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CHAUMONOT AREA

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Department of Natural Resources

Geological Surveys Branch

Interim Report

on

CHAUMONOT AREA

Laviolette and Quebec Electoral Districts

by

W.D.N. Newham

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INTRODUCTION

Location

The Chaumonot Region, mapped in the summers of 1960 and 1961, covers an area of approximately 360 square miles, and is bounded by latitudes 47° 45' N and 48° 00' N; and longitudes 72°30' W and 73°00' W. The region incorporates the Chaumonot township and parts of Papin, Michaux, Borgia, Chasseur and Lavoie townships of the Quebec electoral district; and parts of Cadieux, Adams and Tourouvre townships of the Laviolette electoral district. The Quebec - Robberval county boundary delimits the northern boundary of the region, although one traverse has overlapped into the Becart township in the north-westernmost extremity of the region. The southern boundary intersects the main La Tuque - La Lievre - Robberval road at a point 35 miles north of La Tuque (a large pulp and paper processing town located by co-ordinetes Montreal 140 miles, Quebec City 85 miles north of the St. Lawrence River, and respective road distances of 195 and 140 miles).

Settlements

Rapide Blanc, with a population of approximately 300, is the only town in the region, and is located in the south-westernmost corner (A3-C)[‡] of the area to serve the hydro-electric power projects at the Rapide Blanc and Trenche dams nearby. Other population is restricted to seasonal lumber operations, fishing and hunting expeditions, and transit commercial and tourist traffic on the main roads.

Access

Access is particularly poor east of the Croche River, and has prohibited mapping of the north-easternmost part of the region (E1 and F1).

a) Roads and trails : West of the Croche River, the main La Tuque - La Lievre road unites a system of secondary lumber roads to give reasonable access to all bar the northernmost areas. In the extreme south-west (A3), the paved road to Rapide Blanc links up with a system of trails to give limited access to that part of the region.

‡ Denotes the location square on the map grid system, and the position within the square :- C - central; N - north; S - south; E - east; W - west.

East of the Croche River, serviceable roads are restricted to the southernmost loop (E3-SW) and an old lumber road in the east that is negotiable, with difficulty, as far as the game camp in F2-SW. The main La Tuque - Roboerval road skirts the south-easternmost part of the Chaumonot region (F3), but has been included in the area mapped for the sake of completion.

Where lumbering operations have been active, as in the east-central parts, and most of the area west of the Croche River, a network of winter roads exists. These have often facilitated traversing, where subparallel to the direction of the traverse leg, but have proved particularly important for the exposure of outcrop.

b) Rivers and lakes : Lake shores commonly yield good outcrop, and the larger lakes have proved invaluable for local access.

West of the Croche River, the Trenche Dam (B3-SW), Lake Bouteille (A3-NE) and lake Chaumonot (C1) have been most useful. East of the Croche River, portages linking large and small lakes have proved invaluable and are best indicated on the map (E3, F2 and F3). Most of these connect existing fish and game camps, but in some places, new portages have been cut (e.g. to lake Gingras - F2-SW).

Only the Trenche River above the dam in B1-SW and the Croche River have proved navigable, and the latter has been particularly important for gaining access to the central and northern regions. North of Rapid Chut Bruleé (D2-N), the Croche River is only navigable in the spring flood waters, and then with extreme caution in view of the boulder-strewn river bed. Below the rapids, the Croche River meanders profusely but is navigable throughout the ice-free season.

Natural Resources

These are generally limited, and are restricted to the following :-

a) Hydro-electric power : The Trenche Dam and Rapide Blanc Dam projects on the St. Maurice River are the only operations and together provide approximately 2 billion kw.h/yr which is fed into the Quebec power line network, mainly for use at the La Tuque pulp and paper plant.

b) Lumber : Canadian International Pulp and Paper has exploited large tracts of timber in opening up the western region (approximately 10 years ago), and Consolidated Pulp and Paper began exploiting the eastern region shortly after, but operations were overtaken by the 'spruce bug' affliction which devasasted most of the eastern region leaving a wilderness of deadfall and raspberry brambles.

The Chaumonot region does however fall within a forest protection area and is patrolled by fire and game wardens. A small C.I.P. lumber outfit was active in a spruce stand (A2-NC) in the summer of 1961, but otherwise activity is negligible and mainly confined to conveying logs via the St. Maurice, Trenche, Croche and Bruleé Rivers from operations outside the map area.

c) Tourism : There are numerous fish and game camps in the area which are accessible by road, portage and float-plane (Lakes Culotte (C1-NE) and Çingras (F2-NW)), and the region is dangerously active in the late fall. Partridge and rabbit abound, and moose and deer are present, though seemingly not plentiful. Pike and whitefish are common in nearly all the water systems to the detriment of trout which seem to be confined to isolated lakes and the main rivers - especially the Croche River and in particular below the respective rapids.

PHYSIOGRAPHY

Topography

The region lies on the south-eastern margin of the Laurentian Uplands and comprises a gently rolling though locally rugged topography with an average local relief in the order of 250 ft. The land has a maximum elevation of 1750 ft. in the north-east and slopes away gently to the west and south-west to an elevation of approximately 1000 ft. Several valleys - noticeably those of the St. Maurice (A3-SW), Savane (C2), Croche (D1, D2 and D3) and Renard-Gouin (E2 andE3) Rivers - constitute major topographic discordances with locally exaggerated relief. This is greatest in the lower reaches of the Croche River where it reaches values in the order of 800 ft. The Croche River leaves the area at an elevation of 550 ft., the lowest in the region.

Over most of the central and northern parts, there appears to be an accordance of summits at an elevation of 1250 - 1350 ft. which may represent a former erosion surface.

Glacial activity, and especially the regional deposition of morainic material appears to have subdued the local topography, but the following lithologic controls have been observed and are considered as significant :-

a) Gneisses generally appear to be moderately resistant and form rounded, rolling uplands with a local relief of approximately 250 ft. The more mafic and/or less migmatized gneisses tend to weather out more deeply to form areas of lower relief and elevation. Where the gneissic-migmatite banding is well developed, a series of low ridges and shallow hollows has been developed, and these are often prominent enough to be noticeable on the air photographs. Free-fall faces are rare, and invariably the cliffs in the area are controlled by fracture systems rather than composition weathering effects.

b) Gabbroic rock types, and especially the central gabbro 'laccolith' (B2-CNE), tend to weather readily to form low-lying areas with low, gently rolling relief. Fresh outcrops are rare, and the residual soils, where observed, are brown to reddish-brown in colour.

c) The white anorthosite mass (F3-S) is relatively resistant and forms a rounded, hummocky terrain with a local relief of 150 to 200 ft. The fresh, greyish colour of the rock weathers to a conspicuous white outer surface.

d) The monzonites seem to have a similar topography and relief with the exception of the eastern mass (F2 and F3). This is very resistant, and the presence of a good joint pattern gives rise to a very rugged, hummocky topography with a local relief of 250 to 300 ft. The fresh rock of most monzonites weathers to a whitish outer surface generally underlaid by a thin cascenade stain.

Drainage

The drainage of the area is dominated by the Croche and Trenche Rivers - tributaries of the St. Maurice River)- which extend at least 60 miles north of the area. The present regime seems to be post-glacial in origin, and has resulted from active headward erosion, subsurface seepage and scouring to capture an originalpre- and intra-glacial north-east to south-west system by the faster flowing north - south rivers. Elbows of capture, misfit rivers, reversed drainage, wind-gaps etc. are evident in many places, and relic featyres of the former drainage pattern, glacial activity and overflow channels are sufficiently clear to delimit the stages of the final recession of glaciation (see historical geology). Paired terraces along the lower Croche River indicate that the present river has incised its floor up to 100 ft. below the level of the last glacial meltwaters responsible for the thick deposit of alluvium in the valley.

In In the south-eastern area, the river systems are tributary to the Bostonnais River and have been extensively deranged by glacial deposits (especially in the Gouin River valley - E2) to form a complex system.

Apart from this area, the overall drainage systems are sub-dendritic in nature and sufficiently well developed to show local modification by the underlying geology.

a) Gneisses support a sub-dendritic to sub-rectangular pattern, the latter being controlled mainly by gneissic-migmatite banding and local jointing. The pattern is medium to fine, with a drainage density of approximately 11 miles per square mile.

b) Intrusives generally show an irregular to sub-dendritic pattern with the local development of pincer patterns - especially in the eastern monzonite mass. Drainage density ranges from medium-coarse (7 miles/sq. mile) in the monzonites to very coarse (3.3 miles/sq. mile) in the gabbro laccolith, though the latter value may be dependant on the overburden of till in this area.

GENERAL GEOLOGY

The consolidated rocks of the region are predominantly Precambrian in age and comprise an altered and dynamothermally migmatized complex that has been intruded at different times by a variety of igneous rocks, the dominant diorite and monzonite-granite complexes seeming to have been emplaced during the main orogeny of the region.

The gneisses consist essentially of quartzo-felspathic varieties, minor zones of hornblende-rich types and scattered bands, often in broad zones, of quartzite and impure quartzite (often containing garnet and sillimanite) and amphibolite that are usually only traceable over short distances. In two places, bands of amphibolitic rock seem to have a relic igneous texture and have been classified as meta-gabbros. The gneisses have been injected extensively by bands, veins, lenses and dykes of white and later pink quartzo-felspathic migmatitic material that is commonly intimately associated with plastic deformation of the gneisses.

The diorite complex comprises two main rock types : a coarse-grained foliated/lineated to massive variety and a related hybrid form that is intermixed with, and often gradational to the enclosing gneisses. The coarse-grained variety, with aggregates of hornblende causing the foliation and giving the rock a spotty appearance, occurs as irregular masses along the southern side of the gabbro laccolith (E2) and spanning the Croche River (D2). The former is quartzose and corresponds more to a granodiorite in composition. The hybrid diorites usually form transition zones separating the diorite masses from the gneisses, but they also occur as discontinuous bands which are often concentrated in irregular zones concordant with the regional structure, and traceable for extensive distances. The hybrid diorites and adjacent gneisses are commonly discoloured green, due to the local formation of a high-grade granulite metamorphic facies that is characterized by the presence of pyroxene.

The monzonite complex incorporates genetically related rock types ranging from quartz-poor pink and minor green varieties to pink granites. Three distinct masses have been recognised in the region. The south-western mass (A3 andB3) is mainly a quartz-poor pink variety with a central porphyritic/augen core and a marginal mixed zone containing gneiss relics. The intrusion is surrounded by a broad zone of green-coloured gneisses (granulites) which follow the regional structural trend to the north simulating an extension of the monzonite mass. The eastern monzonite (F2 and F3) is predominantly quartz-rich, coarse-grained to porphyritic and weakly foliated throughout. It contains minor, irregular zones of older, quartz-poor, green monzonite with both gradational and intrusive contacts, and a patch of younger fine-grained material just south of Lake Çingras (F2). The mass represents a multiple intrusion and is rimmed in contact with the gneisses by a zone of mixed, hybrid rocks rich in gneissic relics. The adjacent gneisses have been intensively contorted and plastically deformed, but show negligible green alteration. The north-westernmost mass (A1-N) comprises a zone of green, weakly hybrid monzonite intruded on its southern side by a mass of coarse-grained pink granite which seems to have been emplaced in the nose of a broad fold. The granite consists of a porphyritic core fringed in contact with the gneisses by a transition hybrid zone generally containing gneissic relics. Similar relations have been observed in the dyke-like body further south (A1-SW). The enclosing gneisses have been discoloured green adjacent to the monzonite, but appear unaltered by the intrusion of the pink granite.

The large anorthosite mass in the southeasternmost section (F3) is conspicuously white and uniform in appearance, and seems to be younger than the monzonite complex - probably representing a waning stage in the orogeny responsible for the ultra-metamorphic deformation of the area.

The gabbro complex seems to have been intruded at a later date and most likely accompanied the broad, gentle, open folding indicated by the emplacement of the laccolith body. Gabbroic rocks are confined to the laccolith and its eastern extension across the Savane River valley fault, and to the dyke-like body (B3 - possibly a feeder) extending northwards from the Trenche Dam wall. The laccolith seems to be a saucer-shaped body marked by central concentric structures (also evident on the air photographs) and marginal basal rocks of a more basic, mafic-rich composition. The gabbroic rocks are all relatively unaltered, massive to weakly foliated and coarse-grained with dark grey-green plagioclase felspar as the dominant mineral, and pyroxene, olivine and hornblende plus secondary biotite as the main mafic minerals. At the Trenche Dam wall, the gabbro grades through an intermixed zone to a gabbroic anorthosite consisting predominantly of very coarse-grained green plagioclase felspar crystals.

The numerous medium to fine-grained diabase plugs (C1-NW and C3-SW) and dykes (A1-E, B1, D2-NW, E2-W, F2 andF3) in the area are most likely genetically related to the larger gabbroic bodies.

Folding is represented by two main forms, as expressed by gneissosity, lithology and sometimes confirmatory evidence on the air photographs. Tight to open folding, overfolding and axial warping of both syn- and antiforms is indicated in several places (A3, B2, C1, D1, D3 and E3) and most likely represents deformation during the main orogeny of the region. Subsequent gentle, open folding is only indicated directly by the laccolith body (B2) and confining open synform which, in the west, appears to represent a refolded synform structure.

Faulting is dominated by a major north-east - south-west trend with an apparent right-hand strike separation, and a minor north - south to north-west - south-east trend. Where observed in the field, fault zones are highly fractured and commonly injected by reddish quartzo-felspathic material which has caused local pink metasomatism. The larger faults do not outcrop, but are marked by valley linears such as the Savane (C2), possibly Framboise (B1), petit Croche (E2) and Croche River valleys.

During Peistocene glaciation, an ice-cap most likely covered the area and deposited the thin regional blanket of loamy till. Recession of the ice-cap to transection then valley glaciers deposited valley moraines and eskers, and the final deluge of melt-waters laid down thick deposits of alluvium in the main valleys.

TABLE OF FORMATIONS

Age	Complex	Rock types	
Pleistocene to Recent	Superficial Deposits	River alluvium Glacial moraines and till	
Precambrian		Pegmatites	
	Gabbro Complex	Diabase dykes, sills and plugs	
		Gabbro and gabbroic anorthosite	
	Monzonite Complex	White granulated anorthosite	↑
		Pink granite	
		Pink quartz-rich monzonite	
		Pink and green quartz-poor monzonite	
	Diorite Complex	Diorite and meta-diorite	
		Meta-gabbro	Orogenesis and Ultra-metamorphism
	'Grenville-type' Migmatite - (Para)gneiss Complex (no specific order)	Biotite quartzo-felspathic gneisses	
		Hornblende-rich quartzo-felspathic gneisses	
		Amphibolites	
		Quartzites and impure quartzites	
		Carbonate-pyroxene calcareous rocks	↓

Lithology

The lithology has been interpreted from mineralogical characteristics of the rocks and correlated by structural trends and topographic expression where discernable from both field and air-photograph observations.

'Grenville-type' (Para) Gneisses and Migmatites :

These constitute the oldest and most widespread rock types in the area, and have been extensively injected by quartzo-felspathic material to constitute an ultrametamorphic, migmatized complex. Gneissic structures are generally preserved and are commonly emphasised by sub-parallel bands of amphibolite and/or quartzo-felspathic injection material. There are many zones and areas however, where the gneisses have been plastically deformed with the partial, or complete, deformation of the original gneissic structures. In such areas, amphibolite bands have commonly been disrupted to form boudins, lenses and irregular masses.

On the scale of 1 inch = 1/2 mile, and with the traverse method used, it has only been possible to generalise the regional geology and select the most dominant features observed and mapped for practical interpretation. For example, in A1-SW, continuous outcrop over a 1/4 mile section of road shows seven distinct compositional and/or structural units. Plastically deformed biotite quartzo-felspathic gneisses predominate however, hence the final classification.

The distinction between uniform and mixed gneisses has proved misleading and given rise to a meaningless conglomeration of patches which seem to reflect the sporadic nature of outcrop rather than the underlying geology. The most useful basic distinction has been found to be the composition of the gneisses, and the bulk of the gneisses can be subdivided into two major quartzo-felspathic types - a mafic-poor biotite gneiss and a mafic-rich hornblende variety. A delimiting value of 30 % mafics seems to coincide with a natural difference between the gneisses and shows up the regional trends more clearly than more mafic subdivisions.

Many of the features observed are similar to those mapped and analysed by J. Guy-Bray in the La Lievre area, 15 miles on strike to the north, and the reader is referred to his Ph.D. thesis, "Petrology of the La Lievre area" 1962, for comparisons and contrasts between the two areas.

On a basis of mineral composition mainly, the following gneisses have been recognised.

Biotite quartzo-felspathic gneisses : These constitute the main rock-type underlying the area, and fange from well-banded, medium/fine-grained varieties to non-descript, highly contorted and migmatised types - sometimes even within a few yards of each other. Composition gneissic banding, often accompanied by conformable, weak foliation, can be observed in most occurrences, but it is develpped to a varying degree. This banding is conspicuous in indicating the contortion of the gneisses, and its 'injection' into the adjacent amphibolite rocks. In most outcrops, the gneisses are interlayered with distinct narrow bands of amphibolite or hornblende-rich rock-types that seem to represent primary lithologic banding rather than a concentration of mafics due to a loss of quartzo-felspathic material by differential melting.

Quartzo-felspathic biotite gneisses consist mainly of light-grey sodic plagioclase felspar with 30 to 50 % quartz and minor mafics, predominantly biotite. Grain-size ranges from medium/fine textures of the less deformed varieties to coarse-grained, often porphyritic, textures in the heavily migmatised and contorted gneisses. Pink injection material commonly gives rise to metasomatic effects in the adjacent gneisses with the development of alkali-felspar and microperthites, often as porphyroblasts.

Hornblende quartzo-felspathic gneisses : Several zones and sporadic outcrops are dominated by quartzofelspathic gneisses noticeably rich in mafics (30 to 60 %) with hornblende as the predominant ferro-magnesian mineral. Quartz generally constitutes up to 20 % of the rock, and the rest is made up of sodic plagioclase felspar. In comparison with the biotite quartzo-felspathic gneisses, composition banding is less significant, owing to the tendency for the mafic minerals to form aggregates, but foliation, resulting from the preferential orientation of these minerals is more conspicuous. Grainsize is more uniform and fine to medium grained, but in zones of abundant quartzo-felspathic injection, porphyroblasts of alkali-felspar are often developed in the gneisses.

Some zones of hornblende quartzo-felspathic gneisses, such as those in the south-western (A3 and B3), central (A2, B1 and B2), north-eastern (D1) and south-eastern (E3) regions are traceable over considerable distances and commonly contain numerous large amphibolite bands. They are important in emphasising the regional structure but tend to be very irregular in outline, pinching and swelling and petering out completely (B2-SW), or else merging with zones containing an intermixing of mafic-rich and mafic-poor gneisses (C1-S). The mafic-rich gneiss zones are usually fringed with intermixed gneissic zones, as described above, but these relations are not sufficiently continuous or distinct enough to be designated as a separate unit, even though they were mapped as such in the field.

In detail, the hornblende quartzo-felspathic gneisses are probably more abundant than indicated on the map, but they do not show owing to the nature of the classification, the relative paucity of outcrop and the tendency of these gneisses to weather more readily than the mafic-poor varieties.

Amphibolites : These rocks are scattered throughout the area, generally as individual, discontinuous segments or bands that are noticeably concentrated in some hornblende quartzo-felspathic gneiss zones (e.g. B3-E). Only the larger bodies or zones (generally greater than 20 ft. thick) have been mapped as separate units - as distinct from the thinner bands and lenses interlayered with the quartzo-felspathic gneisses.

Amphibolites are usually fine to medium-grained, uniform and very dense in appearance and comprise greater than 70 % mafics with hornblende as the predominant mineral. Biotite is generally only of minor importance and pyroxene and garnet occur sporadically. Foliation is usually moderately developed, but composition banding is rare.

Most amphibolites seem to have acted as resistant units metamorphically and are commonly intruded by quartzo-felspathic material and even mobilised quartzo-felspathic gneisses. Smaller lenses and masses of amphibolite are often contained in 'swirls' of plastically deformed gneisses.

Quartzites and impure quartzites : Impure quartzites are scattered throughout the area and range from a few feet to a hundred feet or more in thickness. They usually form resistant ridges and often occur in zones interbedded with quartzo-felspathic gneisses. In such cases, they are not readily distinguished from the quartz-rich gneisses.

Quartz usually comprises 50 to 75 % of the rock with white to pinkish felspar, biotite and occasionally garnet and sillimanite as the minor minerals. The rocks frequently show good foliation and composition banding with felspar and biotite forming mixed and/or distinct bands generally only a few inches thick.

The impure quartzites serve as zonal marker horizons in several places, but can only be traced as seemingly continuous bodies in the south-west (A3 - where they form a topographic high readily visible on the air photograph), in the central region (B2 and B3 - where the main body merges into a zone containing individual quartzite horizons), and in the north-eastern area (D1). It is in the central zone (B2) that the only pure quartzites occur. These rocks are very uniform and composed of milky-white quartz with scattered crystals and aggregates of pink felspar and biotite which rarely exceed 10 % of the rock.

In many places, and especially in the plastically deformed areas, quartz appears to have been melted out and intruded into the gneisses as quartz veins, lenses and narrow dykes.

Calcareous rocks : These are restricted mainly to scattered blobs, streaks and lenses in the quartzofelspathic gneisses. The rocks are conspicuous in appearance and weathering and consist mainly of coarse-grained calcite and dark-green pyroxene, the latter often forming crystals an inch or more in length. Quartz is usually minor in abundance and scapolite has been observed in some occurrences. The rocks most likely represent mobilised highly metamorphosed limestones, and are undoubtedly more abundant than indicated on the map, but rarely outcrop in view of their susceptibility to weathering processes.

On the east banks of the northernmost part of the Croche river, and extending northwards out of the region, is a band of grey limestone approximately 50 ft. thick. The rock is relatively soft and uniform, and contains scattered pebbles and aggregates of dark grey quartzitic material up to 1/2 inch mean diameter. The genetic relationships of the limestone are problematic because, although it seems to be a much younger formation, the limestone dips to the east under migmatized quartzo-felspathic gneisses. The limestone may be part of a tight infold, but classification has been omitted for the time being pending further information.

Origin of the gneisses :

The extreme ultra-metamorphic alteration and destruction of original features only enables speculation on the problem. The preponderance of quartzo-felspathic gneisses with sodic plagioclase felspar as the dominant mineral suggests a thick deposit of greywacke or sandy shale intercallated with limy shales and occasional sandstone horizons which give rise to amphibolites and impure quartzites respectively. The hornblende quartzo-felspathic gneiss most likely represents limy shale, but volcanic flows cannot be overlooked as a possible parental material. It must be emphasised that the relative abundance of hornblende quartzo-felspathic gneisses, amphibolites and especially calcareous rocks, as represented on the map, has undoubtedly been curtailed by the tendency of these rocks to weather very readily and therefore remain buried beneath the glacial overburden.

A probable origin for the gneisses therefore involves deposition in a geosynclinal environment, and preferably in or near the miogeosynclinal region as indicated by the abundance of quartzo-felspathic gneisses, and the liberal distribution of impure quartzites.

Migmatite injection material :

Two varieties of injection material, distinct and persistent enough to be classified as separate units, have been recognised in the area.

White injection material : This is widespread in nearly all the gneisses and occurs mainly as fine to medium-grained, intimately related veinlets, lenses, bands and blobs, but also as coarse-grained, pegmatitic injections which often have discordant contacts. White sodic felspar and quartz are the dominant minerals with biotite and occasionally hornblende generally forming very minor constituents. The common occurrence of ductless, ill-defined lenses, low-pressure boudinage concentrations and general intimate relations with the gneisses leads the author to believe that the injected material has been derived locally, or from adjacent gneisses, by syntectic processes. Efforts to trace progressive syntexis in the field have yielded inconclusive results, owing mainly to the paucity of outcrop with respect to the complex nature of the geology.

Pink injection material : This ranges from intimately related, medium/fine-grained bands and lenses to coarse-grained pegmatitic varieties with the latter tending to predominate, commonly as discordant injections. Pink alkali-felspars, microperthites and quartz are the predominant minerals, and mafics are conspicuously absent. Field evidence shows that this material is both contemporaneous and younger than the white injection material - mixed pink and white felspar bearing veins occur in many outcrops and frequently pink, pegmatitic material has been observed to intrude up the centre of white veins or else to disrupt them, but rarely vice versa. Metasomatic effects commonly accompany these injections causing a pink discolo-ration of the felspars in the gneiss and the formation of pink felspar porphyroblasts up to a foot or more from the vein. In heavily injected gneisses, and especially plastically deformed varieties, this may lead to extensive metasomatism or granitisation.

Analysis of the distribution of pink injection material shows that it is conspicuously associated with the biotite quartzo-felspathic gneisses rather than the hornblende-rich varieties - even in the same outcrop. This seems to favour a close three-dimensional genetic relationship with respect to the origin of the pink injection material in contrast to Guy-Bray's thesis that the material has been injected entirely from below.

Green alteration (granulites) :

Over large areas, the felspar of the gneisses is green in colour and weathers with a brownish stain. The discolouration varies in intensity and is difficult to determine accurately in the limiting cases. Guy-Bray's evidence favouring the correlation of the green colouring with the granulite facies and the presence of pyroxene seems applicable to the region, and the following points are significant.

Where mafic-poor and mafic-rich quartzo-felspathic gneisses are intermixed, the latter frequently show greater discolouration. The mafic-poor varieties may even be altogether unaffected, and this preferential alteration most likely reflects primary compositional differences between the two gneisses.

Green alteration is commonly associated with rocks of, and adjacent to, the diorite complex varieties.

Green alteration is very strong adjacent to the quartz-poor (dry) green and pink monzonite masses (A1 and A3) and the white granulated anorthosite (F3), but is lacking in the gneisses adjacent to the quartz-rich pink monzonite(F2 & F3) and pink granite (A1), despite extreme plastic deformation near the former. The presence of volatiles, mainly water, seems to be prominant in suppressing the formation of pyroxene in the granulite facies.

Extreme contortion and plastic deformation does not seem to be a controlling factor of green discolouration, but this again may be dependent on a high concentration of volatiles rather than a high grade of metamorphism.

The regional relationships of the metamorphic facies reveal classes similar to those of the La Lievre région with high amphibolite facies and/or the hornblende sub-facies of the granulite facies dominant. The occurrence of the pyroxene granulite sub-facies however, does not seem to be controlled by the monzonite masses, as suggested by Guy-Bray, but rather by a variety of conditions. Granulites occur in both small patches and bands and large, structurally-controlled zones where they seem to be associated with rocks of the diorite complex. These areas very likely represent former 'hot' or/and 'dry' spots in the ultra-metamorphic complex.

Granulites also occur as metamorphic aureoles around the 'dry' intrusives (green and pink quartz-poor monzonites (A1 and A3), and the white anorthosite (F3)), and the great width of the alteration zone suggests the emplacement of these intrusives during and/or shortly after ultrametamorphism, while the region was still hot. A very narrow zone of green alteration occurs in the gneisses adjacent to the younger gabbro dyke (B3), and also marginal to the laccolith (B2), though in the latter case, the alteration seems to merge with a 'pre-existing' granulite zone.

Plastic deformation :

Contortion and plastic deformation of the gneisses occurs as bands, patches and zones of variable extent, ranging from only a few yards in width (A1 - road) to areas covering several square miles (B1 and F2). The degree and extent of deformation often varies within the same outcrop, so only those showing prominent effects have been plotted on the map. The deformation commonly reflects flow structures which signify a low cohesivity of rocks in these areas. The largest and best developed areas occur in B1 andF2 with the latter seeming to have formed during the emplacement of the adjacent monzonite mass. Plastically deformed areas are often, but not characteristically, associated with rocks of the diorite complex.

The cause of plastic deformation, whether dynamothermal, dependent on primary lithology or related to migmatite/intrusive activity, is uncertain, but very likely involves a combination of processes.

Intrusive Rocks

Intrusives may generally be regarded as belonging to either those preceeding or accompanying the orogeny responsible for ultrametamorphism (meta-gabbro, diorite and monzonite complexes, and white anorthosite), or else to subsequent ones such as the gabbroic-anorthosite complex and scattered dykes, plugs and sills.

Meta-gabbro :

Only two small occurrences have been recognised (B3-E and E3-SW) and both seem to be dyke-like bodies disrupting the adjacent gneissic structure. Mafics, (dominantly hornblende with minor pyroxene and biotite) comprise 60 % or more of the rock and plagioclase felspar plus alteration products completes the balance. The rocks are generally very altered but retain relic igneous textures.

Undoubtedly many of the bodies mapped as amphibolites could be intrusive in origin, but without further evidence, it is unjustifiable to differentiate between them.

(Meta)-diorite complex :

These rocks are very widespread in the area as bands, zones and masses, and two genetically related types have been recognised.

Foliated diorites : Irregular-shaped masses of diorite occur in the central part of the region, spanning the Croche River (D2) and rimming the south-western margin of the central gabbro laccolith (B2). The rocks are characteristically uniform and medium- to fine-grained and consist mainly of white sodic plagioclase felspar with varying amounts of quartz and mafics which individually rarely exceed 25 % of the rock. The mafic minerals, comprising mainly hornblende with minor secondary biotite, invariably form oriented aggregates which give the rock a superficial, very coarse-grained, crudely foliated/lineated, speckled appearance. Quartz varies from negligible amounts, as in the Croche River masses, to approximately 25 % in parts of the mass fringing the gabbro laccolith. This latter mass, unlike the Croche River masses, lacks a greenish colouring of the felspars, and represents a granodiorite rather than a diorite. Furthermore, its margines seem to be better defined and devoid of the hybrid gneissic zone common to other diorite masses.

Hybrid diorite : This rock type occurs as a transition zone between most foliated diorites and the enclosing gneisses, and also as widespread irregular zones and discontinuous patches in the gneisses. It covers a variety of compositions and forms ranging from interlayered diorites and gneisses (complex multiple intrusions) to gneissic, banded diorites. In many of the intermediate forms, it is often difficult to distinguish between the diorites and gneisses. A green colouration commonly accompanies these zones but is not characteristic.

In the map region, these zones are traceable over considerable distances and generally seem to conform with, and emphasise, the regional structure, though local discontinuities, pinching and swelling are common.

Monzonite - granite complex :

Green and pink quartz-poor monzonites, pink quartz-rich varieties and pink granites appear to be related in three main masses as an igneous unit comprising multiple intrusions.

The monzonites are all similar in composition, and consist mainly of perthitic feldspar with variable, though generally minor, amounts of alkali- and plagioclase-felspar in the quartz-rich and quartz-poor monzonites respectively. Mafics comprise up to 40 % of the rock and are noticeably more abundant in the quartz-poor varieties. Hornblende, though often secondary, is common to all monzonites and is generally the most abundant mafic mineral. It is generally associated with green pyroxene in the quartz-poor, and especially green, varieties and with biotite in the quartz-rich monzonites.

The felspars are mostly coarse-grained and commonly contain phenocrysts up to 2 inches long. In the eastern mass, the phenocrysts are conspicuously euhedral and zoned with more calcic plagioclase cores. The mafics however, are usually medium to coarse-grained and well distributed in the ground-mass where they impart a crude foliation to the rock.

The monzonites usually weather with a very white, powdery outer surface that is invariably underlain by a thin cascenade stain.

The monzomites are undoubtedly comparable with the charnockite rocks mapped and described in other regions. The classification, which is dependent on the ratio of alkali- to plagioclase-felspar, is complicated by the dominance of perthites in these rocks, and the consequent difficulties of assessing the true felspar ratios. In view of the presence of free alkali and/or plagioclase felspar in some varieties, and the genetic relationship of the monzonite to the diorites and granites, the author favours the term monzonite.

Each of the monzonite masses has individual field characteristics, and therefore will be treated separately.

South-west monzonite masses (A3 and B3) : The main mass is a quartz-poor pink monzonite which is dominantly massive and coarse-grained, and contains a porphyritic core that shows well-developed augen structures in its western limits. The mass is rimmed by a foliated to gneissic hybrid zone containing abundant gneiss relics. East of the Lake Bouteille fault zone, the hybrid zone is extensively developed around two small massive cores and seems to give the closest correlation between the monzonite and diorite as being genetically related intrusives. Pyroxene seems to have beena primary mineral in the monzonite, and the surrounding gneisses are strongly discoloured green (granulites). One small zone of green monzonite has been observed in the porphyritic core, but the relationships are indistinct.

Eastern monzonite masses (F2 and F3) : This is the largest and best exposed mass, and it is predominantly a quartz-rich pink variety. It contains several zones of green quartz-poor monzonite, and has been intruded by younger diabase dykes and pegmatites. The contact between the pink and green monzonites is gradational in places (F2-S - on the road) but intrusive in others (where the road crosses 47°50'N) with the pink variety intruding into the green monzonite. Reverse relationships have not been observed thus implying that the green variety constitutes an initial intrusion.

Just south of Lake Çingras there is a large area of noticeably finer-grained pink monzonite (not marked on the map) that seems to constitute a separate but related intrusion. Apart from this area, the monzonite is coarse-grained throughout and widely characterised by scattered zoned felspar crystals with more calcic cores. Mafic minerals (predominantly hornblende) are generally fairly evenly distributed throughout the mass as single crystals or aggregates and they commonly impart a crude foliation/lineation to the monzonite. The lineation has a remarkably constant plunge to the south-east at 10 to 40° and appears to be secondary in origin. One small area just east of the road junction (F2-S) reveals a lineation trend cutting across, and distorting (by minute shear-flowage) an inclusion of fine-grained material. Inclusions or small irregular lenses and patches of fine-grained, generally more mafic, material occur in places near the contact with the green monzonite. In other places, small veinlets and narrow patches of fine-grained pinkish material occur in the monzonite, but these are most likely related to the younger intrusive of fine-grained pink monzonite just south of Lake Çingras.

In some places, often in the centre of the monzonite mass, strong foliation and even gneissic banding is developed and these seem to represent zones of shearing formed during the emplacement of the mass.

The only contact observed with the gneisses is represented by a zone 100 ft. or more in width comprising complexely intermixed gneisses, gneissic inclusions and fine to coarse-grained monzonites, all of which have been abundantly injected by pink quartzo-felspathic material similar to that of the migmatites. The large adjacent area of gneisses (F2-W) is complexly contorted and plastically deformed, and veins and dykes of monzonite are present up to 1/2 mile away from the main mass.

The monzonite mass as a whole seems to constitute a multiple intrusion involving at least three different rock types - green quartz-poor monzonite, pink quartz-rich monzonite and a fine-grained pink variety which most likely represents the youngest of these intrusions.

North-west monzonite - granite masses (A1) : This complex consists of two main rock types - a green monzonite and a pink granite.

The green monzonite extends to the north off the map area and is essentially a quartz-poor, hybrid variety with massive to gneissic textures. It is mainly medium-grained and lacks the porphyritic structures of the other monzonites. In the central area, it is intermixed with a variety of rocks, including gneisses and diorites, but field relationships are ill-defined.

The green monzonite has been intruded by numerous pink granite dykes and veins which seem to be related to the large intrusion of pink granite on the southern side of the green monzonite. The relationships and outline of the granite suggest that it might have been intruded into the nose of a large fold. The granite comprises a central massive and coarse-grained to porphyritic mass in which pink alkali-felspar (orthoclase plus minor microcline) and perthites are the dominant minerals. Quartz constitutes up to 30 % of the rock, but mafics - predominantly biotite - are much rarer and rarely exceed 15 %. The central mass is separated from the gneisses by a zone in which the granite is foliated to gneissic and commonly intermixed with gneiss inclusions and bands. This zone is widest on the western side. Similar zones are lacking along the contact of the granite and monzonite. Dykes and veins of a composition similar to the granite in composition intrude the adjacent gneisses and rocks upto a mile from the main mass, but do not seem to be related to any green alteration in the rocks.

The granite dyke-like body to the south of the above mass seems to be genetically related to the Pink granite. It is richer in hornblende though, and the felspars are generally light pink to white in colour. An aureole of greenish altered gneisses (granulites) fringes the intrusion and seems to be related to it.

It should be noted that there is no direct evidence for correlating the granite with the monzonite complex, apart from its location, but this is in accordance with Guy-Bray's observations. The possibility of dating the granite as post-gabbro, and therefore genetically related to the numerous granite dykes in the region is feasible, but dependent on further information.

White anorthosite :

The large, very uniform mass of white anorthosite occupying the south-easternmost corner of the region (F3) is well exposed, and consists almost solely of white to light-grey felspar of a labradoritic composition. Towards the margins apparent assimilation of the country rocks has resulted in the formation of hornblende-rich bands, lenses and aggregates which are well exposed in the anorthosite dyke region on the La Tuque - Robberval road. Two small outcrops of anorthosite in the monzonite seem to represent a dyke, but contact relations are indistinct, and the bodies may in reality be inclusions in the monzonite. Inclusions elsewhere, however, are conspicuous by their absence, but anorthosite dykes have been observed to intrude the gneisses in two places - on the La Tuque - Robberval highway, and on the eastern shores of Lake Chasseur.

The age of the anorthosite is questionable, but the writer feels that it is genetically related to the diorite and monzonite complexes and has been intruded, most probably, as a crystal mush in the waning stages of orogenesis. The writer further favours the idea that the monzonite and anorthosite may have been derived from the same granodioritic magma by fractional crystallization and crystal settling. A dioritic - granodioritic magma is most likely to result from the palingenesis of quartzo-felspathic sediments/gneisses, and rocks of the diorite complex might well represent such a magma. In such a silica melt, it is highly probable that early formed plagioclase-felspar crystals would tend to settle and thus provide an ideal crystal mush that could be squeezed out subsequently.

These ideas are mainly speculative however, and subject to further field and laboratory investigations.

No contacts with the main anorthosite mass have been observed, but adjacent gneisses seem to have conformable trends and vertical to steeply outward-dipping attitudes. Banding of the assimilated, mixed zone seems to have similar conformable relationships.

Gabbro Complex

Several large gabbro intrusions occur in the central-southern part of the region, and it is highly probable that the numerous gabbroic dykes, sills and plugs are genetically related.

The gabbroic rock-types are generally coarse-grained, massive to weakly foliated and relatively unaltered. Plagioclase-felspar, which constitutes up to 60 % of the rock is dark-green to grey in colour, and generally corresponds to a labradorite composition. Incipient alteration to sericite is frequent but usually very minor in extent. Mafic minerals are dominated by pyroxenes, mostly green augite, with minor olivine and hornblende, the latter often being present with biotite as secondary 'cluster' alteration products.

Most outcrops are weathered and show a deep penetration of iron staining. In a few places, the gabbros have been injected by well-defined granite-pegmatite veins and dykes.

The gabbroic areas will be considered separately as they usually have individual distinguishing characteristics.

Central laccolith (E2-NE) :

This oval, saucer-shaped mass appears to represent a laccolith emplaced in a broad synclinal structure. The north-eastern 'hook' most likely represents an extension of the feeder system - drag-folding by the Savane fault is most improbable in view of the consolidated nature of the rocks and absence of fracturing and shearing with respect to the recent nature of the faulting.

Weak foliation in the rock appears to conform with the outline of the intrusive, and concentric structures, both lithologic and topographic (as seen on airphotographs) are evident in the western parts of the mass. The laccolith margins and southern dykes appear to be particularly rich in mafics, and are occasionally associated with small concentrations of magnetite.

Certain zones, concentric in nature, contain numerous small lenses and irregular patches of fine-grained gabbroic material, which present a genetic problem. The fine-grained material generally seems to represent inclusions, and they are commonly fringed with hornblende (reaction) rims. Some of the lenses however, lack these rims and are drawn out to form elongated structures that could be interpreted as intrusive bodies. Positive evidence is lacking however. The writer is lead to believe that these fine-grained patches represent inclusions, and that the concentric zoning indicates that multiple intrusions were involved in the emplacement of the laccolith. The margins of the laccolith are devoid of gneiss or diorite inclusions and assimilation effects. Neither are they 'chilled' where observed in the south, though the mafic dykes nearby are noticeably finer grained.

Central masses (C2-NE and F2-W) :

Spanning the Croche River, and possibly representing an eastern extension of the laccolith body, are several gabbroic intrusions into the diorite masses. Mineralogically, the gabbros are very similar to the laccolith, though the easternmost dyke-like bodies (E2) are noticeably more mafic and contain up to 80 % pyroxene and hornblende.

The large northern dyke (F2) has been extended into the gneisses mainly from airphotograph evidence which seems to corroborate field observations.

Southern gabbro - gabbroic-anorthosite (B3) :

This dyke-like body compliments the laccolith mineralogically and might even have acted as a feeder, though it tapers northwards and seems to be increasingly altered and intruded by granite-pegmatite veins. Where observed by the writer in the southern parts, the gabbro is generally coarse-grained and massive. in places it is intermixed with gneissic relics, and especially marginal to the fault - an excellent example of an altered, garnetiferous gneiss inclusion is exposed in the cutting on the south side of the Trenche Dam wall. Garnet is also present locally in the 'fresh' gabbro outcrops and drill core samples, and undoubtedly represents an assimilation contamination product.

South of the dam wall, the gabbro appears to intrude a very coarse-grained gabbroic-anorthosite. The contact is well exposed, and is marked by a zone approximately 50 feet wide in which the two rock-types are progressively intermixed. Beneath the log shoot, a large, fine-grained green gabbro dyke has been intruded discordantly across the contact zone. The gabbroic-anorthosite consists dominantly of very coarse-grained, green to dark-green plagioclase-felspar crystals containing interstitial aggregates of augite and olivine plus minor, usually secondary, hornblende and biotite. Irregular blocks blasted from the dam wall foundation, and scattered drill-core sections, provide excellent fresh samples and show interesting detailed features, but unfortunately, they cannot be positioned with respect to field relations.

Dykes, sills and plugs

Scattered throughout the area are numerous small intrusive bodies which will be considered lithologically in order of abundance.

Granitic intrusives :

These seem to be widespread and generally occur as narrow, continuous bodies and fracture fillings intruding all aforementioned rock-types, both concordantly and discordantly. Accurate assessment is complicated by the somilarity in the field to some migmatite injections.

The granite dykes in general have a lighter-coloured pinkish-white felspar and higher concentration of mafic minerals (mostly biotite) than the north-westernmost granite mass, but a possible genetic relationship cannot be excluded. It is questionable however, to consider all the dykes as being genetically related and the idea of several ages of intrusion, even of apparently similar composition, is tenable, but difficult to verify without further meticulous field-work and research.

Granitic dykes and sills seem to be most abundant in the west-central and northern regions, but unfortunately, their significance was not fully appreciated at the time and recorded as such in the field.

Gabbro - diabase intrusives :

Small gabbroic bodies occur in various parts of the region, and seem to fall into two main groups.

Dykes and sills : These are sparsely distributed in two main regions, and occur as individual dykes and sills up to 100 feet or more in thickness.

Large dyke- and sill-like bodies of limited outcrop continuation occur in A1-E and B1-C respectively. Both are similar in composition and texture to the gabbroic masses further south, but have markedly higher concentrations of mafic minerals.

The dykes intruding the eastern monzonite mass (F2 and F3) are generally dark-grey, mafic-rich, fine-grained bodies that are also only traceable over short distances. Conformable foliation is moderately developed in some places, and the enclosing monzonite often bears a sympathetic foliation and occasionally crude banding. Where observed, contacts are fairly sharp, but usually characterized by a narrow zone of inclusions (F3-N - road south of Lake Loup) and small diabase veinlets intruding the country rock. It is highly probable that the multitude of small dykes in the central part (F2-S) represents a distributary extension of the larger dyke south of Lake Çingras (F2-NE).

The genetic relationship of these dykes to the gabbro complex is uncertain.

Plugs : Two small gabbroic plugs have been observed in the region.

The northern body (C1-NW) overlaps the map boundary and is conspicuous on the airphotograph as a roughly circular elevation. It consists essentially of a medium-grained gabbro similar in composition to the gabbro masses further south. It is generally massive in the centre but weakly foliated towards the margin with the eastern side being markedly finer-grained. The western contact is represented by a narrow zone containing scattered inclusions of gneissic material and featureing limited injections of gabbro into the gneiss host rocks.

The southern plug (C3-SW) outcropping on the eastern shores of Lake Matte is ill-defined in outline. It seems to comprise at least two separate intrusions. On the northern side, the rock is a very coarse-grained gabbro comprising white plagioclase-felspar crystals and up to 50 % large, euhedral crystals of hornblende plus minor pyroxene, which give the rock an unusual massive 'network' texture. In places the felspar is discoloured pink, as if by metasomatic effects, but no contacts with the gneiss, or granitic intrusions have been observed. On the southern side, a separate body of medium-grained, noritic gabbro has been emplaced, seemingly as a younger intrusion. The rock is massive throughout, and weathers with an unusual rough, pitted surface, the depressions seeming in places to represent the preferential weathering out of biotite clusters of secondary origin most likely. White plagioclase-felspar and brown pyroxene (augite and hypersthene) occupy roughly equal proportions.

Pegmatites :

There are several large, very coarse-grained pegmatites scattered sparsely in the area. They are distinct from the migmatite/granite bodies, and appear to be the youngest igneous rocks in the area. The best examples and exposures are in the gabbro dyke-like body (B3-SC) and eastern monzonite mass (F3-E), and in the latter exposure, the pegmatite is over 30 feet thick. Quartz and pink to white felspar are the dominant minerals, with biotite and magnetite as the main accessories. Apart from allanite in the gabbro dyke occurrence, no unique minerals of importance have been observed.

Calcite veins :

In two localities (A3-E and B3-N), fresh pink and white calcite veins outcrop. The northernmost occurrence (not seen by the writer) is reportedly over 20 feet thick and comprises a uniform, pink calcite with scattered crystals of epidote andppyroxene as the only impurities.

The origin of these veins is uncertain, but they seem to represent one of the youngest intrusions in the area.

Quaternary and recent deposits

Unconsolidated deposits occur in most parts of the area and invariably seem to be the result of Pleistocene glacial deposition.

Non-stratified deposits :

Regional drift : Blanketing the area up to a depth of 10 feet, but with patchy occurrences over higher ground, is a regional deposit of loamy till. The till comprises up to 30 % pebbles, cobbles and some boulders set in a fine sandy-loam matrix. The boulders are generally less than 15 inches mean diameter, and are commonly smoothly rounded with striated and faceted surfaces. Gneissic types are most common in the wide range of compositions, but most conspicuous are the hard, fine-grained, green andesitic varieties. The closest providence of the latter is 250 miles in a north - north-east direction (the common trend of glacial striations), but another possibility is in the Chibougamau area, 100 miles to the north-west. Transportation from here would have had to involve either a swing in the direction of glacial movement, or else two or more stages of transport in a south-easterly, then southerly direction.

Scattered about the area are large erratics up to 8 feet or more mean diameter. Conspicuous amongst these are the weathered green monzonite varieties which were most probably derived from the monzonite masses of the La Lievre region, 15 to 20 miles to the north.

Valley drift : The alluvium in the larger valleys is commonly underlain by a sandy, pebble till generally poor in boulders and lacking the green andesite varieties. An irregular surface is characteristic with kettles and sometimes kames a common feature. The best preserved deposits are in the Cotè-Gouin River valley (E2-SE and F3-NW), and at one point (E2-SE) there is a well-developed end morain approximately 2,000 feet long by 100 ft. wide by 30 ft. high, which has been stabilised by vegetation. A kame terrace is evident high up the western slope of the Coté River valley and serves to indicate the very wide-spread deposition of drift material in this area - probably even more extensive than indicated on the map or airphotograph.

Stratified deposits :

These are mainly confined to the larger 'glacial' valleys in the region.

Eskers : Discontinuous, generally short eskers are scattered in the Framboise-Rothman (A2-N), Savane-Bouteille (B2-SW), Culotte (C1-NE), and Çingras-Coté (F2-NE) valley systems, but they are most abundant and well-preserved in the large Coté-Gouin valley (E2-SE). The eskers are generally 10 to 30 feet high with relatively level to undulating narrow crests - the Rothman valley esker is used as a road foundation. The eskers are composed mainly of a sandy, till-like material rich in gneissic pebbles and cobbles, but lacking andesitic varieties. Local 'clusters' of eskers are frequent, and in the better preserved occurrences individual eskers are sinuous and continuous for over a mile in length.

Fluvo-glacial alluvium : The larger glacial valleys, and especially the Brulée-Croche-Savane-Bouteille and Petit Croche-Croche systems are floored with thick deposits of fine alluvium, most likely deposited by glacial melt-waters. The above valleys are approximately 200 feet lower in elevation than the Renard-Coté-Gouin and Çingras-Coté valleys which most likely accounts for the paucity of alluvium, and better preservation of glacial drift features, in the latter systems. The deposits appear to be well over 100 feet thick in places - as indicated by the deep incision of the lower reaches of the Croche River.

A well-exposed section in the banks of the Croche River just below Rapide Chute Brulée (D2-N) gave the following deposition sequence :-

Top	30 ft.	Fine alluvium - seems to increase in thickness southwards to constitute the dominant exposed formation.
	5 ft.	Reddish gravel - as an irregular lens approx 15 ft. long.
	10 ft.	Mixed zone - interlayered alluvium and sandy to gravelly material containing at least two discontinuous pebble horizons.
	5 ft.	Fine alluvium
	2 ft.	Blue clay horizon - very persistent for a considerable distance downstream and at least into D3-N
	-	Large boulders up to 4 ft or more mean diameter - rarely exposed downstream.

Thicknesses are only approximate but give a good relation of values. The succession is not as simple as summarised above, but features local discontinuities, scour channels etc. that indicate a multiple regime (including dry periods) that culminated in the final deluge.

Structural Geology

In view of the detailed complexity of the geology with respect to the scale of mapping and relative paucity of outcrop, the author considered the mapping of detailed structural features at each outcrop impractical, and concentrated on the general trends and more obvious features. Emphasis has therefore been placed on measurements of gneissosity, foliation and, to a lesser extent, lineation.

The above method has revealed a generally diversified trend of structures which can be correlated with lithologic units to indicate a complexly folded region. The trend is only fairly constant in the northern regions where a north - north-east direction predominates. Variations elsewhere are discussed more fully in the section on folding, page 29.

Meso-structures :

Gneissosity : This refers to composition banding which is predominant in the gneisses, but also occurs in many of the hybrid zones marginal to the intrusive complexes. The whole region has been highly metamorphosed and original bedding features seem to have been destroyed. However, the strong sub-parallelism of gneissosity to distinct lithologic units leads the author to believe that the gneissosity actually coincides with, or represents, bedding, and that the inter-layered amphibolites may actually represent a primary feature reflecting inter-bedded shale horizons.

Gneissic banding is generally present as quartzo-felspathic and mafic-rich laminations ranging from a few tenths to half an inch or more in thickness. These are usually very regular in the biotite quartzo-felspathic gneisses. The gneissosity is commonly emphasised by migmatitic quartzo-felspathic injection material as fine- to medium-grained continuous and discontinuous bands. These 'injections' often have indistinct contacts and lensoid shapes, as if formed by syntectic segregation.

In the mafic-rich gneisses, the gneissosity is often less distinct and represented by mafic laminations comprising clusters or aggregates of hornblende. In the amphibolites, gneissosity is commonly poorly developed and subordinate to the development of foliation planes.

Foliation : This is represented mainly by the preferred orientation of hornblende and biotite and, to a less significant extent, felspar crystals.

In the gneisses, foliation is common and in practically all cases sub-parallel to the gneissic banding, so it has not been designated as a separate unit on the map. Foliation is usually best developed in the amphibolites - at the expense of gneissosity. A cursory π - pole plot shows a wide spread of values to form a girdle indicative of repeated folding, most probably of structurally weak rocks.

In the diorites and monzonites, a crude foliation is shown by the hornblende aggregates, but it is commonly weakly developed and difficult to measure accurately. Foliation in these intrusives appears to be a secondary feature. It is usually not conformable with the contacts of the intrusive, and is distributed throughout the mass rather than representing just a marginal feature. In places (see page 18, line 22) the foliation is transcurrent to primary inclusion features.

In the rocks of the gabbro complex, foliation is generally only weakly developed and sparsely distributed, but where observed, and especially in the central laccolith, it seems to be concordant with the outline.

Lineation : Unfortunately too few readings have been taken in the field, so the following observations must be regarded as tentative in nature. All measurements refer to mineral and/or mineral aggregate lineations.

In the gneisses, the lineation trend varies from north to south-south-east, but practically all the plunges are to the east at a variety of angles. A cursory analysis of lineation plots indicates an irregular girdle around a weak maximum in the east-north-east sector.

In the diorites and monzonites, the lineation plunges persistently to the south-east at a low to moderate angle.

A combined analysis of these results seems to indicate a variation of stress conditions during the orogenic cycle - in accordance with the ultra-metamorphic relations discussed earlier. Directive stress in a general north - south direction seems to have been dominant during the early and main stages of orogenesis, but has swung to a north-east - south-west direction during or after the emplacement of the related igneous masses in the waning stages.

Bedding : This has not been observed directly in the gneisses apart from the example at the base of the contraversial limestone in the north-eastern region. In many of the impure quartzites however, fine laminations and bands resemble bedding planes, and may be relic features.

Folding and contortion : Several areas in the gneisses are characterised by local folding and contortion. This ranges from small drag-folded zones, often associated with migmatitic injections, in the outcrop to large areas in which the individual outcrops are plastically deformed by apparent flow/shear processes. It is regrettable that the plunge of drag-folding was not measured and analysed as a separate entity, but it's value was not appreciated at the time, and observations were confined to other features of structure and lithology.

Macro-structures :

Folding : Large-scale folding is predominantly indicated by variations in lithology and gneissosity trends, and is most evident in the gneiss complex. Hornblende quartzo-felspathic gneisses, and zones containing impure quartzite and/or diorite bands generally emphasise the structures, and occasionally the emplacement of the larger igneous bodies seems to have been controlled by the structural configuration. Two main ages of folding are evident in the region.

a) Orogenic folding : Orogenesis has apparently caused both tight and broad folding, overfolding and warping af a syn- anticlinorium nature. Several syn- and antiforms have been recognised, and they serve to emphasise the complexity of the structures in the region.

In the south-westernmost part (A3), complimentary broad syn- and antiforms are represented by gneissosity and lithology features - a dominant aspect aspect being the extensive ridge of quartzite defining the large peninsula extending into the Trenche Dam. The structures appear to be overturned to the east, but confirmatory evidence is lacking. The emplacement of the diorite and monzonite bodies on the northern edge of the antiform seems to involve a strong structural control.

In the central region (B2), tight folding is evident around the gabbro laccolith and marginal to the Savane River valley fault. Several small syn- and antiforms are indicated, but attitudes vary from relatively open forms on the northern side to tight structures, seemingly overturned to the south, on the southern side of the laccolith. Most of the folds appear to plunge to the east-north-east at shallow to moderate angles.

In the north-western region (A1), broad open folding seems to be the dominant feature associated with the emplacement of the monzonite and granite bodies. The structural picture is complicated however, by extensive local plastic deformation.

In the north-central area (C1 and D1), the Croche River seems to traverse part of the axis of a long tight synform with a western limb that is relatively well outlined by quartzite and hornblende quartzp-felspathic gneiss trends. Lithologic duplication of the eastern limb is more discontinuous and broken up, and may even have been displaced by a fault through the Croche-Renard valley. Further west, the broad fold north-east of Lake Caumonot is strongly emphasised by evidence on the airphotographs.

In the south-central region (C3), two large broad folds are vaguely apparent but lack sufficiently distinctive evidence to be delimited.

East of the Croche River, folded structures are generally indistinct but seem to form large 'infolded' areas in the diorite and monzonite masses. In the south-easternmost region (D3 and E3), a complex M-shaped structure, tightly folded in the east near the anorthosite mass, seems to be indicated by the wide hornblende quartzo-felspathic gneiss zones.

Folding in the eastern quartz-monzonite may be responsible for the distribution of the green monzonite zones, but the author feels that the curved nature of these bodies is the result of sweeping, flow-movements caused by the intrusion of the subsequent pink monzonite variety.

b) Post-orogenic folding : This is only indicated directly by the central laccolith body (B2), which, on its westernmost contact, shows a discordant relationship with the host rocks - a feature clearly visible on the air- photographs.

Folding most likely preceeded the intrusion of the gabbro, but evidence of this and the effects of such folding on the gneisses in general is difficult to assess from the field observations. The aforementioned π -pole and lineation analyses reveal a spread of values, enough to suggest several stages of folding, but insufficient to show the superposition of such a late stage on the orogenic complex. It is most probable however, that any post-orogenic folding was gentle and therefore unlikely to stand out on a tectonic analysis. The shape of the laccolith seems to imply that causitive stress conditions may have been roughly conformable with those responsible for the structures evident in the confining gneissic complex.

Faulting : This is undoubtedly far more extensive than indicated on the map, but seems to range from ill-defined, plastic shearing (as indicated in some of the contorted gneisses and banded zones in the eastern monzonite mass) to large, sharply-defined topographic linears which represent major fractures or fracture systems. The susceptibility of the shear zones to weathering and erosion, particularly glacial, is undoubtedly an important cause of their preferential excavation.

Many linears have been delimited in the airphotograph stereo-analysis, but only those showing features pertinent to faulting (fracture/shearing, mylonite/epidote occurrences, specific quartzo-felspathic injection and metasomatism, lithologic discontinuity and/or displacement etc.) have been plotted as faults on the map. Lithologic displacement is difficult to assess with certainty owing to the complex nature of the geology and paucity of outcrop, but there seems to be enough discrepancy to support the faults marked. In places (B2-S) horsts are evident in the fault planes but do not seem to be excessively fractured.

Two main fault trends and systems are apparent in the region.

a) North-east - south-west trend : Several large sub-parallel valleys (Framboise-Rothman, B1 to A3; Brulée-Savane-Lake Bouteille, D1 to A3; Petit Croche, F1 to D2) are prominent topographic features and very likely represent major fault zones. Only the Savane-Lake Bouteille valley has sufficient supporting evidence to be classified as a fault; lithologic differences on either side of the fault zone between the monzonite masses in the southwest, and the gabbro/diorite bodies in the central region. The regional confinement of these igneous masses however, seems to indicate that movement along the fault could only have been small and/or involved dip slip as the main component. This fault zone peters out to the south-west, and seems to be disrupted in the north-east, and possibly offset by a north - south system, to continue further east as the Croche-Brulée valley linear.

The Petit Croche River valley is marked on its southern side by a well-defined linear that ends abruptly against the western wall of the Croche River valley. This seems to represent a major shear zone extending beyond the region, but it has little field evidence to support it

Many sympathetic linears and shears are evident in many places, but are best exemplified in the south-westernmost region in the Lake Matte (B3-SE) and Trenche Dam (A3-SE). The former site is particularly well exposed to reveal a narrow, highly fractured fault zone 1 to 2 feet wide which appears to represent a normal fault with a downthrown southern block. Lithology differences on either side of the Trenche Dam fault indicate a right-hand strike separation.

b) North - south trend : In general, this system ranges from north - south to north-west - south-east and is widely distributed as small fault systems which displace the north-east - south-west trend at most intersections. Distinctive, fine-grained pinkish-red quartzo-felspathic injection material is associated with all field observations of the north - south fault system.

The system is best exposed in the sharply defined Lake Biais - Lake Savane valley (D2-W), and at several points on the flanks of the narrow central trough the rocks are extensively fractured and sheared. Light-green epidotised surfaces, frequently slickensided, are common, and pinkish-red quartzo-felspathic material is widely injected with accompanying pink metasomatism of the felspars in the enclosing diorite rocks.

The En Couer stream (C3-NE) exposes several north-west - south-east trending schistose fault-zone outcrops which are injected with relatively undisturbed pink quartzo-felspathic veins. The fault seems to be truncated at Lake En Couer by a north - south shear zone which is marked for most of its length by a narrow, very continuous hollow or gulley, 5 to 20 feet in depth.

Genetically related linears in other parts of the region bear features similar to those described above, and displacement within the south-west monzonite mass (B3-N) implies a right-hand strike separation.

The Gouin valley (E2 to F3) constitutes a prominent north-north-west - south-south-east linear that is marked on its eastern edge by a well-defined cliff or very steep slope. Fracturing in the diorite seems to be the main control of the cliff slope which itself may well represent a fault-line escarpment. Positive evidence for a fault is lacking however, and the valley may just represent a glacially eroded feature that peters out southwards towards the anorthosite mass but extends northwards as far as the Croche-Brulée River junction. The Lake Chasseur - Lake Shea (fault) valley further west has a sympathetic trend that peters out northwards into the diorite mass.

An interesting feature is the north-east swing in direction of the Croche River at the 'structural elbow' (D2-S) where the Petit Croche linear intersects the north - south linear of the lower Croche River valley. North - south faults to the north of this point may represent bifurcated extensions of a larger lower

Croche shear zone, but it is also possible that the lower Croche and Petit Croche linears represent a single fracture system resulting from and unusual response to regional stress conditions.

Another interesting feature is the apparent lack of extensive displacement along the larger fault zones. The various igneous rocks and gneissosity/lithology trends, though discontinuous and disrupted across the respective shear zones, are still lacallised in region outcrop relationships.

The faults observed appear to represent the most recent geologic activity and are younger than all intrusive bodies bar the quartzo-felspathic injection material peculiar to the north-south system. Older fault zones undoubtedly exist and may even have been delimited in the stereo-analysis of the airphotographs, but they seem to be sufficiently disrupted and/or indistinct to be of significance in the region. In general, the north-east - south-west system is the oldest, and it appears to have been dislocated and displaced by a younger north - south to north-west - south-east system that is better preserved. Exceptions occur (B2) and serve to indicate that the above interpretation is probably over-simplified, a fact that is governed by the amount of information available.

A meticulous analysis of joint systems may have assisted in unravelling the variation of stress conditions in the area and therefore the resultant fracture systems. In a preliminary investigation however, the author found that the great variation of joint plane attitudes in the same outcrop, and the difficulty of correlating genetically related systems constituted a problem sufficiently great to invalidate the benefits of such a study with respect to the time available for mapping and the distribution of evidence in the field.

Historical Geology

From all the points considered so far, it seems possible to delimit several genetic stages in the geologic and geomorphologic evolution of the region.

1. Initial deposition in a geosynclinal environment, probably near the miogeosynclinal section, of a thick sequence of greywacke-type sediments interbedded with subordinate sandy, calcareous and clay horizons and possibly some extrusive volcanics.

2. Subsequent induration and compaction to form a sedimentary sequence of the rocks. This stage probably involved folding and faulting which may even have

been associated with gabbroic intrusions now represented by meta-gabbro relics.

3. Orogenesis and ultra-metamorphism of the rock types to a high-grade amphibolite facies and involving extreme deformation, often plastic in nature, to form a complexly folded, dragfolded and overfolded region. Syntexis and anatexis seem to have been responsible for the origin, and order of emplacement, of the following 'igneous' rocks.

White and pink, fine- to coarse-grained quartzo-felspathic material which has been intimately injected into the gneisses throughout the region to form an involved migmatite complex.

Diorite complex rock types involving compositions ranging from basic diorite to granodiorite, which have been emplaced as irregular masses with hybrid margins, and widespread hybrid bodies or zones featuring intimate intermixing with the gneisses.

Monzonite complex rock types which probably originate from the progressive fractionation of a dioritic magma to yield the following rock types in order of emplacement; green and pink quartz-poor monzonite, pink quartz-rich monzonite and pink granite. These rocks are inter-related in several large masses.

White, granulated anorthosite which seems to have been emplaced as a mass in the final stages of orogenesis, and could possibly represent an early crystal-settled fraction of the above dioritic magma that has been intruded subsequently as a crystal mush.

4. Minor folding and possibly faulting with the emplacement of rocks of the gabbro complex as scattered masses and dykes ranging from gabbroic-anorthosite and peridotite to normal and noritic gabbro.

5. Intrusion of minor sills, dykes and plugs of diabase/gabbro, granite and pegmatite, and occasional pink and white calcite veins. The gabbroic varieties may be genetically related to rocks of the gabbro complex.

6. Regional faulting involving a main north-east - south-west trend which has been offset by a younger, better preserved north - south to north-west - south-east system. Displacement in general seems to have been small, and where observed, has involved a right-hand strike separation.

7. Pleistocene glaciation seems to have both modified and emphasised the pre-glacial drainage system to yield the following features in genetical order.

Continental galciation with the formation of an ice-cap over the area and subsequent deposition of a regional morain containing rock types derived from considerable distances to the north-west and/or north of the region.

Final retreat of the ice-cap to form transection then valley glaciers which have emphasised the main 'pre-glacial' trends and deposited local valley drift. Meltwaters from these glaciers deposited eskers and local alluvium, and probably carved out the box-channel from north of Lake Shea (D2-SE) to Lake Castor (D3-SE). Valley glaciers appear to have receede from the general north - south trending Renard-Cote-Gouin and Coulotte-Croche systems at approximately 1,000 ft. elevation, to the lower north-east - south-west trending Brulée-Savane-Lake Bouteille and Petit Croche-Croche systems at approximately 800 ft, elevation. A vague cirque-like structure is indicated on the airphotograph in the upper reaches of the Petit Croche River. These lower valleys seem to have confined the bulk of the melt-waters with the resultant deposition of considerable alluvium in the respective valleys. The upper paired terraces along the Croche River slope uniformly from an elevation of 750 ft. in the Petit Croche River valley to 650 ft. in the southernmost limits of the Croche River.

The faster south-flowing rivers, and especially the Trenche and Croche systems, have eroded actively headward to capture the post-glacial south-west flowing rivers and form the present drainage pattern.

Economic Geology

Apart from the extensive deposits of sand and till suitable for road ballast and surfacing, the economic potential of the Chaumonot region is disappointing and confined mainly to small scattered magnetite bands and weak sulphide mineralisation.

Records show that a small area incorporating the present Trenche dam site was staked in 1906 - presumably on the presence of scattered sulphides in the gabbro dyke and minor magnetite bands in the adjacent gneisses. Inhabitants of Rapide Blanc village have reported former positive prospecting for gold on the southern shores of the Rapide Blanc dam and the creek draining Lake Kennedy, both outside the Chaumonot Region to the west and south respectively.

Surficial deposits :

Sands and sandy gravels in the larger valleys, and loamy tills widespread elsewhere constitute an important source for road ballast and surfacing material. Borrow pits and excavations are scattered along the main La Tuque - La Lievre road and occasionally along the secondary branch roads. The Trenche-Rothman valley confluence area (A2-N) in particular provides a vast, easily accessible source of uniform, sandy alluvium.

Building stone :

The massive porphyritic granite of the north-west intrusive (A1), and some areas of the coarse-grained pink and green monzonites, and especially in the eastern mass (F2 and F3), seem suitable for building and facing purposes. Both occurrences are near major highways, but further investigations would be required to verify the economic prospects of this resource.

Sulphides :

Disseminated to sparsely scattered sulphides, dominantly pyrite with occasional chalcopyrite, are widespread in most rocks of the gabbro complex. In places they are concentrated as small discontinuous veinlets and aggregates but rarely in excess of approximately 1 % of the rock.

The most spectacular occurrence is at the Trenche Dam wall (B3-S). Here chalcopyrite is a common to dominant sulphide mineral, and is associated with pyrite as veinlets and aggregates that are well exemplified in the blocks removed from the wall foundation and dumped at the northern foot of the wall. The contact of the gabbro and gabbroic-anorthosite seems to have formed a particularly favourable site, but concentrations here even are far from economical comprising up to 5 % of the rock.

Magnetite :

No deposits of commercial value have been observed in either of the two main types of occurrence.

In the gneisses, scattered small, discontinuous bands and lenses of magnetite-rich amphibolitic rock up to 1 ft. wide occur in isolated places. The best exposures are on the eastern banks of the St. Maurice River opposite the Trenche dam wall. Here several sub-parallel bodies of medium-grained magnetite-rich amphibolite, containing up to 80 % magnetite occur as narrow bands and lens-like structures conformable with the north-north-east - south-south-west trend of the gneissosity.

Along the southern margin of the central gabbro laccolith (B2) and especially in the dyke-like offshoots, concentrations of magnetite and minor ilmenite comprise approximately 60 % or more of the rock. In view of the poor outcrop in this section, further investigations involving more detailed types of mapping, and possibly magnetic surveys might prove useful. The chances of an economic deposit however, seem remote at this stage.

Miscellaneous :

Pegmatites : Several large pegmatite bodies occur in the region, but all appear to be barren. The body intrusive into the gabbro dyke (B3) however, is weakly radioactive - a feature probably associated with the trace occurrence of allanite.

Calcite veins : The large pink and white calcite vein north-east of Lake Bouteille (B3-N) could be quarried as a source of calcium carbonate, but otherwise is of negligible commercial value.