaskwasati Formation
		Unconformity	
	GRENVILLE	Acid intrusive group	Syenite Granite, granodiorite, pegmatite
		Basic intrusive group	Anorthosite and associated gabbros, pyroxenite, peridotite
		Metamorphosed Ultra-basic intrusives	Metapyroxenite, metaperidotite
		Metavolcanic rocks	Amphibolite, garnet amphibolite
		Gneiss complex	Quartzofeldspathic gneiss, quartz-feldspar-biotite gneiss
	SUPERIOR	Porphyritic intrusives	Quartz-feldspar porphyry
		Granitic complex	Granite to granodiorite, pegmatite and migmatite
		Meta-ultrabasic rocks	Metapyroxenite?
		Metasedimentary and metavolcanic rocks	Graywacke, sandstone, conglomerates and iron formation; metabasalt, metagabbro, metamorphosed fragmental volcanics, amphibolite and greenschist
		Gneiss complex	Quartz-plagioclase-biotite gneiss

Superior Province

Gneiss Complex

Much of the northwestern part of the map-area is underlain by quartz-plagioclase-biotite gneiss, largely converted to migmatite. The gneiss is variable in appearance, ranging from a schistose, layered variety to an almost massive type. Most of the gneiss consists of alternating dark- and light-colored layers 2 cm. to 1 m. thick. Variations in the mafic content, chiefly biotite, cause the change in color.

In thin-section, slightly altered subhedral plagioclase (An_{30}) is seen to compose 55 to 65% of most specimens. Muscovite, epidote and carbonate alterations crowd the feldspar laths, commonly replacing one twin preferentially. Ragged, yellow to dark-brown, biotite flakes are evenly distributed through the gneiss, but are well oriented only in the mafic layers. Chloritic alteration of biotite occurs as thin interleaves in the flakes. Biotite forms 10% of most rocks increasing to 25% in schistose layers. Strained quartz grains, 0.5 to 5 mm. long, replace both plagioclase and biotite and constitute a fairly constant 20% of most gneisses. Minor interstitial fillings of clear microcline occur in rocks grading into migmatite. Magnetite and apatite occur commonly as accessory minerals, and zircon and sphene less commonly. Thin layers of amphibolite occur within the gneiss complex. Both gneiss and amphibolite are intruded by dikes and sills of pink granite.

Metasedimentary and Metavolcanic Rocks

Recognizable metasedimentary and metavolcanic rocks occur in two main east-trending belts and in numerous small inclusions in the granite-gneiss complex. The first belt occurs just north of Lake Mistassini, and is composed chiefly of metasedimentary rocks, with minor metavolcanic rocks. The second belt stretches intermittently from the west border of the area, near Holton lake, to Indicateur lake in the north center part of the region; it consists chiefly of metavolcanic rocks, but passes into dominantly sedimentary rocks to the west (Chown, 1962).

The metasedimentary rocks include graywacke, argillaceous sandstone, granule and pebble conglomerates, and iron-formation. All the detritial sedimentary rocks retain a distinct clastic texture, somewhat modified by metamorphism. The original subrounded to angular clast can be clearly distinguished. The sorting and maturity of the rocks ranges from poorly sorted graywackes and siltstones to mature subarkoses and a few thin beds of quartzite. The metamorphic effects tend to obscure the original textures. These effects include stretching of pebbles and granules or of any clast somewhat larger than the rest, straining of most quartz grains, and the complete recrystallization of all argillaceous matrix. The matrix, and possibly some of less resistant clasts, is now converted to a mat of well oriented mica flakes. The mica, chiefly muscovite, penetrates some of the clasts and is bent around others. The iron-formation is essentially a recrystallized chert with minor ferruginous layers, and does not occur extensively. Sillimanite was noted in some of the metasedimentary rocks just west of the area (Chown, unpub. ms.) and serves as an indicator of the metamorphic grade of the second belt of rocks.

The metavolcanic rocks include metabasalt, metagabbro and metamorphosed fragmental volcanic rocks. Each type can be distinguished where the rocks are not too strongly sheared, even through metamorphism to the middle-amphibolite facies. However, recrystallization obscures the textures at the highest level of amphibolite metamorphism in the area. The volcanic rocks correspond chemically to the gabbro-basalt suite. The mineral assemblage is simple in these rocks. Those within the greenschist facies consist of albite, epidote, chlorite and leucoxene, with minor quartz. Pale green actinolite replaces chlorite and some epidote in the transition through epidote amphibolite to the amphibolite facies. Most of the rocks are composed of andesine ($An_{30\ 35}$), blue-green hornblende, and ilmenite, with accessory amounts of quartz, biotite, epidote and garnet (particularly common in the fragmental volcanics). Many of the rocks are strongly foliated and have a nematoblastic texture. Other specimens are simply granoblastic and show either clearly discernible relict textures, or non-oriented granoblastic textures.

Amphibolite containing brown-green hornblende, pink clinopyroxene, and andesine (An_{35-38}) occurs in the extreme north of the area. No relict textures are observed in these amphibolites.

The stratigraphy of the two belts is imperfectly known. Chown (1971) estimates the thickness of the metavolcanic sequence to be greater than 8,000 feet, but extremely variable because the volcanic rocks are of the shield volcano type rather than broad continental flows.

Meta-ultrabasic Rocks

Numerous small lenses of metamorphosed ultrabasic rocks, many too small to map, occur in the area, chiefly associated with the metavolcanic rocks. The rocks have characteristic reddish brown, lumpy, weathered surfaces. Fresh surfaces are dull, with a greenish cast. The mineral composition of the rocks varies slightly with a change in metamorphic grade in the area.

Ultrabasic rocks occurring with blue-green hornblende amphibolites are composed of 1 to 5 cm. tabular hornblende crystals in a matrix of 1 to 2 mm. hornblende and phlogopite crystals. The hornblende is pale green and has the optical characteristics of a magnesian amphibole. Amphibole makes up 90%, phlogopite 5%, and brown spinel with opaque minerals 5% of the rock.

Metamorphosed ultrabasic rocks occurring with clinopyroxene-bearing, brown hornblende amphibolites contain only 50 to 60% partly oriented amphibole crystals 0.4 to 0.8 mm. long. Relict large crystals are visible only on weathered surfaces. Pale pink clinopyroxene, partly altered to a fine-grained mixture of talc, serpentine and magnetite, makes up 30 to 40%

of the rock. Green spinel, magnetite and ilmenite, with minor actinolite and phlogopite, compose the remainder.

The rocks are crudely foliated in all localities, and the foliation parallels that of the enclosing gneisses. Ultrabasic rocks are known to crosscut garnetiferous schists at a locality just west of the area (Chown, 1962).

The rocks are thought to be ultrabasic intrusions that were metamorphosed and folded with the gneisses and metavolcanic rocks. Originally they were probably pyroxenites or peridotites, but may have been hornblendites.

Granitic Complex

Migmatite, a mixture of gneiss and granite, is abundant, and much may actually occur within areas shown on the map as gneiss. Arbitrarily, if the gneiss had more that 25% granitic material it was mapped as migmatite.

Many migmatites preserve the even banding of the gneisses, with alternating layers of gneiss and sills of pink or gray granitic material. With increasing granite content the gneissic layering becomes discontinuous and irregular, often highly contorted. Many small crosscutting granitic and pegmatitic dikes are observed. Most granitic sills have gradational contacts with the gneiss, whereas the dikes have sharp contacts.

Thin-sections show that plagioclase (An_{30-35}) makes up 50% of the typical gneiss. Brown-green biotite, partly altered to epidote and chlorite, makes up 5% of the rock. Large amoeboid quartz grains (30%) appear to replace both plagioclase and biotite. Fresh perthitic microcline (15%) replaces all the other major minerals. A thin sodic rim is added to the andesine adjacent to the microcline. Magnetite, apatite, zircon and sphene are the minor accessory minerals. The granitic parts of the migmatite are essentially identical to the main mass of granite described next.

The granite of the complex appears to be nearly all the result of conversion of gneiss by potassic metasomatism. Much of the rock is actually granodiorite and is partly gneissic, but some massive pink granite is also present, particularly in the Takwa and Tichégami mountains.

The texture of the gneiss is still present in most specimens of granite. Slightly altered plagioclase (An_{24-28}) forms 35% of the rock; it is intergrown with brown biotite, largely converted to chlorite. These minerals are embayed by large amoeboid quartz grains constituting 15% pf the rock. The remaining 50% of the granite is microcline, occurring in crystals up to 1 cm. in diameter replacing the finer-grained earlier minerals. Some sodic rims are present on the remnant plagioclase crystals adjacent to microcline. Much of the microcline in slightly perthitic. Magnetite, apatite, zircon,and sphene are accessory minerals.

The texture of the granite and the permissive nature of many of the satellitic dikes indicate a metasomatic origin for the complex.

However, many structures within the migmatite are discontinuous and contorted, and the granite clearly cuts across or distrubs many earlier lithologic units. Therefore, the main granite bodies are thought to have been mobile and to have intruded the metamorphic series.

Porphyritic Intrusives

Quartz-feldspar porphyry occurs only near the junction of Pépeshquasati and Holton rivers. The main group of exposures may constitute a small intrusive stock or a dike swarm. Some nearby dikes of porphyry cut both the quartz-plagioclase gneiss and granitic dikes intruding the gneiss. To the south, the Papaskwasati Formation overlies the porphyry and the basal arkose of this formation, derived from the porphyry, is almost identical with it.

Most outcrops of porphyry are dark red, but a few are pink, green, gray or jet black. Phenocrysts of glassy quartz and red tabular feldspar rarely constitute more than 35% of the rock and commonly less than 10%.

The rock has a porphyritic, locally glomeroporphyritic, texture. The phenocrysts of hematite-stained plagioclase and potassic feldspar are heavily altered. Quartz phenocrysts are partly resorbed. The mesostasis is partly recrystallized to spherulitic masses of potassic feldspar which radiate from the phenocrysts. Pyrite and magnetite are late forming, minor, accessory minerals. Second generation quartz coats joints and fractures, and fills pressure shadows around quartz and pyrite crystals.

Metamorphism

The sequence of metasedimentary and metavolcanic rocks has undergone two metamorphisms. The first converted the original sedimentary and volcanic rocks to gneisses, greenschists and amphibolites, and developed the pronounced foliation that predominates in these rocks. The first metamorphism shows an increase in grade from greenschist facies rocks in the southern belt, to blue-green hornblende amphibolites in the main volcanic belt, to clinopyroxene-bearing, brown hornblende amphibolites in the extreme north of the area.

The second metamorphism is locally developed, especially adjacent to granitic intrusions; it consists of a partial retrogression of the minerals of amphibolite grade to those of greenschist grade metamorphism.

The two metamorphisms appear to have affected all the early rocks, but the effects are most evident in the metavolcanic rocks.

Grenville Province

Gneiss Complex

Most of the southeastern part of the area is underlain by a complex of quartzofeldspathic gneisses. Four or five varieties of gneiss occur in the complex, but their inter-relations are not discernible at the present broad scale of mapping.

The gneisses range from a fairly massive, coarse-grained quartz-plagioclase gneiss with minor biotite; through a gneiss composed of 0.5 to 5 cm. layers of quartz-plagioclase gneiss alternating with dark gneiss layers rich in biotite; to a well foliated, but massive appearing, dark, quartz-plagioclase-biotite gneiss. Minor layers of amphibolite, garnet amphibolite, and quartz-plagioclase-biotite-hornblende gneiss occur throughout the sequence. Locally, many of the gneisses are cut by small pegmatite dykes and sills, and are permeated by pink potassic feldspar. Some of the less mafic gneisses are converted to gneissic granodiorite. In general, however, there is far less granite in the Grenville gneiss complex than in similar gneisses occurring in the Superior province.

Weathered surfaces of the gneiss are silvery to dusty gray, and have a readily visible layered appearance. The medium- to coarse-grained mineral grains are clearly seen on fresh surfaces. All but the minor accessory minerals can be seen in hand-specimen. Contacts between light and dark layers are sharp and constant along strike. The layers are commonly flexed into minor folds 10 cm to 3 m. in amplitude. Biotite flakes in the gneiss are well oriented parallel to the layering. In rare instances, however, the flakes lie parallel to the axial planes of small folds and cut across the layers in the nose of the folds. In most of the gneisses, particularly in the schistose layers, the mica flakes are elongate or crinkled, imparting a pronounced lineation lying in the foliation plane.

Microscopic examination shows all varieties of gneiss to be fairly similar. The texture of all the gneisses is granoblastic, with anhedral quartz and subhedral plagioclase forming a mosaic of grains 0.1 to 1 mm. in diameter. In some rocks, plagioclase grains are as large as 5 mm. Prismatic and layered minerals are well oriented and are chiefly concentrated into layers. Quartz forms 20 to 30% of most rocks; plagioclase is more variable, ranging from 35 to 70%, inversely to the content of dark minerals. The plagiocalse is oligoclase (An_{20-30}); the more calcic feldspar occurs in mafic-rich rocks, particularly the hornblende-bearing gneisses. Albite (An_{8-10}) occurs in the pegmatite dikes and sills. Microcline is present in trace amounts in over half the specimens examined, and constitutes 20 to 35% of some of the gneisses. The microcline is pink and is clearly visible in hand-specimens. The chief mafic mineral is biotite, pleochroic from pale yellow to dark brown. It ranges from 5% in the quartzofeldspathic gneiss to 20% in the dark, unlayered, quartz-plagioclase-biotite gneiss, but drops to 1 to 5% in the hornblende-bearing gneiss. Blue-green hornblende (5 to 20%) is the chief mafic mineral in the hornblende-bearing gneiss, but small quantities of 0.5 mm. euhedral garnets are also common. Garnet also occurs in the more mafic biotite gneisses. Muscovite is present in most gneisses from trace amounts to 30% in some schistose layers. Epidote, sphene and apatite are present in almost all these gneisses; opaque minerals - magnetite, pyrite and leucoxene - occur in about half the rocks.

Metavolcanic Rocks

Metavolcanic rocks, chiefly amphibolite, occur in thin layers within the Grenville gneiss sequence almost everywhere. In general, however, the layers are not thick, or continuous enough to be mappable units. Where these amphibolites do occur as mappable units, particularly in the central part of the area, the trace of the layers gives some idea of the structural complexity of the area. For this reason, considerable attention was paid to this unit in the field.

Amphibolites constitute all the metavolcanic group, except for local sheared areas where the rocks have been retrograded to greenschists. Both garnet-free and garnet-bearing amphibolites occur, for the most part seperately, but in some localities the two are interlayered. The amphibolites stand out in relief over the quartzofeldspathic gneisses on both the topographic and aeromagnetic maps.

Amphibolite

The garnet-free amphibolites are largely fine to medium grained and strongly foliated. A few are coarsely crystalline and have a completely metamorphic texture. Such amphibolites occur close to pegmatitic intrusions. Some of the amphibolites are relatively massive and retain palimpsest textures suggesting their derivation form basaltic and gabbroic rocks.

Plagioclase and hornblende, and in some cases biotite and epidote, are the only minerals discernible in hand-specimen. Microscopic examination indicates the composition to be andesine (An_{30-35}), 40 to 50%; blue-green hornblende, 25 to 50%; biotite, 0 to 15%; and quartz, 0 to 10%; with minor amounts of opaque oxides, apatite and sphene occurring as primary accessory minerals, and epidote, chlorite and carbonate as minor alteration minerals. Most amphibolites are granoblastic aggregates of 0.2 to 1 mm. anhedral plagioclase and euhedral hornblende, but in a few, relict ophitic textures are visible in the arrangement of numerous plagioclase grains forming a remnant lath enclosed by an aggregate of hornblende grains. In many such rocks, the apparent grain size in hand-specimen is much coarser than the actual grain size seen in thin-section, as the aggregates of hornblende crystals appear, megascopically, to be one grain.

Garnet Amphibolite

About 30% of the amphibolites in the gneiss complex are garnet bearing. The only field difference between these and other amphibolites is the presence of garnets. In most of these rocks, garnets form clearly visible porphyroblasts, up to 1 cm. in diameter, which stand out on weathered surfaces. However, in a few amphibolites the garnets are only 1 to 2 mm. in diameter and are visible only on close examination.

In thin-section, all the garnet amphibolites show a completely granoblastic texture. Euhedral garnet porphyroblasts are shot through with small blebs of quartz, and most are surrounded by a thin selvage of quartz and plagioclase. Garnet constitutes up to 15% of some specimens, but is present in only small amounts in others. Plagioclase and hornblende occur in roughly equal quantities, each composing 35 to 50% of the rock, titan-biotite forms 1 to 7%, quartz 2 to 10%, with traces of apatite, sphene, and opaque minerals constituting the accessory suite. Plagioclase is andesine (An_{30-38}); the hornblende is blue-green in many specimens but brownish green in a few. One specimen examined contained 10% colorless to pale green clino-pyroxene, indicating at least a local increase in the grade of metamorphism.

Metamorphosed Ultrabasic Intrusives

Partly metamorphosed ultrabasic rocks occur in small pods, rarely more than 1,000 feet long, throughout the Grenville gneiss complex. In particular, they occur in a zone extending southeast along strike from Bussy lake to the south border of the area.

All these rocks are metamorphosed, and most have at least a rude foliation which corresponds to the trend in the surrounding gneiss. The masses were not observed cutting across this trend anywhere in the area. In the field, the ultrabasic rocks have a characteristic nubbly weathered surface which is light to dark brown. Many of the rocks are strongly magnetic, others are not at all magnetic.

The major constituent of almost all the ultrabasic rocks is green amphibole, very faintly pleochroic in thin-section. This mineral composes 20 to 95% of all the rocks examined microscopically. It forms a nematoblastic mat of needles 0.5 to 2 mm. long which completely obscures all relict textures in the rocks in which it is dominant. Most specimens, however, retain some relict minerals or textures. Olivine and hypersthene relics occur in different rocks, but not together. Relict minerals are strongly altered to serpentine which formed after the amphibole. Bastite pseudomorphs occur in some of the rocks. Other minerals include minor primary accessory minerals such as magnetite and ilmenite, and metamorphic minerals such as phlogopite, 0 to 15%, talc, 0 to 35%, carbonate, sphene, serpentine and associated opaque minerals.

Anorthosite Masses

Parts of two bodies of anorthosite lie within the map area. The western mass, called the Béthoulat Lake series, occurs just east of Témiscamie river, and has been well described by Neale (1965) and Bérard (1965). The second mass, occurring north and east of Benoit lake, is the western tip of a zoned body mapped by Chown (1964) and Chown and Hashimoto (1965).

The two masses are similar; both contain considerably more pyroxene-rich facies than many of the relatively pure anorthosite occurring farther south, and both have been sheared and granulated. The rock types in both masses are essentially the same; however, the specimens described in this report are chiefly from the eastern, or Pambrun Lake, massif with which the writer is more familiar.

Anorthosite

The anorthosite is composed of over 90% labradorite (An_{40-56}) in large, blue crystals, partly crushed, and surrounded by white, granular labradorite. Crystals are commonly around 8 cm. long. but range from 1 cm. to 1 m.. Locally, the rock is completely granulated and is pure white with a sugary texture. Minor amounts of clinopyroxene in the anorthosite are invariably surrounded by a megascopically visible, double corona of black hornblende and red garnet. The pyroxene occurs both as large euhedral crystals and as irregularly shaped grains enveloping labradorite laths. Minor amounts of ilmenite and magnetite occur as small, discrete, fine-grained segregations surrounded by a garnet halo, or occurring with pyroxene crystals.

Gabbroic Anorthosite

Most of the Pambrun Lake anorthosite mass and the Bétholat Lake series are composed of gabbroic anorthosite. Gabbroic anorthosite, as defined by Buddington (1939), contains more than 10% and less than 25% mafic minerals. This classification has been stretched slightly, as most of the rocks in the area contain 15 to 30% mafic minerals.

The gabbroic anorthosite has a rusty brown, lumpy, weathered surface, mottled light and dark. Most outcrops are deeply weathered and fresh specimens are obtainable only from cliffs or river valleys, where continued erosion has stripped off the rotten weathered rock. Decomposition of the mafic minerals stains the plagioclase uniformly. The plagioclase (andesine-labradorite, An_{40-55}) occurs as large gray-blue crystals up to 30 cm. long, commonly partly broken and seamed by white plagioclase and garnet. Brown clinopyroxene is surrounded by coronas of green or black hornblende and garnet. Pyroxene crystals range in size from 1 cm. to 1 m.. Most stubby pyroxenes are 1 to 20 cm. in maximum dimension, and many are strongly distorted and largely converted to amphibole. In the foliated rocks near the border of the massif, pyroxene crystals converted to amphibole are elongated to "smear" lineations up to 3 m. long.

Pyroxenite, Peridotite

Layers of pyroxenite 5 cm. to 10 m. thick are prominent in the gabbroic anorthosite unit. The pyroxenite is composed of an interlocking mesh of brown pyroxene crystals partly altered to green hornblende, with minor opaque oxides and spinel. The peridotite has a similar texture but contains olivine with the pyroxene. The grain size in both rocks varies directly with the thickness of the layer. Pods of magnetite, ilmenite and spinel with rounded inclusions of olivine and pyroxene occur in north- and east-trending peridotite layers north of Benoit lake and in east-trending layers near Pambrun lake. Few are reported in the Béthoulat Lake series.

Border Facies

An assemblage of anorthositic gneiss, garnet amphibolite and mixed gneisses borders the Pambrun Lake massif in the south and east, and the Béthoulat Lake series on the east. Anorthositic gneiss, a plagioclase-quartz-hornblende-garnet rock with a partly foliated, quasi-igneous testure, is the dominant rock. Garnet and hornblende (with minor biotite) occur in 5 mm. to 2 cm. rounded or elongate clots of 1 to 2 mm. crystals. The granular white groundmass contains plagioclase (An_{25-30}) and 10 to 20% quartz, and constitutes more than 60% of the rock.

Uralitic Gabbro

A mass of porphyritic or ophitic, uralitized gabbro occurs east of Témiscamie river, northwest of Coursay lake. This metagabbro is intruded by massive granite, and may be related to the anorthositic intrusions.

The metagabbro is metamorphosed to the epidote-amphibolite facies, being composed of albite, some chlorite, epidote and pale green uralitic amphibole. Relict porphyritic and ophitic texture is common.

Syenite

Massive to slightly gneissic, pink syenite occurs just east of Témiscamie river, south of Albanel lake. Both syenite and granite are well exposed in the Témiscamie mountains. The close association of the two rocks led Neilson (1966) to consider them as two facies of the same intrusion. Certainly the two rocks differ little in composition except for the paucity of quartz (0 to 15%) in the syenite.

The syenite is medium to coarse grained with a granitic texture. It consists largely of perthitic microcline in large, partly strained and altered crystals, with a trace of albite (An_{10}), 10% biotite and up to 15% quartz. The biotite occurs as clots of ragged flakes partly altered to chlorite and epidote. The quartz occurs in myrmekite sieving potassic feldspar, and as minor discrete grains. Scapolite, muscovite and carbonate occur as alteration minerals in the potassic feldspar.

Granite

The Grenville gneiss complex, in contrast to the basement rocks of the Superior province, contains little granite. Minor pegmatitic intrusions, with associated permeation of the gneiss by potassic feldspar, occur in the gneiss sequence and have been described with the gneiss. Two lenses of gneiss occurring in the southeast are sufficiently rich in potassic feldspar to be considered gneissic granite. By far the largest concentration of granite in the sequence occurs in a ½ to 2 mile wide unit in the northeast-striking tectonic zone, just east of the Témiscamie river. Discontinuous smaller lenses of the granite occur within the adjacent gneiss and amphibolite.

The main lens of granite contains all gradations from a massive, coarse-grained, pink granite with large blue quartz crystals to a strongly sheared granite in which blue quartz "eyes" and random potassic feldspar crystals are the only remnant of the original granite. A distinctive, coarse-grained, granitic, augen gneiss is the most common rock.

The coarse-grained, augen gneiss contains 1 to 2 cm. augen of pink microcline enveloped by thin folia of black biotite. Smaller microcline, plagioclase and quartz grains fill the interstices between the augen. Bluish quartz grains strung out in a line suggest derivation from the crushing of a larger crystal. The rock has a marked foliation, although individual foliation planes are highly irregular as they swing around the microcline augen. Strained quartz makes up 20% of the rock, oligoclase (An_{20-30}) 30 to 40%, and perthitic microcline 20 to 40%. Muscovite 0 to 5% and biotite 5 to 10%, with traces of sphene, epidote and apatite, complete the rock. Thus, the augen gneiss ranges from a true granite to a granodiorite. Blue-green hornblende is a frequent varietal mineral in the granitic augen gneiss, particularly in the section of the complex adjacent to the Béthoulat Lake series. Here, hornblende composes 15% of the rock, oligoclase and microcline occur in equal quantities, and some minor biotite is present.

Massive, coarse-grained granite occurs in several bodies west of the granitic augen gneiss lens. Blue quartz crystals 0.5 cm. in diameter are intergrown with 0.5 to 2 cm. potassic feldspar crystals. The granite has a very low tenor of biotite (less than 5%), a trace of albite (An_{10}), 30% quartz, and 65 to 70% microcline. The distinctive, blue, quartz grains are also clearly seen in a strongly sheared part of this granite (blue quartz gneiss - Wahl, 1953) which occurs along the eastern edge of the zone of massive granite. Broken crystals of potassic feldspar are megascopically visible in parts of the sheared granite, but most of the rock appears to be made up only of quartz and micaceous minerals. In thin-section, however, very fine (.05 to 0.1 mm.) grains of quartz and potassic feldspar are clearly seen amongst the micaceous minerals (chiefly muscovite with minor biotite) that form the groundmass of the rock.

Late Basic Dikes

Dikes of basic rock were noted cutting granitic segregations in the Grenville gneiss in two localities, but all are too small to show on the map.

Several basic dikes cut amphibolite and pegmatite in an exposure 2 miles southeast of Bussy lake. One of the dikes is 3 m. thick, the rest are much thinner. The dike rock is an unfoliated amphibolite with a well-preserved ophitic texture. It contains 50% andesine (An_{35}), 40% blue-green hornblende, 7% biotite and 3% sphene.

Minor thin seams of biotite lamprophyre cut granite and gneiss in several exposures in the southwest corner of the area, about 6 miles east of Témiscamie river. This rock contains numerous phenocrysts of biotite up to 1 cm. in diameter in a foliated matrix of plagioclase and black hornblende.

Metamorphism

Rocks in the Grenville province appear to be metamorphosed to the amphibolite facies throughout. Few amphibolites retain relict textures and most are garnet-bearing; a few contain clinopyroxene. Amphibolites in the northeast-trending tectonic zone appear to be all blue-green amphibolite, possibly slightly lower in metamorphic grade. Slight retrogressive effects are noted adjacent to small, massive, granite intrusions, but these are not widespread.

Late Precambrian Rock Units

Mistassini Group

The Mistassini Group consists of five formations (Bergeron, 1957) all of which are exposed within the map-area, at the north end of the Mistassini basin. These formations are, in ascending order: the Papaskwasati, Chéno, Lower Albanel, Upper Albanel, and Témiscamie Formations. The middle three formations are estimated (Neilson, 1950) to be at least 6,500, and possibly more than 8,400, feet thick. The Papaskwasati Formation is estimated to be 700 feet thick (Chown, unpub. ms.) and the Témiscamie 1,000 feet (Neilson 1950), giving a total of 8,200 to 10,100 feet for the whole group. The group forms a broad shallow trough a little longer and wider than Lake Mistassini itself.

Papaskwasati Formation

The lowermost formation of the Mistassini Group is exposed only at the north end of the Mistassini basin. Elsewhere, along the west and south edges of the basin, dolomitic rocks of the upper formations lap over the basement complex. The Papaskwasati Formation is chiefly composed of gray to white subarkose, quartz-pebble conglomerate and orthoquartzite.

Conglomerate dominates the lower part of the formation, decreasing upwards into massive subarkose with minor conglomerate lenses near the middle of the section. Basal conglomerates contain boulders and fragments of the underlying bedrock in an arkosic matrix; however, most of the conglomerates contain only subrounded to rounded quartz pebbles 0.5 to 5 cm.in diameter in a disrupted framework within a matrix of rounded to subrounded, partly sorted, subarkose identical to the beds of subarkose that enclose the conglomerates. Above the middle of the section, well laminated and strongly crossbedded subarkose and orthoquartzite predominate. These rocks contain moderately to well sorted, rounded and subrounded quartz and feldspar grains, with a little micaceous cement and some quartz cement. Thin interbeds of gray or black shale and minor quartz-pebble conglomerate beds are present. Beds are, in general, more continuous than in the lower section. Near the top of the formation the subarkose contains progressively more and more micaceous matrix and grades into the graywackes of the overlying Chéno Formation.

The mineralogy of the Papaskwasati sedimentary rocks indicates that they were derived from a granite-gneiss terrain such as underlies them. Measurements of crossbed orientation and other current-direction indicators suggest a source to the north and west.

Chéno Formation

The Chéno Formation overlies the Papaskwasati Formation in places; in others it rests directly on the granite-gneiss complex. This formation consists of arkosic conglomerate, graywacke, subarkose and fine-grained dolomite, and represents a transition from the deposition of the clastic Papaskwasati Formation to the Albanel dolomites.

The formation is exposed in Chéno river and in a west-trending cuesta on both sides of the river. It probably underlies much of the drift covered plain north of Lake Mistassini. The formation is quite variable, but in general grades from a fine-grained graywacke at its base to a dolomitic sandstone at the top. Ascending through the section, carbonate cement increase in importance over detrital matrix and secondary quartz. The main clastic framework consists of poorly sorted angular quartz and feldspar grains, with minor rock fragments and glauconite granules. Some beds contain considerable magnetite, thought by Neilson (1966) to be authigenic. The formation is probably 50 to 100 feet thick.

Lower Albanel Formation

The Lower Albanel Formation underlies much of Lake Mistassini and the area between Lakes Mistassini and Albanel. It dips gently east and forms numerous cuestas with west-facing scarps.

The lowermost beds are shaly dolomite, which passes upward into well bedded, gray to blue-gray dolomite which, in turn, grades into massive bedded, ferruginous, buff dolomite and fairly dark gray, massive dolomite. Minor carbonaceous seams and thin intraformational conglomerates occur throughout the sequence. Recrystallised calcite and dolomite with minor chert occur in fractures, vugs and along bedding planes. The dolomite characteristically contains rounded detrital pellets and rounded quartz grains. Most of the dolomites, although partly recrystallized, may be classed as calcarenites. The formation is estimated by Neilson (1950) to be 4,000 to 5,000 feet thick.

Upper Albanel Formation

The Upper Albanel Formation underlies Lake Albanel and also crops out in a narrow zone along Témiscamie river. The formation in 2,000 to 3,000 feet thick (Neilson, 1950). It is composed of sandy dolomite and dolomitic sandstone, dark and light gray crystalline dolomite, and stromatolitic dolomite. The formation may not be completely conformable with the Lower Albanel Formation.

All the dolomites are gray to buff, and usually weather buff. Most contain small, rounded, frosted quartz grains, which locally form over

50% of the rock. Farther south in the Mistassini basin, the upper gray dolomite member contains stromatolites, but none are reported from this map-area.

Témiscamie Formation

The Témiscamie Formation, as used in this report, includes both the Témiscamie and Kallio formations (Neilson - 1950, 1963; Quirke - 1961). This is an extremely important unit as it contains an iron-bearing member which constitutes the only known potentially exploitable mineral deposit in the area. The stratigraphic thickness is difficult to determine because the formation has been chopped up by small faults, but it has been estimated at 1,000 to 1,200 feet by Neilson (1950).

Quirke (1961) did an extensive study of the Témiscamie rocks and divides them into the Boulder Bay formation, the Témiscamie iron-formation with six iron-bearing members, and the Kallio formation. In this report, the Boulder Bay and Kallio formations are considered members of the Témiscamie Formation. The Boulder Bay member, up to 100 feet or more thick, consists of relatively pure quartzite with some chloritic and ferruginous matrix. The Lower Argillite member is 9 to 40 feet thick and is composed of graphitic argillite, in some places rich in iron silicates - minnesotaite and stilpnomelane. The Lower Sideritic Chert member is 20 to 40 feet thick and composed of well bedded quartz-minnesotaite, with some siderite, alternating with siderite-ankerite-stilpnomelane layers. The Magnetitic Chert member is the most important economically. It has an average thickness of 140 feet and is composed of quartz, magnetite and hematite, with minor iron silicates. Relict granules and oölites are commonly observed. The Upper Argillite member is graphitic and composed of iron silicates and carbonates, and is 5 to 45 feet thick. The Magnetitic Iron-silicate member is up to 100 feet thick, is local in occurrence, and is composed of magnetite, quartz, iron silicates and iron carbonates. The Upper Sideritic Chert member is over 100 feet thick and is composed of banded carbonate and quartz, with well preserved oölitic and pisolitic textures.

The upper 800 feet of the formation (the Kallio member) consists of graywacke shale, which is a graphitic, black shale with a conspicuous, slaty cleavage and poorly preserved bedding.

Otish Group

The Otish Group consists of a thick sequence of sandstone, divided into two divisions (Bergeron, 1957) of variable thickness. The group is separated from the Mistassini Group by an erosional gap of 20 miles, but may be traced across this gap through small outliners of sedimentary rocks lying on the basement.

The name Lac Indicateur Formation is proposed for the lower division of the group because of the abundant exposures of the formation southeast of Indicateur lake. Robinson (1956) previously proposed the name Indicateur Lake series for the whole Otish Group, but this name has not been used by other authors. A detailed lithologic description of the formation is beyond the scope of this report, but will be supplied in a later report.

The Lac Indicateur Formation is almost identical to the Papaskwasati Formation. The essential difference between the two formations is that the minor shale beds in the Papaskwasati Formation are gray or black, whereas those in the Lac Indicateur Formation are red. It is possible that the two formations are remnants of a single sidespread formation of Proterozoic sandstone that covered part, or all, of the Superior province. Similar sandstone formations include the Chibougamau Series (Madsley and Norman, 1935) to the south, the Sakami Formation (Eade, 1966) to the northwest, and the Sandgirt Formation (Fahrig, 1960) to the northeast.

The Lac Indicateur Formation is well exposed south and east of Indicator lake. Scattered exposures in a largely drift-covered area west of the lake and many huge blocks, indicate that the formation underlies a large tract in the north-central part of the map-area. A series of small exposures of highly sheared sedimentary rocks in the eastern part of the area belong to this formation, and are preserved near a northeast-trending normal fault.

The Upper division of the Otish Group is characterised by red pigment in the micaceous cement of the subarkose and orthoquartzite that constitute the formation. Interbedded shale and siltstone beds are also red to purple. The dominantly red sedimentary rocks of the Upper division are exposed at only one locality in the area, in a large outlier northwest of Mantouchiche lake. Here a 300-foot section of sedimentary rocks is exposed, and the uppermost 100 feet belongs to this Upper division. The Lac Indicateur Formation at this locality is therefore only 200 feet thick, whereas it is 500 or more feet thick northeast of the area (Chown, 1964).

The dominant current direction in the Lac Indicateur Formation is just north of west.

Otish Mountains Gabbro

Extensive bodies of fresh and uralitic gabbro crop out along the northwest and southeast flanks of the Otish mountains. Most of these bodies are nearly flat lying sills, but some dikes are also present. Dikes of similar gabbro and diabase occur throughout that part of the map-area within the Superior province. It is assumed, by lithologic correlation, that they are all roughly the same age. A whole-rock age date of 1,465 m.y. (Wanless et al, 1965, p. 104) has been established for gabbro from a sill near Conflans lake, northeast of the present area.

The extensive sill, or sills, which covers much of the area east of the present map is well exposed between Epervanche and East Péribonca rivers, particularly north of the Savane River fault. The sill is also exposed capping hills at 5 localities in the northeast corner of the area. Elsewhere in the area, the gabbro occurs as dykes - many of these are 3 to 65 feet wide, discontinuous bodies, such as those mapped by Bérard (1965) north of Témiscamie river. A few larger dikes (over 1/2 mile wide) occur east of Indicateur lake and just east of Pépeshquasati river. The dominant trend of the dikes is N. or N.45° W., though a few trend N.E. or E.

Most of the dikes are composed of uralitic gabbro, as are the contact zones of the sills. A few of the large dikes and the main parts of the sills consist of fresh olivine gabbro.

Olivine Gabbro

The gabbro is pale tan on weathered surfaces, and in many places has a weathered rind about 1 cm. thick. However, most cliff outcrops are fresh and many hilltops have been scraped clean. The gabbro is black, with a faint brown, or greenish, tinge on fresh surfaces. It is fine to medium grained, rarely coarse grained. Individual plagioclase laths 1 to 3 mm. long can be distinguished in hand-specimen, and some 1 to 3 cm. poikilitic clinopyroxene crystals can be detected by rotating the specimen is sunlight and noting the numerous parallel cleavage planes in the mineral.

Plagioclase and clinopyroxene, in ophitic intergrowth, are the principal constituents of the gabbro. Olivine occurs in lesser amounts and is largely altered. Hypersthene occurs in a few specimens. Zoned plagioclase laths (An_{84-60} in cores, An_{60-46} in the rims) occur within the clinopyroxene. Olivine (Fo_{80}) occurs in 0.5 to 1 mm. rounded grains, some rimmed by iddingsite and most partly altered to serpentine and magnetite. Olivine is jacketed by hypersthene where the latter is present, or is enclosed in large clinopyroxene crystals. Colorless or faintly pleochroic clinopyroxene, possibly titanaugite, always encloses plagioclase laths. Most specimens also contain small amounts of titanbiotite, blue-green hornblende and phlogopite. Quartz and potassic feldspar occur interstitially in a few specimens. Magnetite and ilmenite constitute 2 to 3% of most specimens, and apatite is nearly always present. Plagioclase forms 55 to 65%, olivine and clinopyroxene each 15 to 25%, and hypersthene o to 30% of the gabbro.

Ophitic to subophitic texture is uniform throughout the fresh rocks and is also discernible in many of the uralitic rocks. The central parts of the sills usually display poikilitic clinopyroxene crystals. Certain of the dikes are glomeroporphyritic, with several 2 to 4 mm. plagioclase crystals clotting together to form a phenocryst 2 to 6 cm. in diameter. These are randomly and widely spaced through the rock.

Uralitic Gabbro

Much of the gabbro is partly or completely altered. Weathered surfaces of both fresh and altered rock are tan in color, but the altered rock is green on fresh surfaces in contrast to the black of the unaltered gabbro. Many of the coarse-grained rocks have megascopically visible amphibole crystals, commonly with a pyroxene shape retained from the original rock. The texture of fine-grained specimens is completely masked by the growth of numerous fine crystals of amphibole within the plagioclase.

Gabbros that are only partly uralitized serve to show the nature of the alteration. In such rocks the plagioclase is largely lath shaped, but is less calcic (An_{60-30}) and is not as markedly zoned as in the unaltered gabbro. Relics of pyroxene are present in all specimens, and a few retain some olivine. Most of the clinopyroxene and olivine is converted to amphibole that retains the stubby shape of pyroxene grains. Some amphiboles have grown a bit larger that the former pyroxene and jut into the enclosed plagioclase laths. The amphibole is pale green in the center, with a darker, blue-green border. The two amphiboles are homoaxial and grade into one another Epidote is commonly present as discrete, yellow tablets and as saussuritic masses in the plagioclase. Biotite, sphene, carbonate, scapolite and opaque minerals are present. The opaques include pyrite, chalcopyrite and pyrrhotite, as well as leucoxene, magnetite and ilmenite.

Completely uralitized gabbro contains no remnant pyroxene, and much of the calcic plagioclase is converted to oligoclase-andesine (An_{30}). Some dike rocks contain albite. The ophitic texture is visible, though not clearly, outlined by large, uralitic, amphibole crystals. Plagioclase laths are less distinct, as the plagioclase is shot full of needles of hornblende and tablets of epidote. Biotite, epidote and opaque minerals are present in all these rocks; quartz and sphene in a few. Plagioclase constitutes 40 to 50% of the rock; amphibole 40 to 50%; and minor minerals make up the balance. Compositions are difficult to determine because of the fine-grained intergrowth in the rocks.

Quartz-diorite, diorite and noritic gabbro occur in a small dike that intrudes the Témiscamie Formation near Coom lake. This intrusion appears to be a slightly differentiated phase of the Otish Mountains gabbro intrusive series.

STRUCTURAL GEOLOGY

The area includes parts of two major structural provinces of the Precambrian Shield - the Superior and the Grenville provinces. In addition, younger Proterozoic rocks overlie parts of both provinces and have been involved in the latest tectonic activity along the boundary between the two provinces. The structures of the two provinces will be dealt with separately, followed by the later tectonism.

Superior Province

In the Superior province, the overall trend of both rock units and structures is easterly, and dips are, for the most part, steep. Minor, local variations are caused by granitic intrusions and later north-trending cross-folding. The regional picture of early east-trending folds, cross-folded along north-trending axes, fits the pattern proposed by Goodwin (1961) for the central part of the Superior province.

Exact structural determinations are difficult because of the degree of metamorphism of the rocks. However, significant primary structures are preserved in the metavolcanic and metasedimentary rocks, and from these narrow belts a wider interpretation may be attempted. The southern belt of metasedimentary plus metavolcanic rocks is thought to be a syncline (Neilson, 1966), as is the northern belt (Hashimoto, 1960; Chown, unpub. ms.); a zone of scattered bodies of metavolcanic rocks in the extreme north of the area may also represent the remnants of another east-trending syncline of metavolcanic and ultrabasic rocks. The 10 to 20 mile wide intervals between these belts may be complex, east-trending anticlinoriums, assuming that the metavolcanic and metasedimentary rocks are correlatable. Quartzofeldspathic gneiss from just north of the area has been dated at 2,055 m.y. (Lowdon, 1960, p. 28).

Second Folding

The axis of a northeast-trending cross-anticline follows the Pépeshquasati River valley. An increase in the size and number of granite bodies can be noted in this zone, and foliations in the gneiss are contorted. Axes of small folds in the quartz-plagioclase gneiss - b lineations formed parallel to the axes of the first folds - plunge gently away from this cross-anticlinal axis. The east-trending syncline of metavolcanic rocks was arched up by this cross-anticline, but has since been removed by erosion. The cross-folding also twisted the east-trending syncline. Granite apparently accompanied the cross-folding and rose into the cross-anticlinal hinges. Significantly, an age date of 1,670 m.y. (Quirke, et al, 1960, p. 321) was obtained for granite in the Takwa mountains. If the granite is related to a northeast folding, this age corresponds to the Hudsonian northeast folding. Ages younger than 2,000 m.y. near the border of the Superior province have also been attributed to the effects of younger orogenies near the border.

Faults

An east-west fault and several smaller antithetic faults cut the metavolcanic rocks in the Holton Lake area. These have been attributed (Chown, unpub. ms.) to a conjugate fracture system developed when the syncline was cross-folded. Similar east-west faults at the west end of the southern belt of metasedimentary rocks may have a like origin.

Two north-south faults cut the metavolcanic rocks and granite west of Holton lake. These both have sinistral strike-slip separations. Shear and mylonite zones in the granite complex suggest other east-west faults, but little in the area can be established owing to the vague stratigraphy determinable in a series of quartzofeldspathic gneisses.

Grenville Province

Most of the area lying within the Grenville province is dominated by a strong structural trend striking 20 to 40° east of south. This trend is cut off abruptly by a 6 to 10 mile wide, northeast-striking tectonic zone following Témiscamie river. The two structural trends interfere with one another in an irregular transition zone. Some idea of the complexity of this interference zone may be seen in the geology near Bussy lake, where structures are outlined by layers of amphibolite. Elsewhere the structures are not so clearly displayed.

Folds are indicated by the strike and dip of compositional layering in the gneisses. The strong foliation in these gneisses lies parallel to the layering, except in rare localities near the hinges of small folds where the foliation is seen to cut across the layering. The foliation is an axial-plane slip cleavage which strikes southeast and dips steeply. Amphibolite layers in the gneiss sequence are the best markers for tracing folds, but in much of the area these layers appear to be discontinuous or to have been stretched and broken during folding. Most exposures of gneiss are lineated, the most common lineation being the axes of small folds. Oriented amphibole needles and bent biotite flakes parallel the axes of small folds in most cases.

Three main southeast-trending folds occur in the area. These are a partly overturned antiform east of Péribonca river, an upright synform whose axis passes southeast from Bussy lake, west of the Péribonca, and a second antiform southwest of Grande Loutre river. Minor synforms and antiforms lie parallel to the main ones, but are not continuous. Folds in the southwest part of the area swing to the southwest, almost parallel to the trend of the bordering tectonic zone.

No folds were distinguished in the northeast-trending tectonic zone; all strikes are between 30° and 60° east of north, and dips are for the most part steep. The zone consists of a strip of granite and granitic augen gneiss, 1 to 4 miles wide, with massive granite, syenite and some basic rocks in the extreme southwest, bordered by a 2 to 4 mile wide strip of amphibolite which pinches out and becomes intermittent to the south. At latitude 51°30' north the zone bulges out to the west to include the Béthoulat Lake series, 20 miles long and up to 6 miles wide. The northeast structures of the zone cut directly across the southeast trends of the main part of the gneiss, and the east to slightly south of east trends in the adjacent Superior province. The zone swings to the east and dies out in an area of heavy overburden around Coudé lake. A specimen of quartz-plagioclase-biotite gneiss from this zone. has been dated at 1,000 m.y. (Quirke, et al, 1960, p. 321).

Grenville Front

The nature of the boundary between the Grenville and Superior provinces of the Canadian Shield has received attention in many publications. The reconnaissance nature of the present work prohibits both a lengthy review of the relations discovered in other areas and too much speculation as to the nature of the boundary within this map-area.

However, the boundary can be clearly defined through three quarters of the area, starting from the southwest corner and following Témiscamie river north to a point south of Indicateur lake, from where it is untraceable in an area of heavy overburden. The boundary is defined by a 6 to 10 mile wide tectonic zone of gneiss and amphibolite intruded by granite and syenite. The rocks of this zone have a dominant northeast trend and dip steeply; southeastward, they grade into the Grenville gneiss and amphibolite, whereas on the west they are bounded by a fault zone.

In the southwest part of the area, late Precambrian sedimentary rocks of the Mistassini Group are overturned against this fault and are cut by numerous parallel normal faults. Neilson (1966) describes the fault dipping 42° southeast in one exposure on Perdue river. Granitic and anorthositic rocks are crushed in breccia zones exposed at intervals along Témiscamie river (Bérard, 1965; Neale, 1965). There seems little doubt that this fault zone extends southwest to Chibougamau, a total length of 150 miles.

To the northeast, however, the boundary between the two provinces becomes vague, and indefinable at the present scale of mapping. The tectonic zone dies out around Coudé lake, and the fault swings north, passing just west of Témiscamie river,where it may be traced by numerous mylonite zones and sheared granitic rocks. It is significant that a few miles northeast of Coudé lake, near the junction of Péribonca and Epervanche rivers, two major northeast normal faults are first noted. Both these faults appear to be hinge faults, with a south-side-up movement at their western ends, pivoting to a south-side-down movement 10 to 15 miles farther east. Numerous, related, smaller, normal faults, trending north and northeast, have been noted in the area to the east (Chown, 1964). These faults displace Late Precambrian sedimentary rocks of the Otish Group and also the Otish Mountains gabbro.

One feature of the Témiscamie River fault may be significant. The trace of the fault seems to alternate between two directions, 60° and 30° east of north. These two directions are the predominant trends of minor faults both in the Mistassini basin and in the Boivin Lake area (Chown, 1964) to the northeast.

The basement throughout the zone of normal faulting is tentatively classed as belonging to the Superior province on the basis of its granitic content and the general appearance of the gneiss. There appears to be no possible structural differentiation between the gneiss complexes of the two provinces, as the trends are parallel, unlike the rocks farther west. The presence of the Pambrun Lake anorthosite mass does give a limit to the transition zone, if it is assumed that this mass belongs to the Grenville province.

In conclusion, near Coudé lake the boundary between the Grenville and Superior provinces seems to part company with the Témiscamie River fault, and the fault apparently horsetails out into numerous smaller faults. The boundary is poorly defined away from the fault. This relation is similar to that observed in the Chibougamau region at the southern end of the fault.

Proterozoic Folds

The sedimentary rocks of both the Mistassini and Otish Groups dip gently throughout much of the area. Dips over 15° are rare except near large faults. Several broad, open flexures are apparent. The main part of the Mistassini basin appears to be a syncline, somewhat broken by faults, with its axis trending northeast and passing just east of Lake Albanel. The eastern limb of the fold is steeper than the broad, gently dipping, west limb and is characterized by numerous, parallel, secondary anticlines and synclines, some overturned to the east. The trace of a north-east-trending anticlinal flexure passes 2 miles east of Pépeshquasati river; this fold affects only the Papaskwasati and the Chéno Formations. Near Indicateur lake, an open syncline plunging 5 to 10° northeast has a sinuous trace.

All the open flexures have a fanning fracture cleavage. The minor tight overturned folds have a better developed shear cleavage, which is similar in style and trend to the cleavage developed in and near shear zones. Therefore, the whole deformation - gentle flexures and major and minor faults - appears to be related.

PLEISTOCENE GEOLOGY

Glacial Movement

Glacial striae throughout the area, as well as roches moutonnées, drumlins and crag-and-tail structures, indicate the predominant glacial movement across the area varies regularly from S.30°W., near the western boundary, to S.10°W. in the east. However, a later movement is indicated, at least locally, by a series of glacial striae trending S.20°E.. The two sets of striae were observed together just southwest of Indicateur lake, and also in the area to the east of the present map-area (Chown, 1964).

Glaciofluvial and Glaciolacustrine Deposits

Eskers, formed during the wastage of the ice sheet, are prominently developed throughout the region. Certain ones can be traced almost continuously for over 70 miles. The two that follow the valley of Savane and Péribonca rivers are especially well developed. For the most part, the eskers are 25 to 50 feet high and trend south to southwest. Some local eskers are smaller and some trend nearly east-west.

The valleys of Pépeshquasati, Témiscamie and Péribonca rivers are partly filled with sand terraces. These range from 10 to 100 feet above the present water level. The sands are commonly crossbedded and contain numerous beds and lenses of gravel. Neilson (1966) reports many raised beaches visible on the broad sloping terrace north of Lake Mistassini. Many of the terraces occurring along the rivers may also be terraced outwash deposits.

Recent Deposits

Recent deposits are chiefly reworked glacial deposits in lakes, beaches and rivers. Some extensive swamps occur near Péribonca river, just north of 51°30'.

ECONOMIC GEOLOGY

Iron

The most significant mineral deposit known at present in the area is the taconitic iron-formation near Lake Albanel. The property held by Albanel Minerals Limited comprises 117 claims. Surface work, diamond drilling and bulk sampling have indicated a large tonnage (approximately 200,000,000 tons - Neilson, 1963) of beneficiating, iron-bearing material. The company has not announced any plans for development of the property in the near future.

Copper

Numerous showings throughout the area contain small amounts of chalcopyrite and pyrite. Molybdenite is also common in these disseminated deposits. Most of the showings are associated with metamorphosed volcanic rocks in the Superior province, but a few occur in the Grenville.

Merrill Island Mining Corporation Limited holds a group of 90 claims northeast of Holton lake. Detailed geological mapping, a geophysical survey, and about 5,200 feet of diamond drilling were carried out during 1963 and 1964. No work is being done on the showings at the present time. Similar, small, chalcopyrite-pyrite disseminations at the eastern end of the same band of metavolcanic rocks (southwest of Indicateur lake) have apparently not yet been prospected; this locality seems to be the most interesting for investigation at the moment.

Two other small chalcopyrite-bearing showings - one in the Takwa mountains, the other near the junction of Toco and Takma rivers - were staked and examined in the past, but the claims have been dropped.

The widespread occurrence of pyrite and minor chalcopyrite in the metavolcanic rocks, and the presence of the porphyry dike swarm, indicates that the area near the junction of Holton and Pépeshquasati rivers warrants prospecting.

Copper, Nickel

Copper-nickel mineralization could be associated with the numerous basic intrusions, chiefly gabbro, throughout the area. Particular attention should be paid to their contact zones, especially where uralitic alteration is prevalent.

Iron, Titanium

Magnetite-ilmenite pods occur in peridotite and pyroxenite layers in the anorthosite massif north and east of Benoit lake. They are also disseminated through zones of the gabbroic anorthosite. In 1957 close to 200 claims were staked by Albanel Minerals Limited in this area, and extensive sampling was carried out on the oxide-bearing zones. Results of the sampling were not encouraging and the claims were allowed to lapse. The oxides - titanomagnetite, ilmenite, magnetite and hematite - are too finely intergrown, and the deposits are too far from regular transportation facilities, to warrant any development at present. The same applies to the massive iron oxides occurring near Pambrun lake, to the east (Chown and Hashimoto, 1965).

Lead, Zinc

Numerous galena-sphalerite showings in the Albanel dolomite along Témiscamie river were prospected 10 to 15 years ago. Now, the proximity of the Chibougamau - Lake Albanel road to these showings makes them more attractive for a re-examination.

Nickel-Asbestos

Metamorphosed ultrabasic rocks are widespread throughout both the Superior and the Grenville provinces. Brittle asbestos was noted within one of these bodies near the junction of the Péribonca and Savane rivers. Some of the bodies are strongly magnetic and show up clearly on the regional aeromagnetic maps, whereas others do not. However, all these bodies should be closely examined for asbestos and nickel.

Sand and Gravel

The abundant esker, moraine and terrace deposits of the area could readily supply the sand and gravel necessary for any projected construction.

GEOCHEMISTRY

Stream sediment samples were taken during the summer. In all, 271 samples were analysed for copper, zinc, lead, molybdenum and uranium. The results are shown on the accompanying map, and are listed in an appendix to this report.

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RESULTS OF GEOCHEMICAL ANALYSES
(in p.p.m)

Sample No. on the map	Code No. of sample in files of Dept.	Cu	Zn	Pb	Mo	Ni	U		
1	015	8	15	4	1		0.5		
2	014	12	40	40	1		2		
3	016	10	30	24	1		1		
4	013	8	35	14	2		0.5		
5	012	6	70	8	1		1		
6	001	6	45	4	2		0.5		
7	084	8	15	6	1		0		
8	083	6	15	6	1		0		
9	082	6	10	8	1		0		
10	081	8	10	8	1		0.5		
11	006	14	20	16	1		4		
12	005	18	25	24	1		2		
13	004	16	30	28	1		2		
14	080	14	15	20	3		2		
15	009	14	35	12	1		1		
16	010	16	35	26	1		2		
17	077	10	70	16	1		1		
18	003	200	110	30	1		3		
19	007	8	25	14	1		1		
20	018	12	35	14	1		4		
21	017	8	60	12	2		0.5		
22	077	14	15	12	1		0		
23	078	6	20	6	1		0.5		
24	008	12	25	12	1		1		
25	011	12	30	14	1		1		
26	024	6	20	16	1		2		
27	019	24	65	30	3		2		
28	020	12	30	24	2		1		
29	021	6	25	44	2		1		
30	025	4	15	18	3		1		
31	086	8	15	30	2		0		
32	076	6	10	10	1		0		
33	023	12	10	4	1		0.5		
34	022	8	10	14	2		2		
35	002	14	30	24	2		2		
36	053	8	20	28	1		4		
37	056	6	15	4	2		1		
38	054	12	20	16	3		16		
39	051	4	10	8	1		0		
40	052	6	10	12	4		2		
41	228	24	125	130	2		3		

Sample No. on the map	Code No. of sample in files of Dept.	Cu	Zn	Pb	Mo	Ni	U		
42	227	8	15	10	1		4		
43	226	44	20	6	1		0		
44	066	10	10	6	1		2		
45	065	6	10	6	1		1		
46	114	8	25	15	1		1		
47	113	13	13	10	1		0		
48	232	14	35	36	1		0.8		
49	117	10	19	13	2		0.5		
50	093	12	15	4	2		0.5		
51	085	6	10	16	1		0		
52	110	10	44	20	3		0.5		
53	111	10	13	18	1		1		
54	116	8	25	20	1		0		
55	112	15	63	50	1		0		
56	115	30	44	5	1		0.5		
57	101	10	20	14	1		0		
58	105	12	20	6	1		0		
59	094	10	10	4	1		5		
60	104	12	20	6	1		0		
61	102	6	40	60	1		1		
62	087	8	45	80	2		0		
63	088	8	15	14	2		1		
64	230	8	35	14	1		2		
65	239	12	10	10	1		3		
66	231	16	40	18	1		0.8		
67	103	4	10	14	1		0.5		
68	265	4	15	4	1		1		
69	266	10	20	8	1		0.8		
70	267	4	10	4	1		0.5		
71	268	6	10	6	1		0.5		
72	269	4	15	4	1		0.5		
73	270	4	15	6	1		0.5		
74	271	6	10	4	1		0.5		
75	272	8	20	8	2		0.5		
76	067	6	15	4	1		0.6		
77	063	8	15	10	2		0.8		
78	064	8	20	4	1		0.8		
79	061	8	10	4	1		0.8		
80	059	6	10	4	1		0.6		
81	202	20	10	8	2		1		
82	201	4	10	4	1		0		

Sample No. on the map	Code No. of sample in files of Dept.	Cu	Zn	Pb	Mo	Ni	U		
83	058	12	10	12	1		1		
84	057	12	35	16	1		0.5		
85	176	8	15	10	1		0		
86	180	8	15	10	1		1		
87	181	12	15	6	1		0.5		
88	170	4	15	36	1		0.8		
89	191	16	20	32	1		0.8		
90	187	6	35	4	1		0.5		
91	177	14	20	14	1		2		
92	182	8	30	36	1		1		
93	179	10	10	12	1		1		
94	178	12	10	8	2		1		
95	183	6	20	20	1		1		
96	188	10	25	20	1		0.8		
97	189	16	20	16	1		0		
98	185	12	20	40	1		2		
99	184	10	10	60	2		1		
100	091	10	15	6	2		1		
101	089	8	20	12	1		0		
102	107	18	25	4	1		4		
103	106	26	50	50	2		2		
104	092	8	10	4	2		0		
105	096	6	10	4	2		0		
106	109	8	19	15	-		0.8		
107	108	6	20	10	2		1		
108	095	12	15	6	1		0.5		
109	098	8	15	4	2		0		
110	097	16	280	140	2		0.8		
111	213	8	20	6	1		1		
112	214	30	35	14	1		2		
113	222	20	15	22	1		0.8		
114	209	20	20	22	5		1		
115	120	18	25	10	2		1		
116	121	10	19	13	1		0		
117	119	15	13	10	1		0.5		
118	122	8	13	5	1		0		
119	118	8	25	5	1		0		
120	203	10	70	8	2		0.5		
121	124	13	19	13	1		0		
122	200	14	15	6	1		0		
123	068	8	25	14	3		7		

Sample No. on the map	Code No. of sample in files of Dept.	Cu	Zn	Pb	Mo	Ni	U		
124	123	13	19	5	1		0.5		
125	070	10	15	8	4		0.5		
126	069	24	35	8	3		7		
127	237	18	30	10	1		0.5		
128	240	4	15	4	1		0.5		
129	233	12	10	8	1		3		
130	234	20	30	36	1		0.8		
131	235	10	15	20	1		0.5		
132	236	24	25	22	1		1		
133	223	10	20	8	1		0.5		
134	215	6	10	4	1		0.5		
135	217	8	15	14	1		0.5		
136	218	8	35	4	1		0		
137	217	6	10	4	3		0		
138	195	8	40	24	2		0.8		
139	194	8	56	120	–		0.8		
140	196	8	60	4	2		0.5		
141	198	6	15	4	3		0		
142	219	12	50	200	2		2		
143	220	10	20	40	1		0.5		
144	221	14	20	26	1		0.5		
145	210	24	10	8	4		1		
146	211	14	10	10	3		2		
147	197	6	20	26	3		1		
148	072	10	15	6	1		0		
149	193	4	10	34	1		0.5		
150	192	6	20	14	1		0.5		
151	073	8	10	8	1		1		
152	075	10	20	16	2		0		
153	205	14	15	26	2		1		
154	207	10	15	6	1		1		
155	206	4	15	4	1		0.5		
156	204	14	10	14	3		2		
157	208	14	10	20	1		1		
158	074	14	75	56	1		–		
159	071	4	10	4	1		0.5		
160	099	14	110	10	3		1		
161	167	10	40	16	1		0.5		
162	168	12	20	6	2		0		
163	166	6	10	10	2		0		
164	173	10	40	50	2		0.5		

Sample No. on the map	Code No. of sample in files of Dept.	Cu	Zn	Pb	Mo	Ni	U		
165	174	6	10	8	1		0.5		
166	172	6	25	10	1		0.5		
167	175	6	15	26	1		1		
168	171	10	35	36	3		1		
169	169	16	20	20	3		1		
170	165	14	35	36	2		0		
171	162	6	30	6	2		0.5		
172	161	4	25	4	2		0.5		
173	160	24	45	32	1		2		
174	170	4	15	36	1		0.8		
175	159	10	30	14	1		1		
176	163	14	20	22	1		0.8		
177	164	16	25	30	3		0.5		
178	153	15	25	5	1		0.8		
179	152	10	19	5	1		0		
180	154	10	44	10	1		0		
181	151	10	13	5	1		0		
182	155	10	40	24	2		0.5		
183	158	6	20	4	1		0		
184	248	20	10	26	3		0.8		
185	247	16	20	30	1		0.5		
186	246	10	10	4	1		0.5		
187	249	34	35	34	2		1		
188	245	4	10	8	1		0		
189	250	18	45	34	1		1		
190	241	16	30	36	3		0.8		
191	242	8	20	6	1		0.8		
192	244	20	15	18	1		0.8		
193	239	12	25	10	1		0.5		
194	243	12	20	12	1		0.8		
195	238	10	20	12	1		0.5		
196	157	12	25	12	2		0		
197	156	8	35	8	2		0		

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