GOUVERNEMENT DU QUEBEC

DEPARTMENT OF NATURAL RESOURCES

MINES BRANCH

GEOLOGICAL EXPLORATION SERVICE

GEOLOGY OF

PLUTO LAKE AREA

Dubuc and Roberval Counties and Mistassini Territory

By

E.H.Chown

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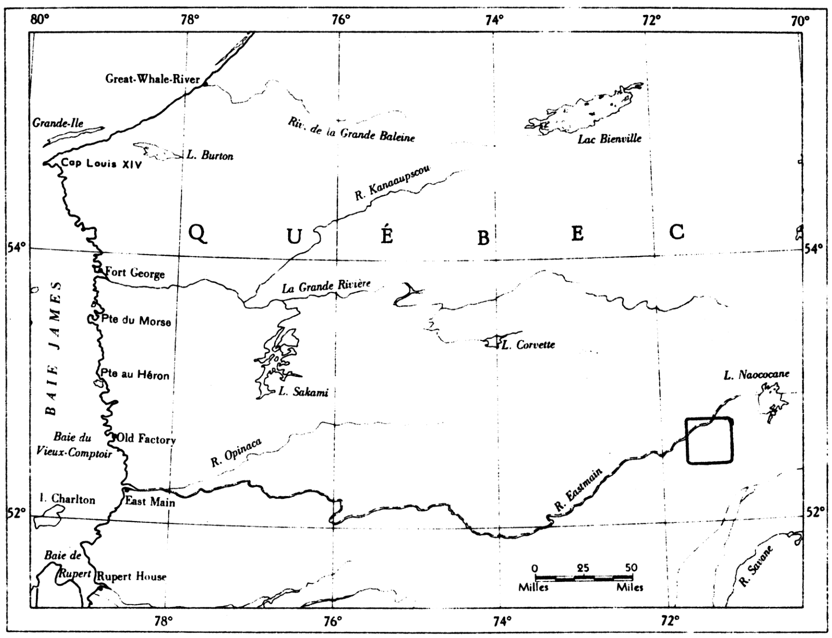

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Preliminary Report

on

PLUTO LAKE AREA

Dubuc and Roberval Counties

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INTRODUCTION

The Pluto Lake area consists of four 15-minute quadrangles lying between latitudes 52°00' and 52°30' and longitudes 71°00' and 71°30'. The four quadrangles are included in the Lac Gaschet (23D/3,W. and E.) and Lac Manet (23D/6, W. and E.) of the National Topographic Series 1:50,000 scale maps. Pluto lake, in the center of the area, is 145 miles northwest of Manicouagan 5, and 140 miles west of Gagnon. The area is accessible to float aircraft from both these bases, and from Chibougamau, more distant to the southwest. Access within the map-area is provided by numerous lakes suitable for aircraft landings and by limited canoe travel along Péribonca, Eastmain, Saffray (Anduin) rivers. A small part of the area was mapped in 1966, and the remainder in 1967. The total area mapped is approximately 735 squares miles.

The area straddles the height-of-land. A portion of the east and southeast drains via the Péribonca river system to Saint-Laurent river. A very small part of the southwest drains via the Témiscamie-Mistassini-Rupert system to James bay. Most of the area drains north into Eastmain river and thence westward to James bay.

A rolling plain slopes gently south from Pluto lake. This plain is punctuated by a few sharp bedrock hills, particularly in an east-west zone just north of the 52nd parallel. North of Pluto lake, mountains rise sharply as much as 800 feet above the level of the lake (elevation 2,200 feet). These mountains have an east to northeast trend. They consist of several sharp, flat-topped ridges, most with sharp cliffs facing north, and somewhat gentler slopes to the south. The ridges are cut by north-south stream valleys (the most notable being Saffray river) which are fed by east-west tributaries flowing between the ridges. Ten miles north of Pluto lake the hills end abruptly along a sharp northeast-trending scarp. The northern part of the area is a swampy plain covered by unconsolidated deposits. Eastmain river, flowing through the plain, has cut into bedrock at numerous places, providing virtually all the exposures in the plain.

Previous Geological Work

Adjacent areas to the southeast (Chown, 1964) and east (Chown, 1965) have been mapped at 1 inch to the mile, and the area directly to the south at a scale of 1 inch to 4 miles (Chown, 1970a). The region north of the 52nd parallel, including the present area, has been mapped at 1 inch to 8 miles (Eade, 1966).

GENERAL GEOLOGY

The bedrock of the area consists of an Archean basement complex overlain unconformably by gently dipping Proterozoic sedimentary and igneous rocks. The Archean rocks are subdivided into metavolcanic rocks (chiefly metabasalt amphibolite, occurring in a northeast-trending isoclinal syncline along the north front of the mountains) and a gneiss-granite suite which encloses the metavolcanic rocks and underlies the swampy plain in the north.

Sedimentary rocks of the Otish Mountains Group are exposed from the northern edge of the mountains to the southern limit of the area. They are divided into two formations. The lower (Lac Indicateur Formation) is the more widespread and consists of two alternating rock facies (pebbly subarkose and orthoquartzite divisible into four members. The upper division, composed of red argillaceous subarkose and subgraywacke occurs only in the central part of the area just east of Pluto lake.

The basement complex and the sedimentary rocks are intruded by a suite of a gabbroic rocks which includes at least three major sills and numerous dikes and connecting sheets. Gabbro intruding the sedimentary group is partly or completely uralitized, whereas fresh olivine gabbro intrudes the basement complex. The gently dipping sedimentary and igneous rocks have been chopped into a series of blocks by a system of normal faults trending 060° and 020°. Sedimentary rocks in the southeast corner of the area are tightly folded into an asymetric anticline trending 070° and overturned to the north.

The north and central parts of the area are heavily mantled by moraine and glacial outwash deposits.

Metavolcanic Rocks

Metavolcanic rocks of the basement complex are exposed along the north rim of Monts Otish, where they are partly covered by Proterozoic rocks. At their western end, the rocks are schistose; at their eastern end, they are more massive, relic structures are preserved, and the section is thicker. The relict structures and textures are sufficiently well preserved to permit identification of both pillowed extrusive flows and volcanic breccias. All the volcanic rocks are now converted to amphibolites. The occurrence of these volcanic rocks on strike with similar rocks studied and analysed chemically by Chown (1970b) and Eakins et al. (1967) is taken as sufficient preliminary evidence to class them as metabasalts.

Metabasaltic Amphibolite

Metabasaltic amphibolite weathers brownish gray and is glistening blue-black on fresh surfaces. It is universally very fine grained and massive to faintly laminar. The rocks breaks readily along foliation planes and has a pronounced lineation. Plagioclase and hornblende are the only minerals visible in hand specimen, although quartz, pyrite and epidote occur in small lenses and cross-cutting veins.

Pillow structures are clearly preserved in many outcrops on the large hill north of Marescot lake. Metamorphism has been static enough to retain the original grain size difference between the chilled rind and the coarser center of the pillows. Westward, the pillows become increasingly deformed until they are recognized only with difficulty.

Metabreccia

A distinctive breccia may be seen in a series of outcrops along the north shore of Marescot lake and underlying the lowermost sill on the north side of the mountains. It consists of strongly deformed fragments having the fine-grained, relict texture of metabasalt and the coarse-grained texture of metagabbro. The matrix of the breccia is assumed to have been finely fragmented basaltic material which is now recrystallized to a paste of amphibolite. All the fragments are now elongated ellipsoids with their long axes plunging almost directly down the dip of the foliation.

The breccia corresponds in almost all respects to the metavolcanic breccias of the Tichegami Group (Chown, 1970b). The one difference is the presence of granitic fragments in the breccia of the present area. Possibly granitic blocks were present in the original breccia, but it appears more likely that the granitic fragments were once a series of small dikes that cut the breccia and were broken and the pieces rounded when the incompetent breccia was deformed and metamorphosed.

Granite and Gneiss

Granitic basement rocks are exposed along the north flank of the mountains, and in the lowlands to the north. In addition, one outcrop of granite was noted in the extreme southeast corner of the area, not far below conglomerate outcrops. Exposure, aside from on the mountain flank and in some parts of Eastmain river, is poor. The unit appears to vary, but no subdivisions were possible at this scale of mapping.

Rocks of the unit range in general from massive to feebly gneissic; rarely, they are strongly foliated. Most are pink to white on weathered surfaces and mottled gray-green with red spots on fresh surfaces. Most are coarse grained (3-5 mm.). The four main varieties of rock are, in order of abundance:

Table of Formation

Cenozoic		Pleistocene and Holocene		Swamp, river and beach deposits Till, moraine and outwash sands and gravels
	Unconformity			
PRECAMBRIAN	Proterozoic	Monts Otish Gabbro		Olivine gabbro, uralitized gabbro, granophyre
		Intrusive Contact		
		Monts Otish Group	Upper Division	Red arkose and argillaceous subarkose and conglomerate, in part carbonate cemented
			Lac Indicateur Formation	Upper orthoquartzite member - orthoquartzite and subarkose Upper subarkose member - pebbly subarkose Lower orthoquartzite member - pink and white orthoquartzite and subarkose Lower subarkose member - pebbly subarkose and conglomerate
	Unconformity			
	Archean			Gneissic to porphyroblastic granite, quartz diorite gneiss, quartz feldspar-biotite gneiss
				Metavolcanic rocks, metabasaltic amphibolite (flows and breccias)

1) Coarse-grained, gray-green gneiss with red microcline porphyroblasts;

2) Feebly gneissic, gray-green gneiss with minor biotite and hornblende aggregates;

3) Coarse-grained quartz-diorite gneiss with lineated hornblende aggregates;

4) Fine-grained, massive, gray-green quartz-plagioclase-biotite gneiss.

The Monts Otish Group

The Monts Otish Group was first roughly subsivided into an upper and lower division by Bergeron (1957). Preliminary detailed work in this and other areas (Chown, 1965), confirms this initial subdivision. The name Lac Indicateur Formation has been proposed (Chown, 1970a) for the lower division, although no type section has been designated and no formal formation description has been made or will be put forward until the final mapping of all the Monts Otish is complete. Bergeron's breakdown was based on the predominance of red clastics in the upper part of the sequence versus gray to white rocks in the lower part. This still seems a valid subdivision, although the exact boundary between the two conformable formations may be very arbitrary.

Lac Indicateur Formation

The Pluto Lake area is underlain chiefly by the Lac Indicateur Formation, and the good exposures here afford new insight into the stratigraphy of the formation. Two facies of clastic rocks, which alternate at least twice and, locally, three or more times, make up the formation. These facies have been named the subarkose and the orthoquartzite facies for their characteristic rocks. Further field studies are necessary to decide whether these two facies owe their origin to different source areas or simply to oscillation of depositional environments, or to a combination of the two.

The Lac Indicateur Formation is estimated to be between 1,000 and 1,400 feet thick. Several partial sections were measured and the composite picture of the formation obtained by putting these sections together is as follows:-

Thickness (Feet)	Member
350-450	Upper orthoquartzite member
50-300	Upper subarkose member
0-250	Lower orthoquartzite member
350-400	Lower subarkose member

The boundaries between the members are abrupt, and indicate rapid fluctuations in the source area or depositing environment (unstable, rapidly deposited subarkose units contrasting with mature, stable orthoquartzite units). This suggests that the deposits were formed in alternating periods of quiescence and uplift, possibly associated with the development of grabens. It is not everywhere possible to define the members precisely in view of large areas with few outcrops. West and north of Pluto lake, the lower orthoquartzite member appears to be missing, and the boundary between the two subarkose members is arbitrary.

Subarkose Facies

Rocks of this facies are almost exclusively pale gray-green on both fresh and weathered surfaces. They occur in thick, massive beds with thin argillaceous partings. Few distinct shale beds were seen.

The dominant rock type in the facies is a pebbly, coarse sandstone or grit, ranging from subarkose to arkose in composition. It consists of coarse (2-4 mm.), angular quartz-feldspar sand matrix with 5-10% randomly distributed quartz pebbles. The pebbles range up to 18 cm. long (cobbles), but are largely 2-5 cm., slightly elongate, and well rounded. Cobbles occur in many places in distinct layers at the base of thick sandstone beds. Few thick conglomerate beds are present, although the abundance of pebbles seems to increase near the base of the succession, and the lower subarkose member is more conglomeratic than upper subarkose.

Most of the pebbles and cobbles in the formation are composed of vein quartz. Red silicified granite probably constitutes less than 1% of the pebbles. One or two small pebbles of iron-formation and one of jasper were identified. A few angular pellets of red shale present locally are assumed to be intraformational in origin.

The base of the sequence is not directly exposed, although granitic basement rock crops out less than ten feet below arkose and conglomerate, northeast of Brissin lake.

The rocks of this facies have the gray-green color indicative of a reducing environment. This may reflect a depositional characteristic (possibly marine) or a post-depositional one, and may be of economic importance, in that uranium occurrences in similar rocks appear to be restricted to rocks of a reducing environment. This makes the subarkose facies rocks, by their chemical and textural character the most favorable for uranium prospecting.

Orthoquartzite Facies

This group of rocks is white to pale pink, or interbanded pink and white. The sandstones are thin bedded and some are very delicately laminated and locally crossbedded. The clastic material in the sandstones of this facies, in contrast to the other, is well rounded and well sorted. Many of the rocks appearing to be orthoquartzite in the field proved, on closer examination, to contain a large percentage of well-rounded feldspar grains, and are actually well-sorted subarkoses and arkoses. Some beds are partly cemented by dolomitic or ankeritic matter which varies from fine-grained, interstitial material to 3/4-mm. crystals enclosing several grains. Some orthoquartzites are cemented by authigenic quartz.

Upper Division

The upper division of the Monts Otish Group is recognized only in one locality, just southeast of Pluto lake. Here a hill displays a 500-foot section of thick to thin-bedded argillaceous, red subgraywacke and arkose with minor shale, conglomerate and carbonate-cemented subarkose.

The dark purple color, locally bleached to pale pink, white, or pale-green blotches, is characteristic of this group of rocks. Most of the bleached areas are either subspherical or are elongate parallel to bedding. They are outlined by a thin (2 mm.) rind of black pigment. Apparently these bleached areas are loci of reduction of the ferric pigment. The subspherical shape suggests that the reducing agent had a point source, possibly organic, which was a characteristic of the original sediment.

Dispersal Pattern

Two lines of evidence are being pursued in an attempt to define the dispersal pattern of the Monts Otish Group. To date, no clear pattern has emerged. First, all current direction indicators (chiefly cross beds) were measured, adjusted for tilt, and plotted on a map, either as arrows or combined in circular histograms. One factor hampering this aspect of the study is the relative scarcity of crossbedded units, particularly in the subarkose facies rocks. However, a broad trend indicates that the sediments were derived from sources south and east of the area.

Second, the five maximum pebble diameters in each outcrop have been recorded, averaged and plotted on a map. So far, no clear decrease in pebble size in any direction may be noted.

Provenance

The abundance of feldspar in all rocks of the Monts Otish Group leaves little doubt that this group was derived from a plutonic, igneous-metamorphic source, such as that immediately underlying the group. The well-rounded grains in some of the rocks indicates that some clastic material has travelled a great distance, but there seems little doubt that all was derived from the Archean basement of the Precambrian Shield.

Correlation

The Monts Otish Group may be traced through outliers west to the Mistassini Group (Chown,1970b). The Lac Indicateur Formation appears to correlate well with the Papaskwasati Formation, the basal unit of the Mistassini Group. The upper division may well be the terrestrial, clastic equivalent of the upper carbonate formations of the Mistassini Group. The writer agrees with Gastil *et al.* (1960) that the lithological similarities between the Monts Otish Group and the Sims Formation which overlies the Labrador Trough rocks unconformably far outweigh a vague correlation placing all iron-formations in one time period, thus equating the Témiscamie Formation (and hence all the Mistassini and Monts Otish Group) with the iron-bearing members of the Labrador Trough sequence. The Sakami Lake Formation (Eade, 1966) may also be a time equivalent as it, too, has many lithological similarities to the Monts Otish Group.

Monts Otish Gabbro

Intrusive gabbros are the best exposed rocks in the area. A detailed study of their contacts and lithology shows the complexity of these intrusions. Southeast of the present area (Chown, 1964, 1965), gabbro occurs in only one recognizable sill. This intrudes the sedimentary rocks near the base of the section and cuts into the basement. In the Pluto Lake area, three major sills are recognized: one, like that to the south, intruding near the unconformity; the others intruding the sedimentary rocks successively higher in the section. These sills are connected by a series of dikes and inclined sheets. A particularly prominent dike extends in an irregular north-south direction through the Gaschet Lake area, where no sills crop out.

Form of the Intrusions

The three sills are exposed in a series of flat-topped hills north of Pluto lake. The lowermost sill is the least extensive of the three. It first appears northeast of Brissin lake, where it is 50 feet thick and cuts across the unconformity into basement gneiss. Southward, it passes under a thick sedimentary section and the second sill. The basal sill thickens rapidly to the east to a 250-foot maximum near Marescot lake. It maintains the same position, intruding parallel to the bedding in the lower subarkose member near the base of the section, and passing into the basement rocks to the north, thereby suggesting that this is the northern limit of the sedimentary basin. This sill disappears abruptly into a north-east-trending feeder dike cutting the basement east of Marescot lake. An extensive area of sill remnants in the lowlands north of the mountains is assumed to be the downfaulted extension of this basal sill, although it may well be another sub-horizontal intrusive sheet. The basal sill is largely composed of fresh olivine gabbro.

The second, or middle, sill is the thickest and most widespread in the area. It varies from 200 feet thick at the western edge of the area to 400 feet or more south of Marescot lake. It is the most variable in its stratigraphic position, intruding the basement at the western border of the area in a broad dish-shaped intrusion which passes westward into a thick sill intruding at, or near, the unconformity. Near Brissin lake, where the basal sill first appears, the middle sill bends up into an inclined sheet dipping 45° to the south and west, and passes upward to the top of the lower subarkose member. The inclined sheet may be seen clearly on the west and south shores of Brissin lake. The sill seems to follow this stratigraphic level fairly well along a line due east; however, to the south, it again tilts up and assumes a higher level within the lower orthoquartzite member. This "stratigraphic" change may be seen in the hills east of Brissin lake, where the sill passes southward into an inclined sheet dipping 50°-60° north. South of Marescot lake, the middle sill reaches its maximum thickness and has the two-tiered, entablature and colonnade joint system of a very thick intrusive or extrusive body. The two tiers are separated by a zone of platy jointing.

The third, or highest sill, may be seen on the hills north of Pluto lake, and covers the regular cuestas north of Manet and Pollet lakes. This sill is fairly regular in thickness and intrudes the upper subarkose and upper orthoquartzite members. It has the apparently unique characteristic of being composite. Just north of Pluto lake, where exposures are continuous, a sill 200 feet thick is separated from a lower 75-foot sill by a thin (6-30') screen of sedimentary rocks. Beneath the lower sill are two much smaller sills 5-10-feet thick which coalesce and eventually join the lower sill. The reason for this characteristic may be simply that lower confining pressure at higher stratigraphic levels permitted branching or splitting of the intrusion.

It should be noted that the gabbro contacts, where exposed, are not perfectly planar, but have many small bulges and rolls, although keeping for the most part to one stratigraphic horizon, except where the whole body is transgressive. In one or two areas, notably northeast of Marescot lake on the basal sill, and north of Manet lake on the high sill, the contacts are quite irregular. These minor contortions of the contacts marn of the large-scale variations which may be expected, and which are discovered in regional interpretation. At both places mentioned above, several small blocks of sedimentary rocks are caught up in the base of the sill. For the most part, however, the intrusive rocks do not contain many sedimentary or basement intrusions.

Lithology

The rock in the basal sill is chiefly a fresh olivine gabbro. The upper two sills and all the dikes and inclined sheets are largely composed of partly to completely uralitized gabbro. However, whether fresh or rheomorphosed, the basic rocks have some recognizable textures in common. At the contact with older rocks, a thin (2-5 cm.) border of chilled (probably originally glassy) rock is present. This grades into progressively coarser rocks closely resembling the diabase common to so much of the Precambrian Shield. A 50-100 feet from the contact, the grain size is increased to 3-5 mm. and the rock becomes a recognizable gabbro. In the central zone of the thick sills, coarsely poikilitic pyroxene crystals 1-2 cm. long are present. Preliminary chemical studies indicate that this central coarse-grained part of the sills may have undergone differentiation. Unfortunately, these textural differences are partly obscured in much of the area by the conversion of the original pyroxene and olivine to pale green uralitic amphibole. In particular, much of the middle and high sill appear to have been affected. The conversion to uralitic amphibole is thought to have taken place at the time of intrusion, or shortly after, and the converting agent to have been intrastratal water derived from the sedimentary rocks. The lower sill intruded dry basement rocks for the most part and was thus spared this alteration.

Olivine Gabbro

Olivine gabbro is black on fresh surfaces and pale tan where weathered. Plagioclase laths (2-4 mm.) are enclosed in pyroxene grains which range from 2 mm. in the fine-grained varieties to 2 cm. in the coarse, poikilitic center of the sill.

Uralitized Gabbro

Uralitized gabbro is the dominant rock in the area. It has a great number of variations, from a rock which is only slightly uralitized to one which is largely converted to chlorite. It was impossible to distinguish chloritized from uralitized gabbros in the field, particularly since both minerals form pseudomorphs of the original pyroxene.

Small (up to 2 mm.) cubes of pyrite occur in all uralitized gabbros. This, coupled with the greenish cast of the rock in contrast with the black, fresh gabbros, is the most reliable means of quick identification of the rock.

Joints

Joints in the gabbro sills and dikes form a rough system of three perpendicular joint sets. Two are perpendicular to the cooling surfaces and one is roughly parallel to it. This third set gives a first approximation of the dips of the body. Morin (1968) made stereographic plots of joint measurements, and found the point maximum of a series of sub-horizontal joint plots very close to the average dip of the sedimentary rocks below the sill. This relationship was found to obtain in all the areas studied in detail. Further, the joints in the inclined sheets and dikes are clearly seen to be either parallel or perpendicular to the contact, and where the sills pass into inclined sheets the perpendicular joint sets change dip to keep perpendicular to the contact. There seems little doubt that the joints are a cooling phenomenon.

Contact Metamorphic Effects

The intrusion of the large gabbro bodies has altered the basement and sedimentary rocks slightly. This effect is limited to a zone of 2-10 meters from the contact, and may be useful to locate unexposed contacts. Basement gneisses are baked and bleached for 5-15 cm. from the contact, and contain pyrite in small fractures. The sedimentary rocks are baked and have a well-developed columnar jointing within a few meters of the contact.

Not surprisingly, the carbonate-cemented sandstones show the most pronounced metamorphic effects. Large (up to 2 cm.) brown ankerite porphyroblasts developed in the carbonate cement of rocks within 3 meters of the contact. Green crystals in the carbonate-cemented sandstones are small aggregates of chlorite.

Pleistocene

A regional study of the Pleistocene deposits of the area by Hughes (1964) summarizes all the pertinent glacial features of the area. The central part of Gaschet Lake area is extensively covered by ribbed moraine. This has been partly modified by the Péribonca and Saffray rivers, but still remains the dominant local physiographic feature. The Saffray River valley appears to have been a major floodway in the wasting stages of glaciation, and a fairly broad esker complex follows the main valley. Flat terraces of fine, crossbedded, alluvial sands with a few lenses of gravel occur in scattered remnants between the eskers. Much of this material has been reworked into the sand beaches of Pluto and Pollet lakes.

Many of the prominent hills have good crag-and-tail structures. These have not been shown on the present map for lack of space, but they may be easily deduced by comparing the bedrock map with a topographic map.

Glacial striae, roches moutonées, and crag-and-tail show the last major glacial advance was 200°-215° southwest through the area. In one locality in the southwest corner, a later set of striae trending 160° was noted. These features agree with observations made near Indicateur and Boivin lakes (Chown, 1964).

STRUCTURAL GEOLOGY

Basement Complex

The dominant trend in the feebly foliated granite-gneiss and in the metavolcanic rocks is slightly north of east. Metavolcanic rocks appear to form a syncline. The well-exposed metavolcanics in a horst block along the north edge of the mountains is the steeply dipping north limb of the syncline. The south limb can be seen only in one window through the Proterozoic cover, on the north shore of Marescot lake.

Proterozoic Rocks

Only the main structure of the Monts Otish can be outlined until the better exposed areas east of Manet lake are mapped in detail. Nevertheless, the present study, taken with information available from the East Péribonca River area (Chown, 1965), provides a general cross-section through the mountains and gives a preliminary idea of the structure. The mountains, and the structures that control them, trend 060°-070°. The structural subdivisions correspond to the main physiographic ones. Proceeding northwest across the strike of the ranges, these are:

1) Foothills - A broad zone of flat-topped hills formed by remnants of north-dipping gabbro sills intruding near the unconformity, repeated by normal faults.

2) Front Range - Narrow zone, 1-2 miles wide, of sharp hills, including the highest hills of the Monts Otish. Major anticline of sedimentary rocks asymmetrically overturned to the north, considerably modified by transecting strike-slip and normal faults. This is probably related to a major thrust fault.

3) Main Range - Broad central syncline of sedimentary rocks which constitute the main part of the Monts Otish, 4-6 miles wide.

4) North Range - Broad series of south-dipping, flat-topped hills, formed of sedimentary rocks capped by gabbro, partly repeated by normal faults. Northernmost ridge composed of basement rocks.

In the Pluto Lake area, only the second and fourth ranges form significant hills, although the main range structure is present.

<u>Front Range</u>

The front range enters the Pluto Lake area in the south-east corner of the Gaschet Lake area. Two extensive areas of outcrop on either side of Péribonca river show the structure of this ranges, and how the intensity of deformation dies out westward.

East of the Péribonca, the anticline consists of a near-horizontal upper limb and a vertical to overturned northern limb. The hinge and the overturned limb are characterized by a series of second-order anticlines exhibiting the same structural style as the main anticline. A constant south-dipping cleavage (45^o-60^o) is present. Most of the small folds plunge gently northeast. Down-dropped and offset blocks of the upper limb obscure the overturned limb in many places.

West of the Péribonca, the anticline remains asymmetric and retains the prominent cleavage. The northern limb, however, is not overturned, but dips steeply north. Minor fold structures are not as prominent, and are found only in the steeply dipping limb. The structure passes under overburden to the west, and is not observable in the next major outcrop area to the west.

Main Range

Physiographically, the main range dies out just east of the Pluto Lake Area. The structural province, however, appears to continue to Pluto lake. The flat-lying, red argillaceous sandstones just east of Pluto lake are assumed to be part of the upper division of the Monts Otish Group, and thus would represent the central part of the syncline. The Monts Otish syncline extends west beyond this point simply as a change in dip of the sedimentary rocks.

North Range

The north range is at its widest and is best developed, in the Manet Lake area north of Pluto lake. Here, a series of three main ridges (with gentle south and steep north slopes) is found, and each ridge is capped by a gabbro sill. Stream action and glacial activity have dissected the main ridges into "blocks", some presenting very prominent hills. Throughout the range the sedimentary rocks and the concordant gabbro sills dip 5°-20° southeast.

Fault

The Proterozoic and basement rocks are cut into many small blocks by a conjugate system of faults striking 000°-020° and 060°-080°. Movement on these faults has not been great, and is chiefly normal, as indicated on the map. Some strike-slip movement is noted, most with a left-hand separation on the north-south set and a right-hand separation on the east-west set. Many of the normal faults appear to be rotational. The abundance of faults in areas of good exposure appears to be indicative of conditions throughout the whole region. The heavy mantle of overburden may reasonably be assumed to cover a great many other faults belonging to the same system.

An interesting comparison may be made between the faults in the Pluto Lake area and those of the Boivin Lake area

(Chown, 1964) where a similar fault system (possibly the same fault system) occurs. In the Boivin Lake area, the faults appear to be deep seated. Strong shearing affected all rocks in or near the fault zone, converting some of the gabbros to amphibolites or chlorite schists. In the Pluto Lake area, however, few faults affected the country rock beyond the actual fault zone. Slickensides and closely spaced joints are found in the fault zones only. The difference between the two areas may be a function of the depth of burial of the rocks at the time of faulting or may be related to an increase in intensity of faulting to the south. The relation of this pronounced fault system to major structures in the region, such as the Mistassini-Témiscamie River fault, must attend final mapping of all the Monts Otish.

ECONOMIC GEOLOGY

Prospecting in the area has been concentrated mainly on an examination of the gabbro suite for possible copper deposits, and the basal sedimentary rocks for uranium. Current exploration has centered on the latter possibility. Several companies (notably SOQUEM, Canadian Johns Manville, Dome Exploration) were active in 1967.

Copper

Minor mineralization is noted at, or near, all gabbro contacts. Thin seams of chalcopyrite and bornite were noted in the gabbro and in the intruded rocks. Malachite stains coat joints in carbonate-cemented sandstones near gabbro contacts. Minor sulfides, chiefly pyrite and chalcopyrite, occur in the metavolcanic rocks.

Uranium

Several groups of claims were staked in 1967 in the area underlain by the Lac Indicateur Formation. It is not known at the time of writing if significant uranium occurrences were found, or whether they were staked for the purpose of "having ground" in a potentially active area. The discovery of uranium in the Papashwasati Formation has made the Monts Otish area particularly interesting.

Aeromagnetic Anomalies

The pattern of aeromagnetic highs on the regional aeromagnetic map can be explained, for the most part, by the presence of gabbro bodies at, or near, surface.

Two significantly stronger anomalies stand out in this pattern. One, in the lower valley of Saffray river, below Manet lake, may be caused by the cumulative effect of metavolcanic rocks capped by a gabbro sill.

The second, just west of the south end of Pluto lake, is by far the highest anomaly in the region, and is made doubly intriguing by the fact that no outcrops were found by ground traverses through this part of the area.

Geochemical Prospecting

In the course of the fieldwork, 359 stream sediment samples were taken and analysed for Cu, Zn, Pb, Mo, Ni, and U in the laboratories of the Quebec Department of Natural Resources. The results are shown on the accompanying maps and tabulated at the end of the report.

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Results of 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	357	6	40	6	2	–	–		
2	336	60	25	10	0	28	2		
3	337	4	15	4	0	–	1		
4	338	–	–	–	–	–	2		
5	364	4	25	2	–	10	–		
6	352	6	25	16	0	8	1		
7	353	4	20	10	–	13	1		
8	362	6	15	2	0	–	1		
9	148	6	15	16	–	–	–		
10	147	–	–	–	–	–	0		
11	146	–	–	–	–	–	0		
12	194	4	10	6	0	10	0.5		
13	305	10	25	8	8	13	1		
14	149	4	20	16	2	10	0		
15	340	10	25	8	8	13	1		
16	302	4	15	6	0	–	–		
17	299	i–	–	–	–	–	–		
18	300	6	20	10	0	8	0.5		
19	301	6	20	10	0	–	–		
20	330	4	20	2	0	3	2		
21	341	4	20	4	0	8	1		
22	190	2	15	10	–	13	–		
23	342	4	20	4	0	13	1		
24	343	2	15	10	0	8	2		
25	331	2	15	4	0	8	4		
26	94	24	40	16	–	13	–		
27	289	2	5	6	0	5	0.5		
28	290	0	20	4	3	28	2		
29	287	6	10	16	0	–	0.5		
30	250	6	10	10	0	8	0.5		
31	136	2	10	6	–	8	–		
32	129	6	15	6	0	5	0.5		
33	127	6	15	10	1	8	2		
34	128	8	10	6	0	–	–		
35	189	–	–	–	–	–	–		
36	358	–	–	–	–	–	1		
37	359	–	–	–	–	–	–		
38	187	10	10	16	0	8	–		
39	188	8	90	30	–	–	–		
40	182	6	25	8	0	10	4		

Results of analyses in p.p.m.

Sample No. on the map	Code No. of sample in files of Dept.	Cu	Zn	Pb	Mo	Ni	U		
41	366	4	15	4	0	8	0.5		
42	92	10	15	16	0	8	1		
43	384	6	20	10	3	12	0.5		
44	245	6	20	16	–	8	1		
45	244	30	10	8	0	13	1		
46	355	24	25	16	0	–	40		
47	356	60	25	10	0	–	2		
48	329	2	15	2	0	3	0.5		
49	363	6	25	4	20	13	1		
50	293	2	15	16	0	5	0		
51	328	6	20	4	0	16	0.5		
52	351	2	15	4	0	8	1		
53	350	4	20	2	–	–	–		
54	344	2	25	6	2	10	4		
55	345	–	–	–	–	–	–		
56	346	4	25	6	–	5	1		
57	191	2	10	10	–	16	–		
58	303	0	10	6	0	10	0.5		
59	361	2	25	2	–	10	–		
60	145	6	15	10	0	–	0		
61	326	2	40	6	0	3	0.5		
62	304	0	20	10	0	8	0.5		
63	456	4	15	6	1	13	0.5		
64	453	–	–	–	–	–	1		
65	455	2	15	2	0	10	0.5		
66	406	4	50	16	–	–	0.5		
67	133	6	25	10	3	8	–		
68	412	20	25	20	0	18	2		
69	411	4	40	16	0	8	0.5		
70	132	10	10	10	0	20	–		
71	97	6	90	16	0	8	1		
72	96	4	40	10	0	8	1		
73	131	4	15	8	0	8	0.5		
74	134	4	15	8	0	8	2		
75	410	4	20	10	0	10	2		
76	286	0	15	16	6	13	1		
77	90	4	75	20	0	8	3		
78	98	–	–	–	–	–	–		
79	252	4	15	20	–	13	–		
80	73	2	25	6	0	8	5		

Results of analyses in p.p.m

Sample No. on the map	Code No. of sample in files of Dept.	Cu	Zn	Pb	Mo	Ni	U		
81	253	4	15	16	0	13	2		
82	174	6	25	20	0	8	2		
83	160	6	15	20	0	8	2		
84	159	16	15	20	-	-	-		
85	135	4	40	10	-	8	-		
86	175	10	15	20	0	18	-		
87	465	10	15	16	0	8	2		
88	464	16	25	2	0	6	1		
89	370	2	15	4	1	8	0.5		
90	383	4	25	16	2	25	0.5		
91	179	4	40	16	0	13	8		
92	178	6	25	16	0	28	1		
93	183	2	15	10	0	8	3		
94	144	4	10	10	0	10	1		
95	143	-	-	-	-	-	-		
96	176	8	25	16	0	20	-		
97	177	16	15	20	2	13	-		
98	142	2	15	10	0	8	0.5		
99	335	6	20	10	0	28	3		
100	192	8	15	8	0	13	0.5		
101	139	-	-	-	-	-	-		
102	140	-	-	-	-	-	-		
103	141	-	-	-	-	-	-		
104	171	-	-	-	-	-	-		
105	172	6	60	20	-	8	-		
106	459	6	15	4	0.8	8	1		
107	458	2	10	4	0	8	0.5		
108	457	-	-	-	-	-	16		
109	452	-	-	-	-	-	26		
110	445	16	25	16	0	-	1		
111	444	4	50	16	-	6	2		
112	450	-	-	-	-	-	-		
113	407	4	20	16	-	-	-		
114	408	2	20	10	-	10	-		
115	404	-	-	-	-	-	1		
116	413	10	40	16	-	-	-		
117	418	4	20	6	0	8	1		
118	409	10	25	20	-	16	2		
119	414	4	15	10	0	5	2		
120	61	2	15	16	0	-	0.5		

Results of analyses in p.p.m.

Sample No. on the map	Code No. of sample in files of Dept.	Cu	Zn	Pb	Mo	Ni	U		
121	415	4	20	20	-	-	0.5		
122	416	-	-	-	-	-	1		
123	417	2	25	10	-	8	-		
124	93	6	25	20	0	8	0.5		
125	63	4	10	6	0	8	1		
126	138	6	15	30	0	8	1		
127	173	-	-	-	-	-	-		
128	137	6	15	30	0	8	1		
129	368	10	20	2	0	5	1		
130	369	4	20	2	0	8	0.5		
131	371	16	25	6	0	15	1		
132	380	4	20	16	0	8	0.5		
133	382	2	15	16	0	8	1		
134	199	2	10	16	0	-	-		
135	381	4	25	20	-	6	-		
136	200	6	15	16	1	8	1		
137	198	4	5	20	0	8	0		
138	197	120	15	8	0	8	0.5		
139	203	8	20	6	0	63	0.5		
140	201	40	10	10	0	20	1		
141	196	6	10	6	0	53	0.5		
142	247	4	15	16	0	3	0.5		
143	248	2	10	8	0	5	0		
144	181	2	15	10	0	8	1		
145	163	4	15	16	0	8	4		
146	161	4	15	16	0	8	0		
147	180	4	40	10	0	13	2		
148	162	8	40	10	-	20	-		
149	124	16	15	6	0	18	-		
150	123	-	-	-	0	-	-		
151	121	8	10	10	0	8	3		
152	292	6	25	20	-	-	4		
153	296	300	25	10	0	16	16		
154	333	-	-	-	-	-	-		
155	332	-	-	-	-	-	-		
156	56	2	10	6	-	13	0		
157	59	4	10	6	0	8	2		
158	67	-	-	-	-	-	-		
159	62	2	15	10	-	13	8		
160	379	4	20	20	0	8	1		

Results of analyses in p.p.m

Sample No. on the map	Code No. of sample in files of Dept.	Cu	Zn	Pb	Mo	Ni	U		
161	118	6	10	6	0	8	4		
162	251	6	10	16	–	5	2		
163	119	10	15	6	0	8	4		
164	117	6	15	10	–	20	–		
165	327	4	25	6	–	16	0.5		
166	258	6	15	16	0	13	5		
167	308	4	25	16	0	–	2		
168	291	4	25	6	–	10	–		
169	102	16	25	20	0	18	2		
170	306	24	60	80	1	1160	16		
171	103	6	50	16	–	8	–		
172	195	4	5	8	0	8	0.5		
173	104	2	25	10	0	8	–		
174	105	4	140	16	0	8	1		
175	108	4	25	10	0	8	2		
176	106	2	15	16	0	8	0.5		
177	246	4	15	10	0	8	0.5		
178	107	4	15	10	0	10	1		
179	122	24	15	6	1	25	3		
180	166	4	15	10	0	8	–		
181	282	0	15	16	1	10	0.5		
182	165	6	10	16	0	13	4		
183	281	4	15	10	1	13	1		
184	376	4	20	16	–	–	0.5		
185	231	2	15	10	0	8	0		
186	230	4	15	4	8	10	2		
187	377	2	20	10	–	5	1		
188	375	2	40	24	0	3	0.5		
189	374	24	40	50	0	–	2		
190	280	2	10	16	0	8	0.5		
191	71	2	10	20	0	8	0		
192	72	–	–	–	–	8	–		
193	58	6	5	6	–	13	0.5		
194	57	–	–	–	–	8	–		
195	10	6	25	20	–	18	6		
196	8	4	15	6	0	8	1		
197	7	6	25	10	–	20	–		
198	70	–	–	–	–	–	2		
199	294	30	25	16	–	8	–		
200	75	4	15	6	–	13	–		

Results of analyses in p.p.m.

Sample No. on the map	Code No. of sample in files of Dept.	Cu	Zn	Pb	Mo	Ni	U		
201	295	20	60	50	–	–	5		
202	288	6	15	6	–	10	–		
203	360	2	20	4	0	3	0.5		
204	249	10	15	10	–	8	–		
205	76	4	10	10	–	8	–		
206	78	4	5	10	–	20	–		
207	77	6	10	10	0	–	2		
208	79	4	10	10	–	–	1		
209	80	6	10	10	0	10	3		
210	86	30	25	10	–	13	–		
211	87	24	25	6	0	20	–		
212	81	–	–	–	–	–	–		
213	100	20	40	16	0	25	20		
214	101	6	25	10	0	–	–		
215	113	2	15	10	0	8	0.5		
216	112	2	20	16	0	8	3		
217	3	4	25	16	–	–	–		
218	111	4	25	10	0	8	2		
219	110	2	40	16	11	18	2		
220	109	2	15	16	0	8	0		
221	366	4	15	4	0	8	0.5		
222	269	4	15	20	–	33	3		
223	268	–	–	–	–	–	6		
224	267	10	10	10	–	–	1		
225	278	2	10	16	0	8	0.5		
226	373	10	40	4	–	10	1		
227	372	8	50	24	–	13	1		
228	232	6	20	16	–	6	0.5		
229	234	2	10	16	–	6	0.5		
230	334	6	40	20	–	8	–		
231	348	–	–	–	–	–	1		
232	233	6	20	30	–	8	–		
233	347	6	20	4	–	–	2		
234	69	–	–	–	–	–	–		
235	40	6	60	16	–	–	0.5		
236	39	2	40	90	7	8	1		
237	18	8	25	24	0	13	2		
238	19	4	40	10	6	8	2		
239	17	4	10	6	–	20	–		
240	367	30	40	6	–	10	–		

Results of analyses in p.p.m

Sample No. on the map	Code No. of sample in files of Dept.	Cu	Zn	Pb	Mo	Ni	U		
241	238	2	10	8	0	8	1		
242	239	6	5	16	–	10	–		
243	42	2	20	6	–	20	–		
244	240	2	5	10	0	3	–		
245	41	6	70	16	–	8	0		
246	16	4	10	6	0	8	0		
247	243	0	10	6	0	5	2		
248	21	–	–	–	–	–	–		
249	24	–	–	–	–	–	32		
250	22	4	40	24	–	20	2		
251	15	6	15	10	–	8	2		
252	4	4	60	16	–	–	–		
253	12	4	25	20	–	8	0.5		
254	10	6	25	20	–	18	6		
255	5	6	25	10	0	–	2		
256	2	4	25	20	–	45	–		
257	11	6	15	20	0	0	4		
258	1	8	90	20	0	–	8		
259	403	6	25	4	0	8	4		
260	400	6	20	10	0	10	8		
261	402	56	50	6	0	–	–		
262	401	20	60	6	0	18	6		
263	378	2	15	10	0	8	1		
264	116	4	10	10	0	8	16		
265	115	2	15	6	0	8	–		
266	114	4	5	10	0	8	5		
267	82	2	5	6	1	5	0		
268	170	4	20	16	–	190	–		
269	83	6	25	24	–	25	–		
270	84	6	15	10	–	13	–		
271	236	4	5	6	0	8	0.5		
272	89	2	20	16	0	8	0		
273	284	0	15	16	–	–	–		
274	285	0	10	10	3	8	0.5		
275	158	6	20	44	6	8	1		
276	235	2	10	6	0	5	0		
277	237	2	10	10	0	5	0.5		
278	48	–	–	–	–	–	4		
279	53	–	–	–	–	–	–		
280	85	4	40	10	–	8	–		

Results of analyses in p.p.m.

Sample No. on the map	Code No. of sample in files of Dept.	Cu	Zn	Pb	Mo	Ni	U		
281	52	4	25	10	0	8	1		
282	50	2	25	6	–	–	–		
283	55	4	15	16	–	20	–		
284	51	–	–	–	–	–	–		
285	20	4	25	10	–	13	2		
286	23	–	–	–	–	–	6		
287	168	6	15	16	0	–	–		
288	169	4	10	16	–	–	–		
289	167	2	5	10	0	8	0.5		
290	88	4	15	6	0	8	0.5		
291	60	4	10	16	0	8	0.5		
292	157	8	15	20	0	8	–		
293	156	–	–	–	–	20	–		
294	283	0	10	10	0	13	2		
295	431	6	50	30	–	–	–		
296	155	6	25	76	0	13	1		
297	154	–	–	–	–	20	–		
298	153	10	90	24	20	28	–		
299	152	6	25	24	0	8	–		
300	150	10	40	16	–	–	–		
301	151	6	90	10	9	23	1		
302	35	4	25	10	–	13	0.5		
303	25	6	40	20	–	–	–		
304	26	4	40	16	–	8	–		
305	13	–	–	–	–	–	0.5		
306	44	6	90	10	0	10	2		
307	34	4	15	10	0	8	1		
308	31	6	40	30	–	20	1		
309	33	2	25	6	–	5	1		
310	32	4	15	6	0	8	1		
311	420	2	15	6	0	13	1		
312	421	2	25	16	0	–	2		
313	422	4	15	10	0	–	2		
314	423	–	–	–	–	–	2		
315	424	–	–	–	–	–	–		
316	425	4	20	30	0	–	–		
317	430	2	20	10	0	12	–		
318	429	4	25	16	–	–	1		
319	428	4	20	56	–	12	–		
320	426	2	25	10	–	8	–		

Results of analyses in p.p.m

Sample No. on the map	Code No. of sample in files of Dept.	Cu	Zn	Pb	Mo	Ni	U		
321	46	–	–	–	–	–	6		
322	36	10	25	26	0	20	2		
323	37	6	60	20	–	8	–		
324	45	4	10	10	–	–	–		
325	28	–	–	–	–	–	1		
326	27	4	25	10	0	8	1		
327	38	4	25	6	–	5	1		
328	29	6	25	16	–	–	0.5		
329	30	6	60	10	–	8	0.5		
330	257	4	10	20	0	10	0.5		
331	256	4	15	30	0	–	2		
332	255	2	10	10	0	10	1		
333	254	2	10	16	–	28	–		

– no determination

0 element not detected

Results of analyses in p.p.m.

Sample No. on the map	Code No. of sample in files of Dept.	Cu	Zn	Pb	Mo	Ni	U		