GEOLOGY OF THE McOUAT
GAUVIN AREA

Mistassini Territory and

Roberval Electoral District

Quebec.

by

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INTRODUCTION

General Statement

The geology at the southern end of Lake Mistassini was studied during the summers of 1956 and 1957. This thesis is a presentation of information gathered in the field, and deals with the problem of the Grenville front in the McOuat - Gauvin area.

Field work was carried out under the auspices of the Geological Surveys Branch of the Department of Mines, Quebec. Material in this thesis has been published in Preliminary Report No. 356 on the McOuat - Gauvin area. (Sater, 1958).

Location

The McOuat - Gauvin area is bounded by latitudes 50° 15' and 50°30'N. and by longitudes 73°30' and 73°45'W. The 15' sheet covers 192 square miles in Mistassini Territory and Roberval Electoral District, and includes parts of McOuat, Gauvin, Joybert and Bonne townships.

The area is 50 miles northeast of Chibougamau, and 10 miles east of Mistassini Post in Duquet area.

Access

Mistassini Post, established circa 1813, occupied a strategic position on the routes of pioneers. Explorers reached the Post from Lake St. John by way of Asuapmuchuan River or Mistassini River. The construction of a road from St. Felicien to Chibougamau in 1950, and of a railway line from Beattyville to Chibougamau in 1957 has facilitated access to the Lake Mistassini region.

Air services operating from Chibougamau provide convenient means of transport to the area. A road from Chibougamau to Waconichi Lake, completed in 1957, allows access by way of Poste Bay.

A railway line from Chibougamau to the iron deposits at Lake Albanel is under consideration. Preliminary surveys for the route, conducted in 1957, passed through Gauvin and McOuat townships.

Continuous stretches of water and connecting portages allow easy access to most parts of the area. The route from Chalifour River to File-Axe Lake along River à la Perche has many rapids.

Previous Work

James Richardson (1872) gave the first account of the geology of Lake Mistassini region. He described briefly the lithology of the limestone group.

McOuat (1873) described gneisses along River à la Perche, and located a shear zone between gneisses and dolomite.

Low (1886) classified the Mistassini Group as Cambrian limestones. In later report, (Low, 1897) he describes hornblende gneisses and schists on File-Axe Lake. In a report on the Chibougamau mining region, Low (1906) describes the Mistassini Group as Upper Huronian limestone, and records the discovery of galena and sphalerite at the narrows north of Mistassini Post.

The Chibougamau Mining Commission, (Farribault, Gwillim, and Barlow, 1911) classified the dolomites as Lower Ordovician.

Norman (1939) described some aspects of the Pleistocene geology in the region. In a later paper, (Norman, 1940) he recognized a fault along the eastern contact of the Mistassini Group, and inferred that gneisses were thrust to the northwest against the dolomites.

Neilson (1947) made a geological reconnaissance of the Mistassini basin.

The Department of Mines, Quebec, has mapped Bignell area, (Gilbert, 1951) and Duquet area, (Deland, 1957) southwest and west respectively, of the present area. Several sheets of the north end of Lake Mistassini, have also been mapped, (Neale, 1952; Neilson, 1950 (a), 1953; Wahl, 1953).

At present there is an unmapped area of 15' latitude between Albanel area (Neilson, 1953) and the McOuat - Gauvin area, (Sater, 1958).

Field Work

Mapping was done by pace and compass traverses at intervals not exceeding 0.5 mile. Shoreline surveys were carried out to examine exposures on lakes and rivers.

Vertical aerial photographs, on scales of 1:15,840 and 1:31,680 were used in planning traverses. Information on the shape and distribution of glacial features was obtained from these photographs. The strike of dolomite beds at Diagonal Lake, and the northwest fault at Guinea Lake are conspicuous in aerial photographs. Aerial photographs showed displacement of dolomite ridges by faulting, and revealed several gneiss outcrops along scarps.

A base map on a scale of 1:31,680 was prepared by La Compagnie Photo-Air Laurentide, Quebec, from 1:15,840 scale photographs and ground survey controls.

B.E. MacKean, senior assistant, and P.B. Clibbon and J.R. Perreault, junior assistants, were industrious aides in the field party.

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Dr. J.A. Elson directed the thesis, and gratitude is expressed for his supervision.

RESOURCES

Vegetation and Soil

The region is well forested except in low muskeg areas. Black spruce and jack pine, with sparsely interspersed balsam fir, grow throughout the area. Stands of yellow birch and poplar are found on better drained soils along many ridges. Glacial drift forms poor sandy soils.

Game and Fish

Animals are scarce in this region, their numbers having been depleted by Indian hnnters from Mistassini Post. Moose were seen on rare occasions; and few bear trails were found. Beavers, muskrats and otters survive in remote areas; wildfowl are plentiful.

Pike, pickerel and trout abound in lakes and rivers.

Climate

Break-up occurs in late May or in early June. Weather during the summer months is mild, with temperatures seldom exceeding 80^{o}F. Rainfall is heavy in all of the summer months. Continuous rains come from the south and southwest; storms commonly blow from the northwest. The smaller lakes are reported to freeze in late October.

Settlement

There are no dwellings apart from a derelict winter cabin on River à la Perche. The area is frequented by Cree Indian hunters and trappers from Mistassini Post.

TOPOGRAPHY

Relief

Relief in the area is 300 feet. The watershed between the Hudson Bay and the St. Lawrence drainage basins passes west of File-Axe Lake and between File - Axe and Heidi Lakes at an altitude of 1500 feet above sea level. File-Axe Lake is at an altitude of 1485 feet.

File-Axe Lake, Heidi Lake and Lamentation and Revelation lakes lie along a ridge of gneisses. The ridge slopes westward to a sand plain on the east side of Chalifour River. (Plate 1.A,). The sand plain extends northeastwards across Gauvin and McOuat townships in a 4 miles wide zone with few outcrops. The altitude of the plain is 1270 feet. Chalifour River is at the same level as Lake Mistassini, 1220 feet above sea level.

A plateau, 120 to 200 feet above river level, lies between Chalifour river and Abatagouche bay in Duquet area. The plateau is bounded by dolomite cliffs curving around the nose of a syncline, passing through Diagonal Lake. South of Diagonal Lake the land is low and swampy. It is the fringe of a drumlin belt in Duquet area.

Drainage

The drainage system is not well integrated, and large areas are underlain by swamp. Chalifour River and River à la Perche drain the land on the west side of the water-shed.

Lakes are shallow. Bedrock shoals and scattered outcrops along the shore indicate that the larger lakes owe their origin to bedrock structures. Smaller lakes occupy shallow depressions in the glacial drift, and their shapes are influenced by the forms of the glacial deposits.

PLATE 1 A, View westwards from near Revelation Lake; dolomite plateau forms the horizon.

PLATE 1 B, Boulders around a kettle lake, N.E. part of McOuat township.

GENERAL GEOLOGY

Pleistocene drift overlies Precambrian rocks and forms conspicuous topographic features in drumlins and eskers.

The Precambrian formations belong to two provinces of the Precambrian Shield, the Superior Province and the Grenville Province, which in the McOuat - Gauvin area are in faulted contact. The relative ages of the Precambrian formations are not known.

In the Superior Province dolomites of the Mistassini Group lie in a syncline plunging northwards at 10° to 15°. The syncline is truncated obliquely on the east by a northeast trending fault zone. Lower members of the group are truncated by the fault; upper members dip steeply or are overturned along the east limb.

An assemblage of gneisses, schists and granitic rocks is regarded as part of the Grenville Province because of a northeast structural trend and the presence of folded medium grade metamorphic rocks. Regional foliation of the gneisses strikes northeast and dips southeast between 35° and 70°.

TABLE OF FORMATIONS

Cenozoic	Pleistocene	Sand, silt, till.
	Unconformity.	
Precambrian	Mistassini group	Pink and buff crystalline dolomite; Grey stratified crystalline dolomite and dolomitic shale
	Granitic Intrusions	Pegmatites and aplites.
	Gneissic rocks.	Orthogneiss group: Granodiorites, diorites. Paragneiss group: Amphibole schist, Biotite gneiss, Hornblende gneiss.

PLEISTOGENE GEOLOGY

A record of the Pleistocene glaciation is observed more in deposits of glacial drift than in erosional features. Rock debris in the drift is apparently of local origin; large blocks of bedrock have been displaced but have not been moved far from the original sites.

Glacial drift is composed mainly of sand and gravel, with local deposits of till. Boulder fields occur over the gneiss terrain in the east part of the area. Sand plains with drift mounds and kettle lakes (Plate 1.B) cover extensive areas. Sections along Chalifour River show that there the drift is well sorted into gravel and sand, and that the sand is stratified and cross-bedded (Plate 2.A).

Drumlins in the area are over a mile in length, 1000 feet wide and 50 feet high. Over the Mistassini Group the drumlins are distinct, closely spaced parallel ridges trending S. 15^{o}W. to S. 20^{o}W., whereas drumlins on gneiss bedrock are isolated and not well outlined except where they are flanked by lakes. Over the gneisses the trend of the drumlins is S. 5^{o}W. to S. 10^{o}W.

A prominent esker crosses the drumlin trend between Chalifour River and River à la Perche and winds its way northeastwards across the area. The esker is as much as 100 feet high with sides sloping at 30^{o}. In places along its length the esker divides into two ridges, separated by shallow lakes. Nodes along the esker where it follows the east bank of Chalifour River are about 1000 feet apart. This esker can be traced almost continuously for 130 miles from Opemisca Lake to Temiscamie River (Norman, 1939). Small sinuous eskers are found at File-Axe Lake.

Glacial striations range from due south to S. 10^{o}W., and are observed only on the gneisses. Shoreline exposures of gneiss are usually whaleback bosses, showing glacial striations along their length. The shape is evidently due to the parallelism of gneissic structures with the direction of ice advance.

At Diagonal Lake the strike of dolomite beds is transverse to the direction of ice advance. Troughs between successive north-facing cuestas are filled with glacial drift and large dolomite blocks have been dislodged on the south side of the scarp.

The Glacial Map of Canada (1958) shows a divergence of glacial trends from the southeast end of Lake Mistassini. The division between the two trends follows the height of land. It is clear that the pre-Pleistocene topography has been little changed by glaciation, and that topography more than bedrock structures shaped the course of ice advance.

PLATE 2 A, Stratified sand at Chalifour River.

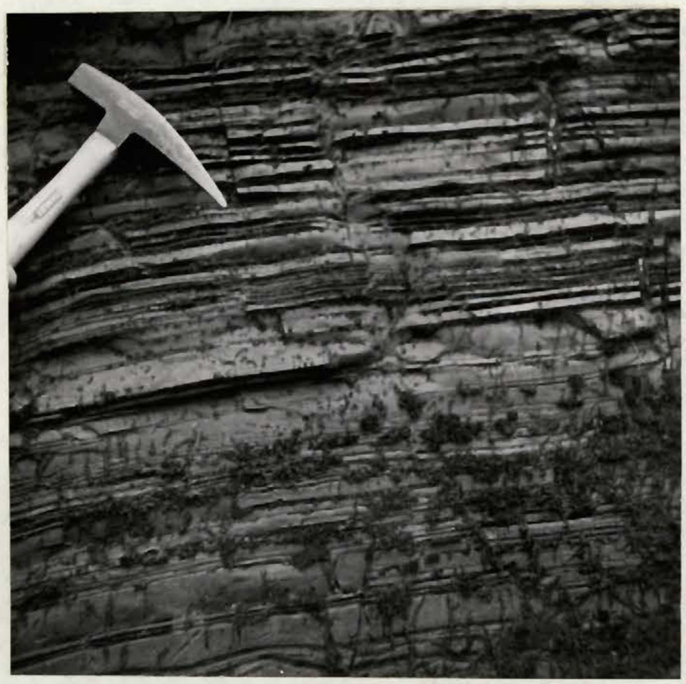


PLATE 2 AB, Differential weathering of dolomite beds, south of Diagonal Lake.

THE MISTASSINI GROUP

General Statement.

Dolomites of the Mistassini Group, previously referred to as the Mistassini Series, are exposed in the northwest part of the area.

Neilson (1953) and Wahl (1953) divided the Mistassini sediments into a Lower Albanel formation, an Upper Albanel formation, and a Temiscamie formation. The Lower Albanel formation does not include the lowermost members of the Mistassini group. Although ultimately this classification will be applied throughout the Mistassini syncline, its application at present is restricted to beds mapped continuously along strike.

Deland (1958) divided the lower members of the Mistassini group into 3 formations on a basis of texture, structure, and composition. These formations are:

3) crystalline dolomite,

2) non-crystalline dolomite,

1) conglomerate, and dolomite with concretions.

The crystalline dolomite formation has been subdivided into 2 members on a basis of colour, the lower member being mostly grey to white, and the upper member mostly red.

The crystalline dolomite formation can be traced continuously into the McOuat - Gauvin area and is the only formation of the Mistassini Group present. Two divisions are recognized: a lower well-stratified group of grey crystalline dolomite and dolomitic shales, and an upper massive group of pink and buff crystalline dolomites. A zone of cryptozoon structures occurs in the upper group.

The complete succession of each division did not lie within the map - area. Stratigraphic thicknesses have not been measured.

Grey Stratified Dolomite and Dolomitic Shales.

The stratified dolomite is a grey to dark grey, medium grained, crystalline rock, weathering to a brown or grey chalky surface. Beds are less than an inch to 15 feet thick. Bedding is indicated by colour and texture changes, or by intercalated shale lenses and argillaceous partings. Differential weathering produces a fluted surface emphasizing the bedding of thinly bedded dolomites. (Plate 2.B.). Bedding planes between massive beds are sharply defined. Minor disconformities are indicated by mudcracks and dessication breccias. Chert nodules lie along bedding planes. (Plate 3.A.)

Intraformational conglomerates are a feature of the dolomites in the vicinity of Diagonal Lake. The conglomerates consist of flat lenticular fragments of dark grey dolomite in a lighter grey dolomite matrix, as seen on a weathered surface. The fragments, varying from 0.2 inch by 2 inches to 2 inches by 6 inches, are generally not well aligned. Intraformational conglomerates range from a few inches to 4 feet in thickness.

PLATE 3 A, Chert lenses along bedding planes, near River à la Perche.

PLATE 3 B, Sedimentary breccia in dolomite, northwest of Diagonal Lake.

A sedimentary breccia, distinguished from intraformational conglomerates by the coarseness and irregular outlines of its fragments, occurs in several localities northwest of Diagonal Lake. The fragments are conspicuous on a weathered surface; their physical relief and darker colour contrast with the matrix. (Plate 3.B.). The fragments are randomly oriented. The extent of the breccia zones is unknown but theyare probably local, intraformational features.

Arenaceous facies are found in the lower members. The sand fraction consists of frosted quartz grains, averaging 1 millimeter in diameter. Quartz grains may constitute 50 per cent of the rock, but the amount varies greatly over short distances. Cross bedding is a common feature in the sandy dolomites.

A brittle, black, greasy bituminous compound, identified initially by Low (1897) as anthraxolite, and confirmed by later analysis (Wahl, 1953) occurs sparingly but widespread through the dolomite. It is particularly noticeable in the form of small clusters, generally 0.2 inch in size, occupying small vugs. It is found as thin films along fractures, and may be the constituent of some stylolites.

Brown and grey argillaceous dolomites form a minor part of the group where it is exposed although valleys between cuestas might be underlain by softer, shaley rocks. Argillaceous material consists of minute shreds of sericite and chlorite with small authigenic crystals plagioclase or microcline, and very fine quartz grains.

Pink and buff dolomites.

The division is based on the contrast between the underlying grey stratified dolomite and this group of pink and buff, generally massive dolomites. The contact between the two divisions was not observed. The change appears to be abrupt, although small disperse patches of pink carbonate in the grey stratified dolomite near its upper contact may indicate a progressive change. It is believed however, that the contact is an unconformity associated with a marked change in stratigraphy.

The rocks are typically massive, fine to medium grained crystalline dolomites varying in colour from pink to buff. The rocks are hard and dense, and resemble jasper on a fresh surface. Coarser grained varieties are mottled pink, light grey or white. Bedding, where present, is marked by changes in colour, silt intercalations and shale partings.

In most cases colours are related to stratigraphy and correspond to changes in texture and composition. However, some colour changes are due to alteration, as is evidenced by colour changes across joints, relicts of grey dolomite within a pink dolomite, and dark red seams transecting pale bands.

Rounded and frosted quartz grains 1 millimeter in diameter occur disseminated in the massive dolomite, constituting locally 10 to 20 percent of the rock. Very fine quartz grains can be identified microscopically in narrow silt bands in the dolomite. Hematite is distributed sparingly in dolomite crystals.

The pink and buff dolomites are cut by a network of closely spaced quartz and chalcedony veins (Plate 4.A.). The veins are 0.5

PLATE 4 A, Quartz and chalcedony veinlets in dolomite, Lock Lake.

PLATE 4 B, Fault breccia in pink dolomite, from Guinea Lake.

inches wide, and are made of a core of quartz crystals in a comb structure bounded by spherulitic chalcedony aggregates.

Cryptozoon Zone.

At Lock Lake a zone of well-developed crytozoon structures is associated with quartz and chalcedony veins. The cryptozoon structures are columns of concentric hemispheroidal laminae of buff crystalline dolomite and light grey silty dolomite. (Plate 5 A and B). Siliceous veins are parallel to the laminae or radial to the concentric structures. The radius of the outside shells is 3 feet; a centre, or nucleus, was not observed.

The exposures of cryptozoon structures on Lock Lake are in the topmost part of the pink and buff dolomite division found in the area. It is not known if these structures form a continuous horizon. Neilson (1953) and Wahl (1953) describe similar occurrences in the Albanel and Temiscamie River areas.

Structure of the Mistassini Group

The southern end of the Mistassini syncline is truncated obliquely by the Mistassini fault zone. Lower members of the group are cut off by the fault, whereas members higher in the succession maintain the shape of a syncline with a steepened east limb.

The grey stratified dolomite shows steepening of the rim of the syncline towards the east. Where the strike of the beds parallels the Mistassini fault zone, in some places the beds are overturned. Overturning through 10^{o} or 15^{o} is inferred from the proximity of vertical beds and beds dipping steeply west with beds dipping steeply east. Some beds close to the contact with gneisses dip east at 40^{o} or 50^{o} and are not overturned, as can be seen from scour channels along bedding planes.

PLATE 5 A, Cryptozoon structures, Lock Lake.

PLATE 5 B, Cryptozoon structures with quartz veins, Lock Lake.

Tight folds (Plate 6.A), drag folds (Plate 5.B) and faults indicate the degree of deformation in the grey crystalline dolomites. In general deformation of beds is greater in the north.

Joint sets in the grey crystalline dolomite do not show a clear pattern, but N. 5°E., N.10°W., and N.50°W. are common directions. Joint planes dip at random.

The pink and buff dolomites, in contrast to the underlying grey dolomites, are flat lying, or dip gently around the nose of a syncline plunging northwards at a low angle. Minor undulations in the bedding may be due to cross-bedding or in some cases to reef-forming organisms.

Joints in the pink and buff dolomites show a consistent pattern striking north-south, N. 10°E., N.80°E., and N.80°W. Joint planes dip steeply and generally are vertical.

Faults associated with the Mistassini fault cut the dolomites in a northwesterly direction. These faults offset dolomite ridges, form linear features like that at Guinea Lake, and brecciate the dolomite. (Plate 4.B.)

Depositional Environment of the Mistassini Group

The lower members of the Mistassini Group have features of the orthoquartzite-carbonate association of sediments deposited on a stable shelf.

The dolomites were deposited in shallow water under quiet conditions. Frequent emergence is indicated by mudcracks and dessication breccias. The high degree of sorting of the detrital fraction and the rounding and frosting of quartz grains suggest that the detrital fraction is wind blown material derived from a low-lying land surface nearby.

The sparse but widespread occurrences of anthraxolite, the concretions at the base of the group, and the cryptozoon structures at Lock Lake attest to the existence of organisms at the time of deposition of the sediments. No evidence to support or deny organic processes for their origin was obtained in the course of this investigation. The concretions and cryptozoon structures point to peculiar conditions of deposition or diagenesis and may prove useful in correlation.

PLATE 6 A, Tight fold in dolomite beds, east of Chalifour River.

PLATE 6 B, Drag along fault in dolomites, lower rapids River à la Perche.

PLATE 7 A, Stratiform exposure of paragneisses, River à la Perche.

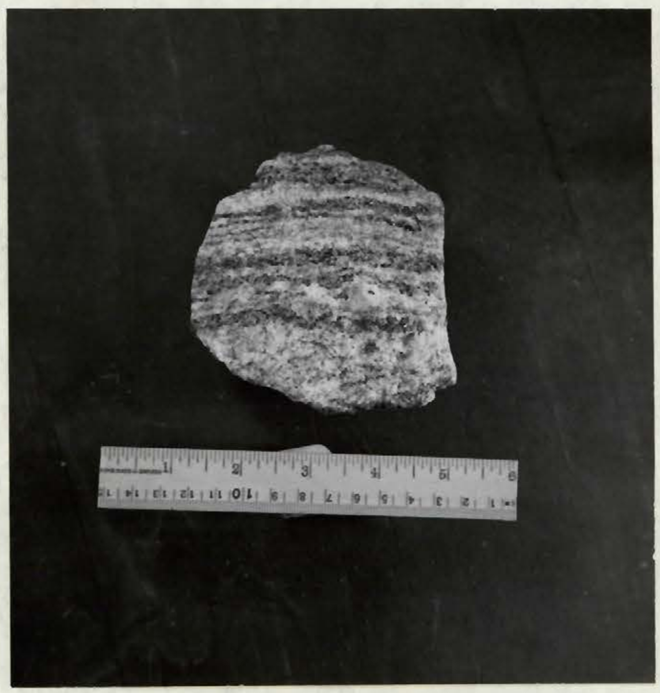


PLATE 7 B, Banding of biotitic and feldspathic layers in paragneisses.

GNEISSIC ROCKS OF THE GRENVILLE PROVINCE

General Statement

Metamorphic rocks underlie the area east of the Mistassini fault. Exposures are scant and occur mostly along shorelines. Isolated outcrops are found inland along scarps. Two genetic divisions are recognized, paragneisses and orthogneisses, which occur in separate areas and are mapped as separate formations. Age relationships are uncertain.

The orthogneiss group, which is predominantly magmatic, is exposed in the west, adjacent to the Mistassini contact. The rocks are granodiorites and diorites containing large inclusions of altered amphibolites. Assimilation of the amphibolite inclusions is evident along contacts. At some exposures the inclusions are oriented, giving a coarse overall gneissic structure to the outcrop. Minor inclusions of metamorphosed clastic sediments are present. Dynamic metamorphism has produced gneissic structures within the magmatic rocks.

The paragneiss group is composed mainly of metasedimentary gneisses, and occupies the eastern part of the area. Regional metamorphism of the epidote - amphibolite grade has changed sediments to biotite and hornblende gneisses. In the field the sedimentary origin of these gneisses can be recognized by stratiform exposures (Plate 7.B.), and locally by cross-bedded structures. Lit-par-lit intrusions of granite give rise to composite gneisses. (Plates 8 A and B.).

Hornblende schists form conformable and transecting bodies within the biotite and hornblende gneisses. The schist zones are not more than 2 feet wide and pinch out along strike. Many of these schists are metamorphosed basic intrusions which still show intrusive contacts, Some of the conformable schist zones are possible metamorphosed sedimentary beds. The problem of hornblende schists within similar gneisses of the Grenville Province is discussed by Osborne (1936), Wahl and Osborne (1950), and Engel and Engel (1953).

Granodiorites and granites intrude the paragneisses as aplite and pegmatite dykes.

Shearing along the Mistassini fault zone has markedly affected the gneisses. Chlorite schists and amphibolites veined with pink feldspar occur close to the contact. Chlorite and hematite slickensides coat the surfaces of shear planes. Granodiorites on the contact are mylonitized.

Biotite Gneiss

Biotite gneiss is the dominant rock in the paragneiss group and is a grey, medium grained foliated rock. Foliation is due to original sedimentary beds of different compositions, now metamorphosed to feldspathic and biotitic layers. Alternating mineral bands are from 0.5 inches to several feet thick. Where foliation is poorly developed the gneiss is a medium grained granitic rock with a uniform granoblastic texture.

The rock is composed of mosaics of recrystallized quartz grains with sutured contacts, generally in bands of different grain size, and interstitial feldspar crystals. Quartz constitutes 35 to 50 percent and plagioclase (An 25-28) 20 to 50 percent of the rock. Potassic feldspars are generally absent. The biotite content is variable; overall it amounts to 10 percent, but it is more abundant in narrow bands. Chlorite, muscovite, clinozoisite, epidote and allanite, and scapolite

PLATE 8 A, Lit-par-lit intrusion of granite in paragneisses, east of Een Pond.

PLATE 8 B, Interstratal intrusion of granite in paragneiss.

are present in minor amounts. Apatite, magnetite, sphene and zircon are accessory minerals. Small disseminated pyrite crystals occur locally.

The meta-sedimentary origin of the biotite gneiss can be recognized by a granoblastic texture, a high tenor of quartz, and alignment of inequant quartz grains parallel to the foliation.

Hornblende Gneiss.

Bands of hornblende gneiss occur with biotite gneiss. Medium grained hornblendic bands alternate with feldspathic bands, 1 to 3 inches thick, but foliation is not as well developed as in biotite gneiss.

The rock is composed of 35 percent quartz, 35 percent plagioclase An 23, and 25 percent femic minerals, forming a medium grained granoblastic texture with parallel orientation of the femic minerals. Hornblende in large subhedral crystals and epidote, chlorite and biotite are the femic constituents. Apatite, magnetite and sphene are accessory minerals.

A band of flaser gneiss is developed along the western margin of the paragneiss group. The rock contains lenses of feldspar and thin quartz stringers in irregular hornblende bands.

Hornblende Schist

Narrow lenticular or tabular bodies of hornblende schist occur in the paragneiss group. The rocks are fine to medium grained dark green schists, locally with saussuritized porphyroblasts.

The rock is composed of 30 to 60 percent hornblende, 10 to 25 percent clinozoisite and epidote, 15 percent plagioclase (An 28 - 38), 15 percent quartz and 10 percent biotite and chlorite. The femic minerals form a compact schistosity with interstitial plagioclase and quartz. Porphyroblasts are formed of clinozoisite and epidote with calcite. Apatite, magnetite, rutile and sphene are accessory minerals.

Granodiorites.

Granodiorites are pink to grey, medium to coarse grained intrusions, occuring in both the orthogneiss and the paragneiss groups.

In general the rock contains 25 to 35 percent quartz, 35 to 55 percent plagioclase (An 23 - 34), and up to 25 percent hornblende, biotite and chlorite, in an allotriomorphic texture. Potassic feldspar, if present, is microcline and constitutes less than 15 percent of the rock. Apatite, magnetite and sphene are accessory minerals.

Granodiorites in the orthogneiss group show a rough alignment of crystals, undulatory extinction of quartz grains, and intense alteration of feldspar to sericite and kaolin or to scapolite. Calcite or dolomite is common in the altered granodiorite. Granodiorites in the paragneiss group show little alteration. It is not known if granodiorites of more than one age are represented.

Diorite

A medium to coarse grained hornblende diorite is exposed along the southwest margin of the area, about 3 miles south of Souris Lake. The diorite contains amphibolite inclusions, and is cut by fine grained pink granitic dykes.

Plagioclase An 33 makes up 55 percent of the rock, and is altered to kaolin and sericite. Hornblende and chlorite form 25 and 15 percent respectively of the rock. Apatite, epidote and sphene are accessory minerals. Quartz is generally absent, but may amount to 10 percent. The rock has a medium grained allotriomorphic texture.

Granites

Granite intrusions are common in the orthogneiss and paragneiss formations. The intrusions range from aplites to pegmatites, and include several varieties in an intermediate grain size. The rocks are pink, and characteristically have large quartz aggregates or crystals conspicuous on a weathered surface. Coarse graphic textures of quartz in feldspar are found. Perthitic intergrowths and exsolution veinlets of orthoclase in plagioclase occur in graphic granites. Feldspars constitute 65 percent, and quartz 25 percent of the graphic granite. Muscovite and sericite are present in small amounts.

Field relations of some of the pegmatites are problematic. Gradational contacts with wall rocks, and partially assimilated inclusions are common. Relicts of the schistosity of biotite in biotite gneiss are preserved across some pegmatites without disruption in alignment with opposite walls. Metasomatic replacement rather than magmatic intrusion has been the process of formation of the pegmatites.

THE MISTASSINI FAULT ZONE

A resumé of investigations along the enigmatic Grenville front is given by Hewitt (1957). Norman (1940) established the presence of a fault between the dolomites and gneisses to the east of Lake Mistassini and advanced the hypothesis that the gneisses were overthrust to the northwest to account for a disturbed zone of folds and faults in the dolomites along the contact. Neilson (1947) inferred the contact was a high angle reverse fault dipping southeast, associated with parallel subsidiary faults. Regional mapping by the Department of Mines, Quebec, indicates that the contact between the dolomites and gneisses is a fault zone striking northeast and dipping 45° to 55° southeast. (Bergeron, 1957) . The contact has been observed at one place only, at Perdue River. (Neilson, 1950a, 1950b.).

The fault zone has been traced from Bignell River in the southwest, (Gilbert, 1957) to Bethoulat Lake in the northeast, (Neale 1952, 1953), extending beyond the length of the eastern limit of the Mistassini syncline. The fault zone has been called the Mistassini fault zone.

In the McOuat - Gauvin area the contact is not exposed, however deformation of the dolomite beds and shearing in the gneisses indicate the rocks are in faulted contact. The attitude of the fault zone can be inferred only from overfolding of the dolomite beds, from shear joints in the gneiss, (Plate 9.A,) and from striations on slickensides and grooves on joints. Observations of these features are recorded in figures 1, 2 and 3. Movement occurred along directions between N. 20°W. and due west, at inclinations from 15° to 80° southeast, and 10° to 70° northwest. The directions of the contact are N. 10°E. at

Chalifour River and N. 50° E. at River à la Perche. The dips of the contact are unknown.

Fault-line scarps are identified in the gneisses at Een Pond and at the arcuate lake west of Revelation Lake. Gneisses are exposed in these places along west facing scarps 40 to 50 feet high. Evidence for the fault-line scarp at Een Pond is provided by the sag pond and by a drainage pattern in the vicinity showing some degree of structural control. The unusually high exposures at both places further suggest that they are due to faulting. The directions of the scarps, measured on aerial photographs, are N. 50°E. at Een Pond and N. 10°E. at the arcuate lake west of Revelation Lake. These directions are parallel to the directions of the contact between dolomite and gneiss. Clearly the fault-line scarps are part of the Mistassini fault zone.

Deformation of the dolomite beds, in particular the degree of overfolding, is greatest in the north. Norman (1940) points out that deformation of dolomite beds is greatest southeast of Lake Albanel, and least at the southern and northern ends of the syncline. In the McOuat-Gauvin area the progressive deformation is observed in stages separated by northwesterly faults. These faults offset faults along the contact and appear therefore to be younger. However, the increasing deformation towards the middle of the syncline is related to the faults along the contact and to faults cutting across them in a northwest direction. It is suggested that the three fault directions are contemporaneous and are part of a zone of block faults known to be 5 miles wide.

The Grenville Province has moved up relative to the Superior Province. Displacement along the fault zone is unknown. A vertical

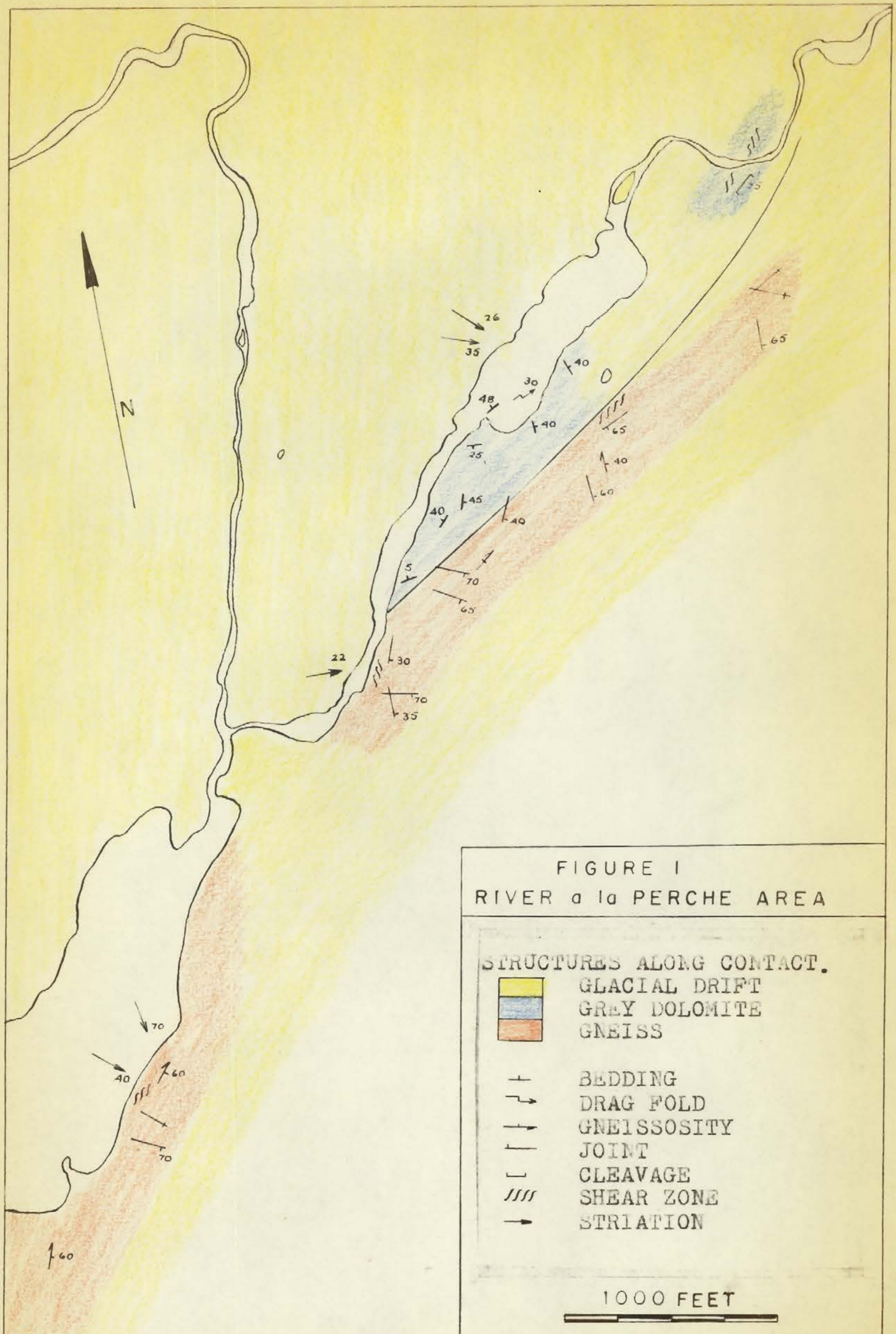


FIGURE I
RIVER a la PERCHE AREA

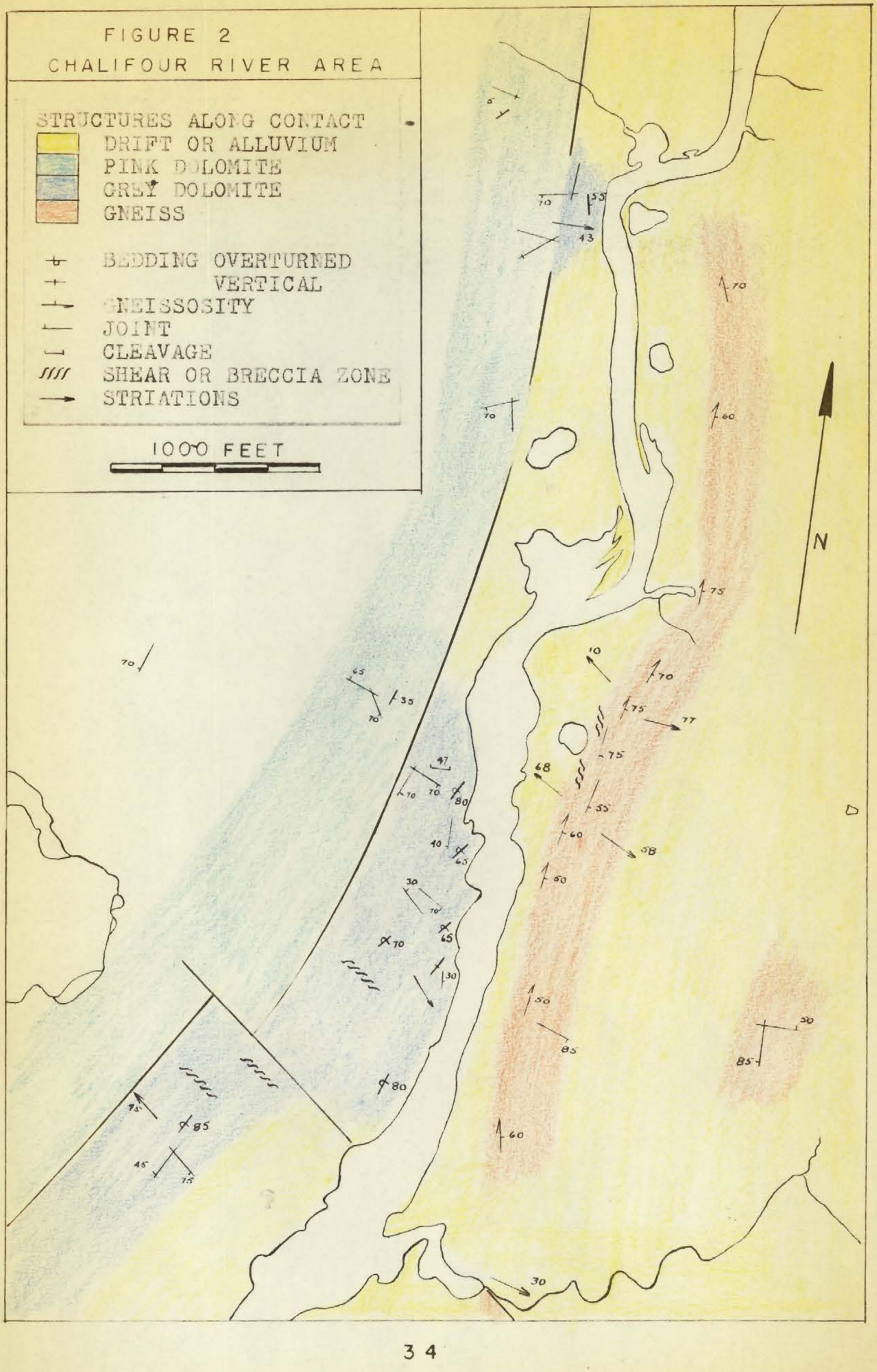


FIGURE 2
CHALIFOUR RIVER AREA
STRUCTURES ALONG CONTACT
DRIFT OR ALLUVIUM
PINK DOLOMITE
GREY DOLOMITE
GNEISS
BEDDING OVERTURNED
VERTICAL
GNEISSOSITY
JOINT
CLEAVAGE
SHEAR OR BRECCIA ZONE
STRIATIONS
1000 FEET
N

PLATE 9 A, Shear joint in gneisses at the Mistassini fault, Chalifour River.

PLATE 9 B, Drag fold in dolomite near the Mistassini fault, River à la Perche.

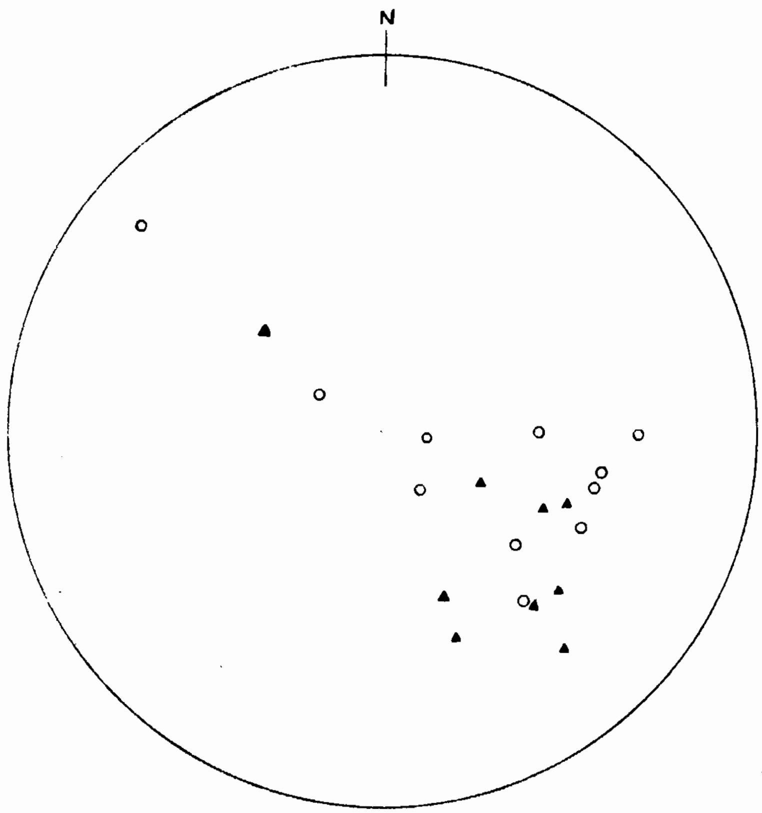


FIGURE 3.

STEREOGRAPHIC PROJECTION OF LINEATIONS IN VICINITY OF THE MISTASSINI FAULT

o SLICKENSIDE STRIATIONS.

▲ DIP OF SHEAR ZONES, GROOVES ON JOINTS.

separation of at least 8000 feet is required to remove the thickness of sediments in the Mistassini syncline.

<u>Cataclasis of Rocks along the Mistassini Fault</u>

Cataclastic structures are confined to a narrow zone in granodiorites along the contact with dolomite.

A mylonite from the Chalifour River area shows bands of epidote and chlorite pinching and swelling through coarse anhedral plagioclase crystals. Fine, sutured quartz grains occur in narrow bands resembling flow structure, pinching between feldspar crystals.

Granodiorites near the contact are grey, fine to medium grained rocks, closely resembling in hand specimens an impure quartzite or greywacke. In thin section the rock is cut by carbonate and chlorite veins. Feldspars are intensely sericitized, and plagioclase twins are distorted. Quartz grains show strained extinction.

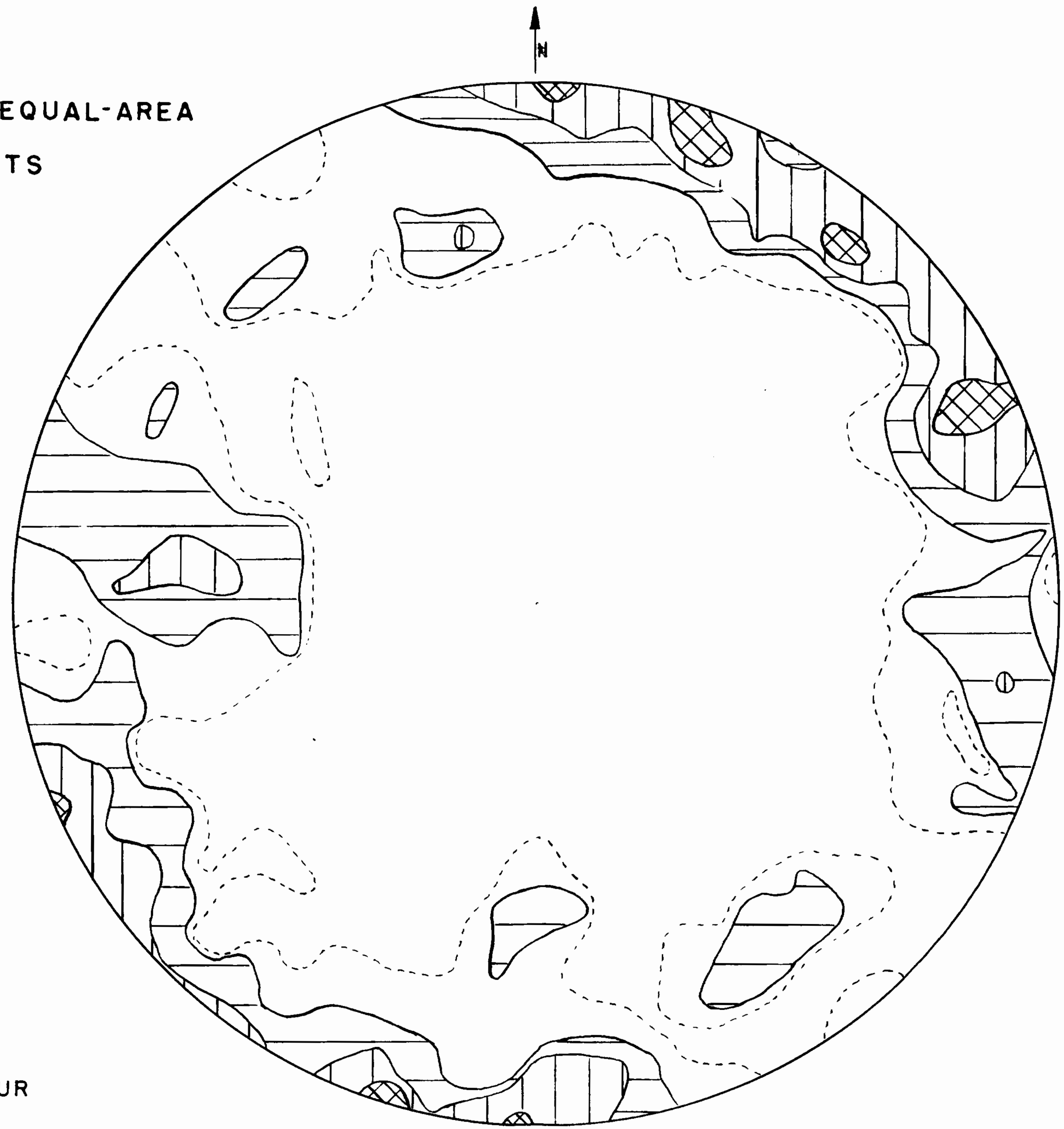
A schist zone marks the position of the Mistassini fault on River à la Perche. Sheared rocks are talc-chlorite schists and a fine grained, dense, feldspathic rock, with locally abundant milky quartz. In thin section this rock is a fine grained cataclastic aggregate of quartz, carbonate minerals, plagioclase, chlorite, sericite, pyrite and iron oxide minerals. Disseminated pyrite crystals and a limonite grossan are conspicuous. Quartz and calcite veinlets occupy well developed cleavage planes.

In the same vicinity at River à la Perche, east of the contact, boulders of mottled crystalline dolomite are enclosed in sheared zones in the gneissic rocks. (Plate 10, A and B.) The boulders are 1 or 2 feet across and are surrounded by a chlorite selvage up to 1 inch thick. One shear zone strikes N. 65^{o}E and dips 85^{o}S. E. In thin section the dolomite crystal boundaries are crushed, and secondary twinning is present in many grains. Chlorite veins pass through the rock following the dolomite crystal boundaries.

PLATE 10 A and B, Dolomite boulders enclosed in shear zone in gneiss, River à la Perche.

FIGURE 4.

CONTOURED SCHMIDT EQUAL-AREA PROJECTION OF JOINTS IN GNEISS.



304 POLES

(cross-hatched)	3 - 4 %
(vertical lines)	2 - 3 %
(horizontal lines)	1 - 2 %
- - - - -	0·5 % CONTOUR

THE MISTASSINI FAULTS IN RELATION TO JOINT PATTERNS IN THE GNEISSES OF THE GRENVILLE PROVINCE

Joints were systematically studies in the course of geologic mapping. The strike and dip of joint planes which persisted across an outcrop were recorded to the nearest 5°. Interpretation of relative ages of intersecting joints was not attempted for reasons of expediency. The genetic interpretation of joints as tension or shear fractures was considered only in the vicinity of the Mistassini fault. Shear joints were identified by the presence of slickensiding.

Observations of the attitudes of joint planes are recorded in figures 5A, 5B and 5C. In the upper diagrams frequency of the direction of strike is represented by the length of each radial line. The dip of each joint plane is recorded by its pole in the lower diagram.

Each diagram is drawn for a specific area. The grey dolomite division and the pink dolomite division represent stratigraphic units. The Souris Lake division incorporates joints in the orthogneiss group. The other divisions are separate areas in the paragneiss group, which are determined by the extent of outcrop at each locality.

Figure 4 is a compilation of all joints recorded in the gneisses. Most joints strike northwest, with maximae at N. 25°W., N. 50°W., N. 70°W., and due west. Other joint sets strike N. 10°E . N. 50°E., and N. 80°E.

The northwest joints dip vertically or at angles steeper than 80°. The trend N. 50°W. is reflected in the joint pattern in the grey dolomite division, in breccia zones in the dolomite, in faults cutting across the Mistassini fault, and in linears like that at Guinea Lake.

Joints striking N. 10°E. generally dip 60° to 75° southeast. This is parallel to shear joints observed in the gneiss at the Mistassini fault on Chalifour River. The trend N. 10°E. is the direction of the Mistassini fault through McOuat township.

Joints striking N. 50°E., dip 80° southeast or 75° northwest. The direction N. 50°E. is parallel to the trace of the Mistassini fault at River à la Perche.

Clearly, joints in the gneisses reflect the three directions of faulting in the area.

Ten joint sets can be identified in the gneisses from figures 5A, 5B and 5C. Joints strike N. 10°E., N50°E., east -west, N. 10°W., N. 25°W., N. 40°W., N. 50°W., N. 70°W., and N. 85°W. The directions N. 10°E., N. 80°E., N. 10°W., N. 50°W., and N. 85°W. are represented in the joint patterns in the Mistassini Group.

Neilson, (1950, 1952) in an examination of linears at the northern end of Lake Mistassini, records 4 principal sets, striking N. 25°E., N. 50°E., N. 65°E., and N. 5°W. Neilson states (1952), "these form a pattern which must be related directly to regional forces. The pattern is interpreted to indicate that major crustal forces in late Precambrian time were directed towards the northwest and resulted in shear fracture in the crust in a direction approximately N. 50°E., Linears at N. 35°E. and N. 65°E. may represent shear fractures developed under the same compressive forces."

In view of the complex tectonic history of the Grenville Province as well as the usual hazards of strain analysis, no explanation of the origin of joints sets can be made. Instead it is postulated that joint sets had developed, through forces unknown, in the gneisses prior to the Mistassini fault. Forces which caused the Mistassini fault would cause movement along such planes of weakness, and displacement would be distributed along this intersecting pattern of joints.

By this mechanism three intersecting faults are contemporaneous and displacement is distributed over a wide zone in a block faulted area; by differential movement of adjacent blocks progressively greater displacements can be achieved over a short length of strike. These three conditions fit the Mistassini fault zone.

Suggestions have been made that the gneisses were thrust northwestwards against the Mistassini group. Forces which produced this movement can not be identified.

Joint sets in the gneisses at the time of the Mistassini deformation would be planes of weakness along which movement could take place. Preferred planes would be determined by their angular relations to the direction of thrust and to the opposing thrust of an abutment. Each joint set recorded in the gneisses could have transmitted movement; many joints are shear and tension fractures caused by movement. Ultimately, the most conspicuous faults would be those along the contact of the Mistassini group where different rock types are in contact.

Support for this hypothesis is available on a regional scale. The Tectonic Map of Canada (1950) shows that the Grenville front changes direction from N. 5^{o}E. to N. 50^{o}E. at the southern end of Lake Albanel. Norman (1940) suggests this 45^{o} deflection is caused by the intersection or divergence of two faults. Results of Neilson's linear analysis (1950, 1952) and the present joint analysis indicate that at Lake Albanel N. 50^{o}E. is the dominant trend, whereas in the McOuat - Gauvin area

FIGURE 5A.
STRIKE AND DIP DIAGRAMS OF JOINTS FROM RESTRICTED AREAS

MARGONNE LAKE
E. FILE-AXE LAKE
FILE-AXE ISLANDS
W. FILE-AXE LAKE

FIGURE **5B.**
STRIKE AND DIP
DIAGRAMS OF JOINTS
FROM RESTRICTED
AREAS

NORTHEAST ARM
STALWART - KNOTTED LAKES
HEIDI - LEE LAKES
LAMENTATION - REVELATION LAKES

FIGURE 5C.
STRIKE AND DIP
DIAGRAMS OF JOINTS
FROM RESTRICTED
AREAS

GREY DOLOMITE
PINK DOLOMITE
EEN POND
SOURIS LAKE

joints striking N. 10^{o}E. are more common than joints striking N. 50^{o}E. It is possible therefore that the change in direction of the fault zone is related to the change in joint patterns. The reason why the joint patterns should change will only be found after careful mapping has shown the distribution and relationships of the different gneissic formations and intrusions.

There is obviously a fundamentally important structural relationship between the paragneisses, the orthogneisses and the Mistassini fault zone. The Grenville front is marked by isolated shallow sedimentary synclines extending northeastwards from Lake Mistassini. The longer axes of each syncline lies along an arc, and each syncline in truncated on its south or southeast limb by a fault or fault zone. The position of each syncline was determined by structures in the underlying gneisses and granites, and these same structures have been the locus of later faulting. The concept of consequent tectonics is obviously applicable in this fault zone; the attitude of the fault zone and of individual faults in the zone must have been controlled by pre-existing structures in the gneisses and granites. Evidence has been put forward that these structures were joints.

ECONOMIC GEOLOGY

Galena with lesser amounts of sphalerite was found in the grey, bedded dolomites south of Chalifour River in the south-central part of McOuat township. The sulphides occur as replacements of dolomite along a zone 2 feet wide. Dolomite beds in the vicinity are disturbed, as can be seen by marked changes in dip. Mineralization may be associated with shearing.

Chalcopyrite occurs as fracture fillings in quartz veins on the northern island in the centre of File-Axe Lake. The quartz veins are 3 to 5 inches wide and occur along a 4 feet wide sheared zone in paragneisses.

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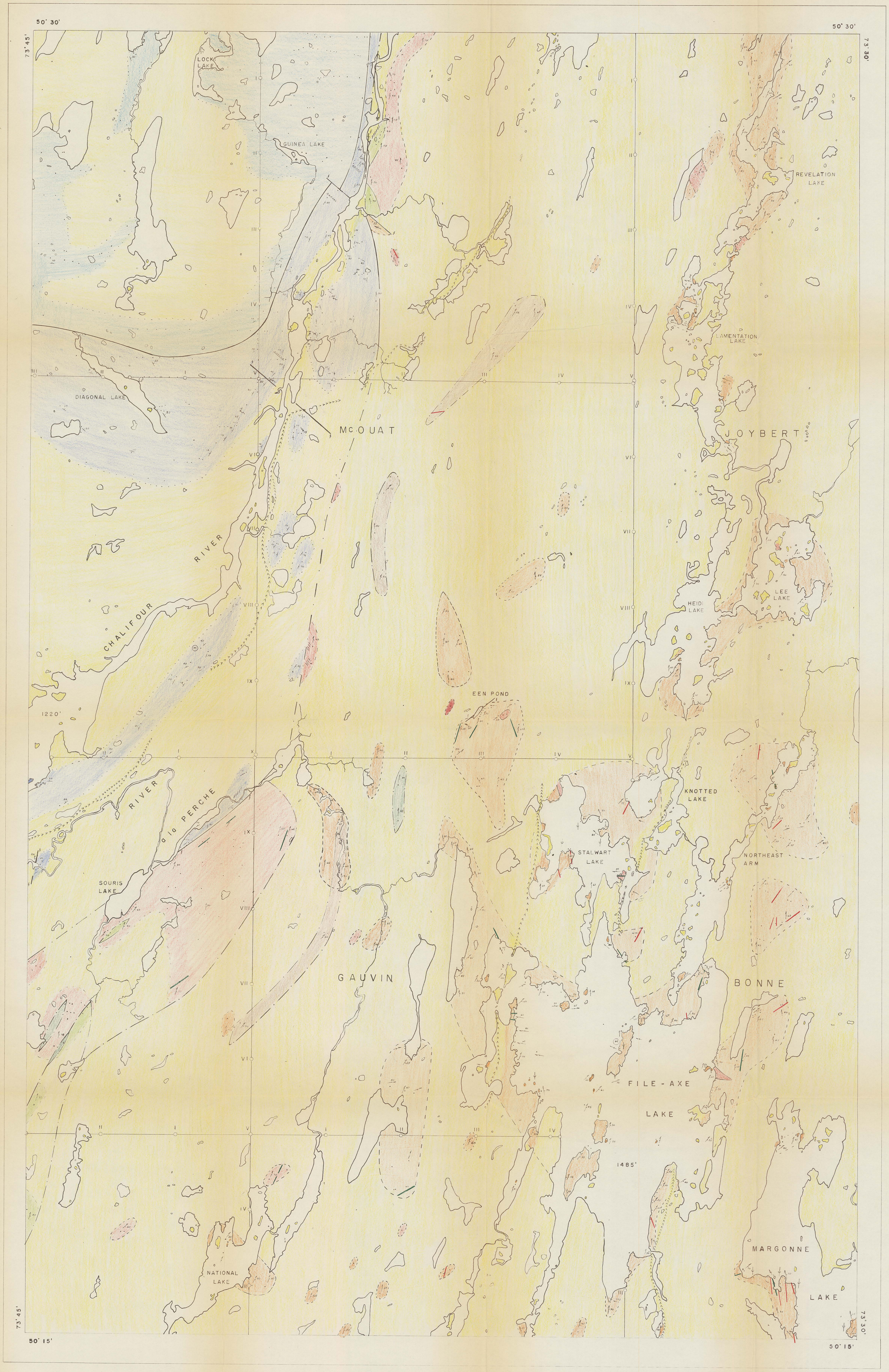


GEOLOGICAL MAP

McOUAT-GAUVIN AREA

MISTASSINI TERRITORY AND ROBERVAL COUNTY QUEBEC

PLEISTOCENE
- GLACIAL DRIFT

MISTASSINI SERIES
- PINK AND BUFF DOLOMITE
- GREY STRATIFIED DOLOMITE, DOLOMITIC SHALE

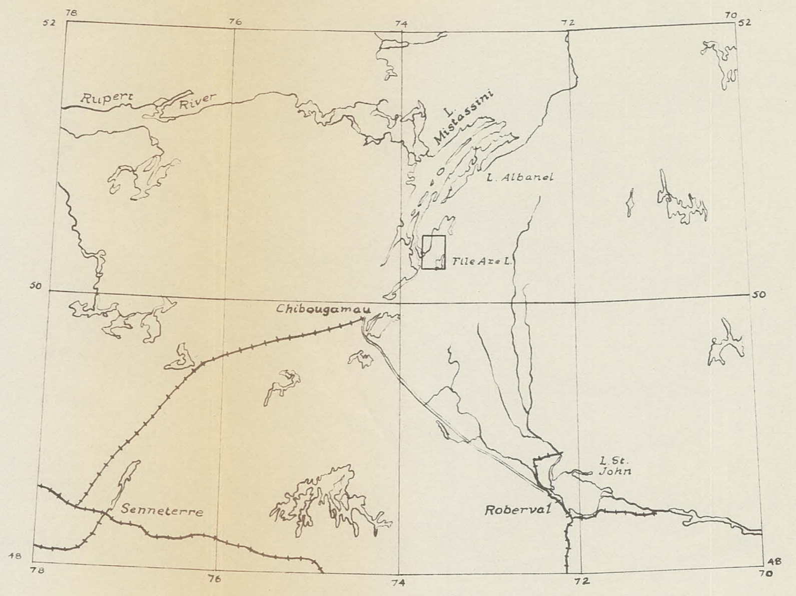
GRANITE INTRUSIVES
- PEGMATITES, APLITES, GRAPHIC GRANITE

ORTHOGNEISSES
- GRANODIORITE
- DIORITE

PARAGNEISSES
- BIOTITE GNEISS,
- HORNBLENDE GNEISS,
- AMPHIBOLE SCHIST

SYMBOLS

- GEOLOGICAL CONTACT DEFINED
- GEOLOGICAL CONTACT ASSUMED
- STRIKE AND DIP OF BEDS
- STRIKE AND DIP OF GNEISSOSITY
- STRIKE AND DIP OF CLEAVAGE
- FAULT
- BRECCIA
- ESKER
- GLACIAL STRIATION
- OBSERVED OUTCROP
- MINERALISED OUTCROP
- SHEAR ZONE
- AXIS OF MINOR FOLD



GEOLOGY BY G. S. SATER, 1957

BASE MAP FROM LA CIE. PHOTO-AIR LAURENTIDE, 1955.

SCALE
1 INCH = ½ MILE

MILES