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NORTHWEST QUARTER OF LEVY TOWNSHIP

L.E. Wolhuter

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Geological Report

on the

NORTHWEST QUARTER OF LEVY TOWNSHIP

ABITIBI-EAST ELECTORAL DISTRICT

by

L. E. Wolhuter

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INTRODUCTION

General Statement

The northwest quarter of Levy township, an area of 25 square miles, was mapped during the summer of 1962. During this same period samples for geochemical study were also collected from those parts of the Opémisca Batholith lying outside the map-area.

Location and Access

Northwest Levy township is situated about 1 1/2 miles north of Chapais, a mining village approximately 300 miles north of Montreal. The area is readily accessible by way of Chapais which has road, rail and air connections to the major centres in the province. A rough bush road which is best travelled by four-wheel-drive vehicles branches northward off the Chapais-Senneterre highway at a point 2.7 miles west of Chapais. It penetrates as far as the property of Coniska Copper Mines Ltd. An alternate but circuitous route leading to the northern part of the map-area is by canoe from West Bay on Opemisca lake, 7 miles west of Chapais, along the Senneterre highway.

Field Work

The area was mapped on a scale of 1000 feet to the inch during the summer of 1962. Four range lines striking due west were cut and posted by the Department of Lands and Forests, Quebec, during the spring. At the start of the field season the range, township, median and centre lines were chained and picketed to provide control in the geological mapping. Outcrops in ranges IV and V were located by pacing along compass traverses between the range lines. Traverses were run either due north or due south and were spaced at intervals of 400 feet. Over large parts of this area picket lines at intervals of either 300 or 400 feet had been laid out by private mining companies for geophysical and/or geological surveys. The picket lines greatly facilitated mapping and were used wherever possible.

The northern three fifths of the area is underlain entirely by granitic rock and all mapping was done on overlays on vertical aerial photographs enlarged to a scale of approximately 1000 feet to the inch.

Acknowledgements

The writer's student assistant for the field season was Mr. P. Girard whose services are hereby gratefully acknowledged.

Previous Work

In the summer of 1896, Bell (1897, 1902) undertook a reconnaissance of the Nottaway river basin. His assistant Brock ascended the Chibougamau river from Waswanipi lake and proceeded as far east as Waconichi lake. His brief description of the geology along the shores of Opemisca lake is the first written account of any of the rock types in the present map-area.

Low (1906) also mapped the shores of Opemisca lake during his survey of the Chibougamau mining region in 1905. He was followed twenty five years later by Tolman (1931) who mapped the southern part of the Opemiska Quadrangle. Tolman's map at a scale of two miles to the inch includes the present area.

Regional mapping by Norman (1938a) in 1937 and 1938 at a scale of 1 mile to the inch (Geological Survey of Canada Map 602A) did much to elucidate the lithology and structure of the region.

Claim groups in the southern part of the map-area have been mapped at various times by mining companies.

PHYSIOGRAPHY

Topography

Levy township lies in the Abitibi upland of the Superior province, one of the major structural and physiographic units of the Canadian Shield (Bostock, 1964).

The average altitude in the map area is about 1250 feet above sea level. With the exception of Springer mountain, the strip of country to the south of the adamellite batholith is low and flat and local relief does not exceed 50 feet. Within the adamellite however, the topography is slightly more rugged and diversified. Numerous rocky knolls rise from 50 to 350 feet above the surrounding swamp and drift-covered plains and the average relief is probably somewhere between 100 and 150 feet.

Springer mountain, a typical monadnock in the southeast corner of the quarter, rises almost 600 feet above its surroundings and is a conspicuous landmark.

Drainage

The map-area is in the Hudson Bay drainage basin. With the exception of the extreme southwestern corner the drainage is northeastwards to Opémisca lake which lies in the basin of the Chibougamau river. Streams in the southwestern corner drain into the Obatogamau river.

The drainage has been glacially disarranged and the area is dotted with numerous small lakes and ponds. The streams are generally sluggish and practically devoid of rapids. The majority meander tightly across the countryside and have not yet begun to dissect bedrock. There is a pronounced tendency for most streams to flow northeast — the direction from which the ice-cap made its last advance.

Except where they flow through open swamp the streams are fringed with an extremely dense growth of alder which greatly encumbers traversing.

Pleistocene land forms

The varied land forms that came into being as a result of the continental ice-cap can be divided into the customary erosional and depositional varieties.

Erosional features

Striated, polished and grooved rock surfaces are present in many parts of the area but, in general, weathering has obliterated much of the finer detail on exposed rock surfaces. Measurements of striations at several points show that the advance of the ice-sheet was to the southwest.

The abrasive action of the ice-sheet resulted in low, flat or dome-shaped outcrops many of which have the characteristic roche moutonnée shape with smooth gently sloping stoss sides on the northeast and rough, quarried lee sides on the southwest. Springer mountain exemplifies this feature on a much grander scale. Its northeastern side slopes fairly uniformly at a rate of approximately 1 in 6 whereas the southern and southwestern sides are fronted by precipitous cliffs.

A small isolated hill approximately 1 mile west of Lamoille lake in the northwestern corner of the area is completely surrounded by beach terraces formed in glacial lake Barlow-Ojibway (Norman, 1938b). Only Springer mountain (elev. 1781 ft.) and a high hill (elev. 1550 ft.) immediately east of Knife lake projected above the surface of this former glacial lake when it was at its highest level.

Depositional features

The bedrock is largely covered by a sheet of clayey to sandy ground moraine which ranges in thickness from a mere fraction of an inch to several scores of feet. Much of the till in the low-lying areas is covered by muskeg or swamp.

Annual or washboard moraines, as described by Norman (1938b) and Mawdsley (1936) occur mainly in the low lying areas. They are not as abundant as in the southern half of

Levy township. The general trend of these elongated morainal ridges is east-southeast.

Among the most conspicuous physiographic features of the region are the elongated tracts of sand and gravel that extend for many miles in a northeasterly direction. They generally trend at right angles to the annual moraines, or, in other words, parallel to the direction of ice retreat. For a detailed description of their size, shape and topographic expression the reader is referred to the article by Norman cited previously.

GENERAL GEOLOGY

General Statement

The entire area is underlain by rocks of Precambrian age and covered extensively by glacial drift.

The oldest rocks are those customarily referred to as Keewatin-type. They are composed of an assemblage of metamorphosed acid and basic lavas, tuffs and agglomerates. The strike of the volcanic rocks changes gradually from approximately west on the Levy-Daubrée township line to northwest in the vicinity of Springer mountain. In the area north of Springer mountain the strike changes very abruptly from northwest to northeast as the contact with the batholith is approached.

The volcanic sequence is intruded by a series of layered basic and ultrabasic sills. The epidiorite-quartz metagabbro sill is considered to be the oldest although there is no direct field evidence to support this premise.

The second, and presumably younger, group of intrusives consists of layered pyroxenite, gabbro and serpentinite in that order of abundance.

The constituent minerals of the volcanic and pre-granitic intrusive rocks have been altered extensively to low-grade metamorphic minerals of the greenschist facies.

The intrusion of the basic and ultrabasic rocks was followed by the emplacement of a large granitic (adamellite) batholith to the north. The marginal zones of the batholith are generally monzonitic, probably due to the desilication of the adamellite by the low-silica country rock. Large xenoliths of amphibole-, pyroxene- or biotite-rich hybrid rock are common within this peripheral zone of monzonite. Outside the batholith the country rock shows little or no contact metamorphic effects.

The plutonic rocks and the central parts of the thicker basic flows are usually medium- to coarse-grained and massive. In contrast, the fine-grained volcanic rocks are almost invariably schistose. The dip of the schistosity and bedding, where determinable, is invariably steep.

The entire pre-granitic succession is part of the north limb of a tight, isoclinally folded synclinal belt which borders the southern margin of the Opémisca Batholith. The belt is repeated on the north side of the batholith by a major, composite anticlinal fold. The adamellite and other intrusive masses to the east are aligned along the axis of this anticline. The synclinal belt to the south of the batholith has been further deformed and dislocated by cross folds and faults. The two most prominent sets of faults strike north-northeast and north-west, as shown on the map.

Copper-bearing veins were intersected in several diamond drillholes on the property of Coniska Copper Mines Ltd., but to date none of these has proved to be economical.

Table of Formations

CENOZOIC	Recent and Pleistocene	Till, stratified sand and gravel.
Great Erosional Unconformity		
PRECAMBRIAN	Intrusive rocks	Hornblende Adamellite Monzonite Biotite-, hornblende- and pyroxene-rich hybrid rocks.
		Intrusive Contact
		Ultrabasic Complex: Ventures Gabbro Foliated Gabbro Pegmatitic gabbro and pyroxenite Upper Green Pyroxenite Black Pyroxenite Serpentinite Lower Green Pyroxenite
		Intrusive Contact (?)
		Epidiorite and quartz metagabbro
		Intrusive Contact
	Keewatin-type rocks	Chloritic and amphibolitic greenstone (metabasalt), metasomatized basic lava, metarhyolite, acid and basic tuff and agglomerate, metagabbro.

Keewatin-type Rocks

Amphibolitic and Chloritic Greenstones

a) Metabasalt

Typically, the metabasalt is a dark-green, fine- to medium-grained, massive to schistose rock. The essential mineral constituents are sausseritized feldspar, amphibole and chlorite. Diabasic texture is noticeable in many specimens, but generally, strong amphibolitization and recrystallization have completely masked the original fabric. In the strongly schistose basalt, the constituent minerals have a well-developed platy habit and in certain outcrops a conspicuous lineation can be seen on the foliation planes.

The flows range in thickness from a few to many tens of feet. Most of the larger outcrops however, are partly covered by patches of moss and sandy or clayey till and the exact thickness of the flows cannot always be determined. A few reliable top and bottom determinations were made but the majority of pillows are distorted and permit at the most an approximate strike determination only. No pillows were observed in the volcanic rocks west of Springer mountain. This is perhaps because the fine-grained basalt in this region is invariably strongly schistose and most, if not all, primary structures may have been obliterated. A diligent search in this area failed to reveal any evidence for the stratigraphic top determinations shown on Norman's map (Geological Survey of Canada, map 602A).

Grain size decreases both upward and downward from the coarser, medium-grained basalt in the centre of the flows. The fine-grained basalt is generally moderately to strongly schistose in contrast to the medium-grained basalt which is usually massive. This is undoubtedly due to the relative ease with which movement (slippage or shearing) can take place along the interflow contacts, the greater permeability of the contact zones to chemically active vapours and solutions and the ability of the chilled, fine-grained basalt adjacent to the contacts to recrystallize more readily than the coarser-grained varieties.

Seen under the microscope, the metabasalts consist of a crystalloblastic intergrowth of four or more of the following minerals: amphibole, albite, epidote, chlorite, leucoxene and quartz. Significant quantities of carbonate occur only in strongly sheared basalts. Pyrite, sericite and biotite (stilpnomelane?) are present in some specimens but never make up more than 1% of the rock.

In the more massive varieties of metabasalt, blastophitic and granoblastic textures are most common. Felty or nematoblastic texture prevails in those rocks in which the amphibole has a distinct fibrous or prismatic habit, whereas lepidoblastic texture is confined to the schistose basaltic greenstone.

Amphibole typically occurs in xenoblastic grains. In a few sections the (001) zone is well developed, resulting in stout, equidimensional prisms and more rarely in slender prismatic crystals. Although the exact shade, tint or hue varies from section to section, the general pleochroic formula for the amphiboles is as follows:

X = Pale buff
Y = Pale yellowish (turtle) green
Z = Pale bluish green.

The amphibole appears to be an aluminum-poor actinolite common to the rocks of the greenschist facies.

Albite is anhedral and interstitial to amphibole in the granoblastic varieties of greenstone and more or less lathy in the blastophitic types. The grains are mostly clear and very rarely twinned. Consequently it is most difficult to distinguish albite from quartz especially in the very fine-grained rocks.

Epidote, either clinozoisite or pistacite, has a most characteristic habit. Almost invariably it occurs as tiny, irregular, semi-opaque "nests" or aggregates of minute xenomorphic granules which show grey or anomalous blue interference colours under strongly convergent light. In a few specimens, especially the coarser basalt, these aggregates have recrystallized to larger xenomorphic crystals of clinozoisite or, more rarely, pistacite, and show much stronger birefringence, Chlorite occurs as scaly aggregates in the more massive rocks and in the schists as subidioblastic plates or porphyoblasts, the parallel arrangement of which imparts to these rocks their characteristic fissility.

Small framboidal aggregates of leucoxene or sphene which are almost universally present in the greenstones, result from the alteration of titanic iron ore. Some of these aggregates still contain distinct lamellae of unaltered opaque ore (magnetite?).

Carbonate minerals are virtually confined to the schistose metabasalts.

Petrographically four distinct types of metabasalt are distinguishable:

1. Actinolite-albite-epidote greenstone

Actinolite ranges from 45% to 70%, albite (and quartz where present) from 15% to 45% and epidote from 2% to 15%. One or more of the minerals iron (-titanium) oxide, leucoxene or sphene is invariably present in quantities ranging from 2% to 7%. Chlorite never exceeds 1% by volume. Biotite (stilpnomelane?), pyrite and carbonate occur as minor accessories. These rocks are always massive and original textures are only slightly modified by recrystallization.

2. Actinolite-albite-epidote-chlorite greenstone

The mineral composition of this group is generally as follows: actinolite, 30% to 60%; albite, 20% to 55%; epidote, always less than 15%; chlorite, always more than 2% but less than 15%; leucoxene, sphene and/or titanic iron ore, 2% to 12%. A sprinkling of flaky sericite is present in the albite in some sections. Texturally they are similar to the rocks of group 1.

3. Chlorite-epidote-albite-actinolite greenstone and schist

In contrast to the previous group, these rocks contain abundant chlorite (more than 20%) and epidote (more than 15%) and relatively little actinolite (less than 15%). Massive as well as schistose greenstones occur in this group. The range in mineral composition is: Chlorite, 20% to 35%; epidote, 25% to 30%; albite, 25% to 30%; actinolite, 5% to 15% and titanic minerals, 5% to 15%. Accessory carbonate and pyrite are present in some sections but they do not make up more than 1% of the rock.

4. Carbonate-chlorite-albite (-quartz) schists

These rocks are characterized by the absence of actinolite, abundance of carbonate and chlorite and a schistose texture. Many of them are well laminated. The relative proportions of the constituent minerals vary widely, not only from one sample to the next but also, in a single specimen, from lamina to lamina. Quartz is usually present and is a major constituent of many of these schists. Accessory leucoxene, sericite or epidote are sparingly present in some.

b) Medium-grained metabasalt or metagabbro

It is not possible to distinguish the medium-grained metabasalt, found in the central parts of flows, from medium-grained (intrusive) gabbro purely on the basis of texture. Throughout the southern part of the area scattered outcrops were found which, because of their relatively coarse texture, could not be classified with any certainty as either basalt or gabbro. In several of the larger of these outcrops there was indeed a noticeable gradation to finer-grained phases but the latter were invariably devoid of typically extrusive features and may therefore be the chilled margins of intrusive sills.

The absence of structures such as pillowed surfaces and flow breccias may be largely owing to lack of continuous outcrop which in turn could result from the more rapid rate of weathering and erosion of the easily sheared and altered fine-grained contacts of lava flows. If this is so, one would expect the coarser, more resistant, less altered, interior parts of the flows to persist long after the margins have eroded away.

Although deep-seated plutonic intrusion of these medium-grained gabbroic rocks can not be ruled out, the following field evidence should be weighed when considering their origin:

(a) They are found frequently in areas where typical extrusive basalt is common.

(b) They often appear at the same stratigraphic horizon at which basalt does elsewhere along strike.

(c) Like basalt, they are interbedded with narrow bands of acid flows and fragmental rocks.

(d) They rarely have sharp contacts with recognizable basalt where the two rock types occur in the same outcrop. In fact, along the northwest slope of Springer mountain and in the southwest quarter of Levy township, a complete gradation can be seen from fine-grained pillowed basalt to medium-grained basalt which is identical to the coarser gabbroic varieties mapped elsewhere in the area.

It is of course possible that during the volcanic cycle, sheets of basaltic magma were injected near surface into a sequence of lavas still in the process of cooling. If this is so, these sheets should perhaps be considered more correctly to belong to the realm of volcanic rather than plutonic rocks.

Typically the medium-grained metabasalt or metagabbro is a speckled rock composed of sausseritized feldspar, amphibole and chlorite and minor leucoxene. A little granular, blue opalescent quartz is present in a few outcrops. Blastophitic or granoblastic texture is most common. Dark-green amphibole grains range from xenoblastic to prismatic in outline. In the Springer mountain area the amphibole grains tend to cluster together and give rise to a characteristic knotty weathered surface. Closer to the granite, these clusters become spindle-shaped and their parallel arrangement defines a distinct lineation. The lineation plunges at angles ranging from 35 to 65 to the northwest, north and east. The direction of plunge closely parallels the local strike of the schistosity of associated fine-grained basalt.

In gabbro/basalt of low colour index, individual amphibole grains are usually completely surrounded by aggregates of xenoblastic feldspar grains or matted feldspar laths. In rocks of higher colour index, the feldspar is interstitial either as single or clustered xenoblastic grains or as a mat of tiny laths. In almost all these rocks the extensive replacement of albite by very fine crystalloblastic amphibole granules or needles results in a rock which is dark and pyroxenitic in appearance on fresh surface.

The mineralogical composition of these rocks is similar to that of types 1 and 2 of the metabasalt proper.

(c) Metasomatized basic lavas (epidosites)

A sequence of fine-grained, highly altered, pillowed lavas is exposed in the immediate vicinity of the fire tower on Springer mountain in southwest Levy township. The zone averages about 1200 to 1500 feet in thickness and extends southeastwards to the Campbell Lake fault and northwestwards across the median line into the northwest quarter of Levy township. Extensive outcrops occur a few hundred feet south of where the zone abuts against the Opémisca adamellite batholith. Narrow bands or patches also occur in both the over and underlying basalt.

The colour of the lava ranges from olive drab to pale green, greenish grey and dark green. Irregular whitish to creamy and yellowish-drab patches of secondary minerals impart a characteristic mottled appearance to the rock. This mottling is especially noticeable in the pillows which are usually highly distorted or contorted. Alteration is most intense along the chilled selvages and alongside anastomosing fractures, joints and tiny shears in the interior of the pillows. In many outcrops the original outlines of the pillows are virtually obliterated.

Where alteration has been most intense and pervasive, rocks bearing a superficial resemblance to rhyolite may result. Where it has been only slight to moderate, the original metabasalt is still recognizable. Narrow bands of true rhyolite and of medium-grained basalt do occur in the zone of metasomatized lavas.

Under the microscope the dark, relatively unaltered lava is recognizable as a metabasaltic greenstone consisting essentially of a granoblastic intergrowth of amphibole, epidote, albite and sphene. The epidote (clinozoisite?) occurs as scattered semi-opaque "nests" and also as clear, crystalline granules interlocking with amphibole and seemingly replacing it.

Towards the metasomatized rock there is a progressive but irregular increase of epidote. Nevertheless, the eventual transition from greenstone to epidosite is sharp. The latter rock consists of fine-grained, granular, semi-opaque clinozoisite (?) enclosing much larger recrystallized xenoblastic grains and aggregates of clear clinozoisite. In many places the fine-grained clinozoisite outlines vague lathy shapes which presumably indicate former plagioclase crystals.

Metarhyolite, rhyolitic tuff and agglomerate

Acid volcanic rocks are found sporadically throughout the pre-granitic sequence. They are seldom more than a few hundred feet in thickness and seemingly occur in narrow, impersistent bands or lenses.

The varieties of rhyolitic rocks present in the area include massive rhyolite, rhyolitic tuffs and agglomerates. Of these, the fragmental rocks are most abundant. The massive rhyolite is easily recognized but the banded varieties are invariably sheared and, for this reason, it is ordinarily impossible in the field to establish whether they were originally flow banded lavas or laminated fine-grained tuffs. Agglomerate is scarce and is found only locally associated with tuff.

The massive rhyolite varies from a creamy, creamy-grey or greyish-white aphanitic rock with waxy lustre to a bluish-grey glassy variety. Feldspar phenocrysts are common to both types. Secondary epidote results in yellowish overtones and near the ultrabasic intrusions some rhyolite is altered to a mottled reddish, yellowish and greenish rock.

As has been mentioned above, there is a great deal of uncertainty regarding the exact origin of the schistose, fine-grained, banded rocks, i.e. whether they were originally tuffs or flows. Of the acid volcanics which are unquestionably of pyroclastic origin, the most common variety is one which is composed of feldspar grains and angular fragments of dense rhyolite in a schistose matrix. The majority of the fragments range from 3 to 5 mm. in diameter. With increase in fragment size they grade locally into agglomerates or agglomeratic tuffs. In the vicinity of major shear zones, the matrix minerals as well as the fragments are deformed. The rock is more schistose, more amphibolitic or chloritic and consequently darker in colour and it becomes indistinguishable from amphibole-chlorite schist derived from metabasalt or metagabbro.

This variation is well illustrated in the band of acid volcanic rocks that crosses the township median line about 6000 feet west of the southeast corner of the map area. A strong shear zone along the contact between these rocks and the greenstone to the east has obliterated the original relationships between the two rock types. The western (upper) end of the acid sequence is agglomeratic. The fragments are closely packed and embedded in a grey fine-grained schistose matrix. The rock has a discontinuous or interrupted banded appearance owing to the elongation of the fragments parallel to the schistosity. Narrow bands of creamy-grey to grey, dense rhyolite are interbedded with the tuff. To the east, the rock becomes less agglomeratic and more schistose, and the fragments become greatly elongated and flattened in the planes of schistosity. The Progressive increase in the intensity of deformation of the tuff is accompanied by a concomitant increase in amphibole, resulting in a dark green laminated schist. Scattered white streaks or laminae in the schist are the only visible evidence of the original rhyolite fragments present in the tuff. In a similar way, the metabasalt, especially the coarser-grained gabbroic variety, changes from east to west from a moderately altered greenstone to an amphibolitic schist in which the feldspar (?) grains are preserved as thin white smears or streaks.

A rather rare but distinctive variety of rhyolitic tuff consists of abundant, rounded to angular, feldspar grains and flinty rhyolite fragments in a hard, fine-grained, siliceous matrix. The fragments are closely packed, unsorted and range in size from 1/2 to 4 mm. The rock has a granular appearance, not unlike some of the more porphyritic varieties of rhyolite. It is possibly a welded tuff.

The rhyolitic rocks are characterized by a relatively simple mineral composition. Quartz, albite and sericite granoblastically intergrown are the dominant matrix minerals. The sericite content varies considerably from sample to sample depending largely on the degree of deformation and alteration. Minor chlorite and carbonate are present in many of the rhyolites and in some make up at least 10% of the rock. Leucoxene or sphene are constant accessories whereas pyrite, hematite, zircon, tourmaline and magnetite are rare.

Most of the acid rocks are porphyritic. Rounded and corroded quartz phenocrysts are present in a few of the rhyolites but albite phenocrysts are by far the most common. They range in composition from An_2 to An_5 and are usually twinned, either simply (Albite law) or complexly (Ala A/Manebach Acline or Acline/Manebach Ala). In many of the rhyolites the albite phenocrysts have been replaced by a granular mosaic of quartz and one or more of the minerals chlorite, carbonate, and sericite. All stages of alteration from incipient to total replacement may be seen.

With increasing deformation the massive rhyolites pass into semischistose and ultimately into strongly schistose rocks in which the entire rock has been intimately sheared along closely spaced cleavage planes. In many of these, sericite (white mica) is the dominant constituent. The schistosity is defined by the parallel orientation of individual mica flakes which interlock to form continuous films or sheets and which impart to the rock its characteristic fissility. Carbonate and chlorite are generally more abundant in the schistose than in the massive rhyolites.

A few albite or quartz phenocrysts may survive the increased deformation but most, especially albite, are mechanically and chemically aggraded in response to the greater stress imposed on them. They are converted to rudely lenticular aggregates (augen) of xenoblastic quartz, albite, carbonate and rarely chlorite.

Intrusive Rocks

Epidiorite - Quartz Gabbro Complex

The rock types referred to under this heading form a layered sill which is exposed for a distance of about 1 mile along the west half of the median line. Extensive outcrops are found in the southwest quarter of Levy township. The sill has a surface width of about 3000 feet where exposed, and because of the steep dips prevailing in the area, this figure is believed to represent closely the true thickness. The epidiorite, which may reach a thickness of as much as 1000 feet, occupies the basal portion of the sill.

a) The epidiorite member

Epidiorite is a convenient field term used to describe a speckled, medium-grained metamorphosed leucogabbro composed essentially of uralitic amphibole, sausseritized feldspar and leucoxene. In general, it has a colour index lower than 40 and megascopically appears to have a hypidiomorphic granular to slightly subophitic texture. Although the rock is generally referred to as diorite in the Opémisca region, chemical, microscopic and field evidence clearly indicate that it is not at all dioritic. It is for this reason that the writer, following Williams, Turner and Gilbert (1954, p. 243), has chosen to call it an "epidiorite". In this way the common field name is retained while at the same time the prefix "epi" indicates that the rock has attained a composition somewhat similar to true igneous diorites purely as a result of metamorphic changes in its original mineral assemblage.

The amphibole in the epidiorite is pale greasy green or olive green and occurs typically as roughly equant, squat prismatic grains with slightly ragged or feathery edges. The plagioclase has a characteristic creamy to milky colour and a waxy lustre. The size, shape and textural relationships of the feldspar grains are difficult to judge because of the strong sausseritization. Quartz is scarce and where present, probably does not make up more than 2% to 3% of the rock. Leucoxene is a minor but very common constituent. It ranges from whitish grey, grey and flesh grey to lavender and various hues of yellow and brown. The exact colour is generally dependant on the degree of deformation in the rock.

The rocks near the base of the epidiorite are dark in colour and typically gabbroic. A dark-green metapyroxenitic (amphibolitic) basal phase is exposed on the median line. Similar basal amphibolites are also found in diamond drill holes that intersect the epidiorite on the Chiboug Copper property in the southwest quarter of Levy township. The melanocratic basal phase grades rapidly upwards into normal epidiorite. Leucocratic phases in which the colour index is as low as 20 are found sporadically near the middle and upper parts of the epidiorite body.

The mafic rocks at the base of the epidiorite consist essentially of a recrystallized, granoblastic aggregate of uralitic amphibole (actinolite), about 60%; brown pleochroic hornblende, 20%; and colourless chlorite, about 20%. Carbonate and minor accessory epidote, sphene-leucoxene, apatite and opaque ore make up the rest of the rock. Optical properties of the amphiboles are as follows:

Actinolite:

X = Very pale brown
Y = Pale greenish brown
Z = Pale grey green to bluish grey green

$Z > Y > X$

$2V_z = 100°$ (Average of four determinations)
$Z \wedge c = 15°$ (" " " ")

Hornblende:

X = Light to medium brown
Y = Dark brown
Z = Dark brown to greenish brown

$Z > Y > X$

$2V_z = 106°$ (One determination)
$Z \wedge c = 14\ 1/2°$ (Average of two determinations)

The epidiorite is composed largely of saùsseritized plagioclase and a pale green amphibole. The relative proportions of these minerals varies considerably from one locality to the next but except for the dark gabbroic rocks near the base of the sill plagioclase is always well in excess of amphibole. Chlorite is generally less than 5% but in or alongside shear zones in the epidiorite it may be the most abundant mineral in the rock. Other minerals present in accessory quantities are leucoxene, clear crystalline epidote, carbonate, clear albite, sericite and apatite.

The plagioclase in the epidiorite is completely opaque due to the large amount of sausserite within it. The crystals are generally euhedral and lathy, but some are almost equidimensional. Locally, the plagioclase laths are clustered together to form aggregates with somewhat irregular outlines. It is these clusters, irresolvable to the naked eye, which impart to the rock its megascopic pseudohypidiomorphic – granular texture.

The large amphibole plates enclose the plagioclase poikilitically to subophitically whereas the smaller grains occupy the angular interstices between the plagioclase grains. Brown hornblende, small isolated patches of chlorite, tiny stringers or trains of ilinenite, patches and grains of carbonate and minute granules of epidote (less than 5μ) all occur within the amphibole. The optical properties of the pale amphibole are as follows:

X = Very pale buff to almost colourless
Y = Very pale yellowish green
Z = Very pale bluish green

Z Y X

$2V_Z$ = 103 (Average of 6 determinations)
Z c = 15 (" " 8 ")

In some epidiorites extensive recrystallization of the former pyroxene (relics of which were found in amphibole in one section only) to fibrous uralitic amphibole (actinolite) has virtually obliterated any pre-existing texture. Only a few lath-shaped clinozoisite aggregates, pseudomorphous after calcic plagioclase and blastophitically enclosed in amphibole display any similarity to the texture described above.

b) The transition zone

The transition from epidiorite to quartz gabbro is an extremely subtle one even though it takes place within a distance of about 100 feet. The first noticeable change involves the feldspar. Aggregates of tightly appressed, slender laths emerge from the indistinct, sausseritized "pasty" plagioclase of the normal epidiorite. Secondly, the pale greasy-green amphibole gives way to a darker, distinctly prismatic or bladed variety. Thirdly, but not everywhere, the transition rock becomes porphyritic as larger, but rather stubby, prismatic grains of dark-green euhedral to subhedral amphibole make their appearance. However, porphyritic texture is not necessarily a strictly transition zone phenomenon. Small, sporadic occurrences of porphyritic epidiorite are found in areas far removed from the transition zone.

The almost imperceptible gradation from epidiorite to quartz gabbro and the lack of continuous outcrops do not justify the fixing of arbitrary limits or boundaries to the transition zone, and for this reason, it is not shown as an independent unit on the map.

c) Quartz metagabbro

The quartz metagabbro is a massive medium-grained rock, dark greenish grey on fresh surfaces. The dark colour is deceptive, and is due mainly to granular epidote and very fine chlorite scales and amphibole needles lodged in or penetrating the plagioclase laths. The mineralogical composition and texture of the gabbro are best studied on smooth, glaciated outcrops or outcrops from which the moss has been stripped in recent years. On these lichen-free surfaces, the rock has not decomposed to any great extent, yet it has been exposed to the atmosphere for a sufficiently long period to allow bleaching of the very fine chlorite and amphibole which otherwise obscure most detail.

The gabbro has a speckled appearance owing to the intergrowth of uralitic amphibole and sausseritized feldspar. The texture can be described as relict subophitic or intergranular, but is not the typical variety that one normally associates with gabbro or diabase. The feldspar laths are slender, almost acicular, and although they appear to be orientated haphazardly, there is a local tendency towards a subparallel alignment. In hand specimen, this is frequently seen as a grouping together of feldspar laths in sheaf-like bundles. The individual sheaves themselves show no preferred orientation. Because of the high feldspar content of the gabbro and the proneness of the laths towards local parallelism, the interstitial amphibole itself readily assumes a prismatic or bladed habit. Grain size of the quartz gabbro ranges from 1 mm. to 5 mm. but most grains have a length of 2 to 3 mm.

The average quartz content of the gabbro is probably between 5% and 10% although exceptionally it may be as high as 20%. Two varieties of quartz were distinguished: the first and by far the most abundant variety is clear but has a bluish tinge and occurs as rounded drop-like or anhedral grains averaging about 1.5 mm. in diameter. In the weathered crust on many of the gabbro outcrops the quartz appears to have lost its distinctive blue colour.

There is reason to believe that this quartz may be secondary in origin, having resulted either from the breakdown of the original minerals in the gabbro during metamorphism or from the introduction of extraneous silica or, perhaps, from a combination of both processes. This assumption is based on the observation that usually the more intensely chloritized gabbro also has the higher quartz content. A similar relationship seems to exist between pyrite and chlorite although this is not meant to imply that strongly chloritized gabbro necessarily contains much pyrite and quartz. Either one or the other, or both, may be absent.

The second variety of quartz, only rarely seen by means of a hand lens, is clear to greyish, very fine in grain (less than 1/4 mm.) and appears to be interstitial to the feldspar and amphibole grains. Because of its small grain size it is undoubtedly more abundant than would seem from a megascopic examination of hand specimens. Probably this is the quartz so commonly forming micrographic intergrowths with feldspar in the quartz gabbro.

Leucoxene has much the same colour, shape and abundance in the quartz gabbro as in the epidiorite and medium-grained metabasalt or metagabbro. Not uncommonly, grains of unaltered, steely-grey magnetite-ilmenite are found in the quartz gabbro.

Microscopic examination of the quartz metagabbro shows that it is composed of a blastophitic intergrowth of uralitic amphibole (actinolite) and sausseritized plagioclase. These minerals make up the bulk of the rock. With one exception, plagioclase in the thin sections studied is always in excess of amphibole which averages between 35% and 45%. Minor quantities of epidote (clinozoisite) and quartz are invariably present, and so are accessory iron-titanium minerals (one or more of ilmenite-magnetite, leucoxene, sphene). Chlorite, pyrite and sericite were seen in most thin sections but in volume none of these exceeds 2% of the total mineral content of the rock.

The original texture of the quartz metagabbro appears to have been intergranular. In the early stages of magmatic crystallization, the pyroxene grains (now pseudomorphically replaced by amphibole) grew freely and without interference from plagioclase to form elongated prisms. However, as space became more restricted single grains or aggregates of small xenomorphic pyroxene grains crystallized in the interstices of the interlocking framework of the more abundant plagioclase laths. Although many of these interstices are irregular in outline, the long slender plagioclase laths, especially where they were subparallel or only slightly divergent, gave rise to openings which also were elongated and bounded by straight sides. It is the pyroxene (now amphibole) which crystallized in intergranular fashion in these elongated angular interstices which in hand specimen gives the false impression of having a blade-like or prismatic habit. Some of the amphibole granules do partly enclose plagioclase laths projecting into the interstices in true subophitic fashion.

Plagioclase usually occurs in long slender laths which distinguishes the quartz gabbro from other gabbros in the area. The laths attain a length of 3 mm. and have a length to breadth ratio as high as 8:1. The amount of sausserite in the plagioclase varies considerably from specimen to specimen. In some, the laths consist of clear albite containing less than 15% of small scattered clinozoisite granules and a little flaky sericite. In others, the albite is almost completely masked by a dense, semi-opaque mat of epidote and sericite. Polysynthetic twinning according to the Albite law is common but in most laths the twin lamellae have been bent during deformation and the grains have a wandering extinction. In a few thin sections the plagioclase was partly replaced by scaly chlorite or cut by narrow stringers of chlorite. The composition of the albite, as determined on suitable grains in three different thin sections, ranged from An_4 to An_8.

In addition to the two textural variants of amphibole described above, a third type, occurring as fine-grained scaly aggregates, was noticed in some thin sections. The mineral which this particular amphibole replaced (?) must have crystallized late during the cooling of the magma, for the aggregates are interstitial not only to the plagioclase laths but also to the larger amphibole grains. Whatever the habit of the amphibole, the optical properties seemingly remain constant. Because of the strong deformation which led to bending and rupturing of the grains, very few thin sections have amphibole suitable for the determination of optical properties by means of the universal stage. The amphibole in the quartz metagabbro however, is distinctly different from that in the epidiorite. In grains from three thin sections the optic axial angle ($2V_z$) was at least 110° in one section, and between 122° and 125° in the others. Extinction angles ($X \cdot c$) ranged from 15° to 17°. Many grains show mottled coloration due largely to minor and irregular "bleaching". The pleochroic scheme is as follows:

X = Pale buff to pale yellowish brown
Y = Light yellowish green to green
Z = Light bluish green to blue green or greenish blue

Z > Y > X

The optical properties suggest an actinolitic amphibole, the slightly darker shades indicating perhaps a more iron-rich variety than in the metabasalts or epidiorite.

Hardly any quartz is present in the gabbro immediately above the transition zone but it increases noticeably towards the middle and top of the sill. Initially the quartz occurs as anhedral interstitial grains or less commonly as a partial replacement of any of the other grains. At higher stratigraphic levels in the sill most of the quartz is micrographically intergrown with albite except in the finer-grained chill zone at the top of the sill where only a little interstitial quartz is again present. Locally the quartz is penetrated by fine crystalloblastic needles of amphibole.

Chlorite is rather scarce within the quartz metagabbro. It occurs as small stringers or scales in albite and as tiny irregular patches in some amphibole. The remaining minerals occur in the same way as they do in the metabasalts and metagabbros.

The Opemiska Ultrabasic Complex

The complex derives its name from the Opemiska Copper Mine in the southwest quarter of Levy township where it was first mapped in detail and subdivided into its constituent members by the mine geologists.

The complex, which has a maximum thickness of about 3,600 feet, consists of a number of concordant sills ranging in composition from serpentinite (metadunite and metaperidotite) to pyroxenite, uralitized pyroxenite and metagabbro. In the type-area the sills form an orderly, well-defined succession in which the pyroxenites and serpentinite occupy the bottom two thirds of the sill and the two gabbro members the upper part. To the northwest both gabbros wedge out and extend for only a short distance into the present map area. They are superseded by discontinuous irregular to lenticular bodies of gabbroic or pyroxenite pegmatite. Increased alteration of the pyroxene grains to fibrous amphibole and, to a lesser extent chlorite, near the Levy-Daubrée township line tends to erase the subtle colour and textural differences among the various pyroxenites and they become more or less indistinguishable from one another.

Because of thick overburden over much of the area and the general scarcity of outcrop it is seldom possible to observe the transition from one rock type to the other in the field. Much of the information discussed below is based on the study of the cores from the many diamond drill holes that have intersected the ultrabasic complex.

a) The Lower Green Pyroxenite (Amphibolite)

The lowermost member of the ultrabasic complex is a green to greenish-grey medium-grained amphibolitized pyroxenite commonly referred to as the Lower Green Pyroxenite. It is composed of an interlocking mass of distinctly prismatic grains of green to greenish-grey, grey, or brownish-grey amphibole and pyroxene. Specks of brown hornblende and a little leucoxene or magnetic iron ore can usually be seen. Much of the original pyroxene has been converted to amphibole during the regional metamorphism of the area. Locally the pyroxenite contains as much as 15% feldspar and grades toward gabbro in composition. The feldspar is usually interstitial to the amphibole and pyroxene. Small irregular bodies or lenses of coarse-grained pegmatitic pyroxenite and gabbro are also present but by no means as abundant as in the Upper Green Pyroxenite.

Microscopically, the Lower Green Pyroxenite is seen to consist of a hypidiomorphic-granular to felty mass of interlocking amphibole and pyroxene prisms and minor accessory minerals. The range in composition is as follows: actinolite, 20% to 75%; clinopyroxene, 20% to 70%; hornblende, trace to 5%; iron-titanium minerals, usually less than 5%, but as much as 10%. Carbonate, epidote and chlorite are generally present in trace quantities only. Sausseritized albite occurs only in feldspathic pyroxenites and the coarse-grained gabbroic pegmatites.

The actinolite is a pale bluish-green uralitic variety which replaces the original (magmatic) pyroxene grains either partly or completely. The amphibole prisms are terminally frayed and have evidently grown extensively during the metamorphic period. In many thin sections splintery outgrowths from one grain penetrate an adjacent grain. The original pyroxene crystals had a distinctly elongated prismatic habit and the crystalloblastic growth of amphibole has merely served to emphasize this feature even more. Some of the larger amphibole prisms contain small sprays or plumose aggregates of much finer fibrous actinolite. In several thin sections, mostly from the upper half of the sill, similar sprays or diversely oriented aggregates of fibres or blades of amphibole also occur interstitially to the larger amphibole and pyroxene grains. Near the top of the Lower Green Pyroxenite the bulk of the actinolite occurs in this fashion. Determination of optical properties of the actinolite by means of the universal stage yielded the following results:

$2V_Z = 102^\circ$ (Average of 15 determinations)
Standard Deviation: 2.7°

$Z \wedge c = 15.8^\circ$ (Average of 14 determinations)
Standard Deviation: 1.2°

X = Very pale buff
Y = Pale yellowish green
Z = Pale bluish green

$Z > Y > X$

There seems to be no noticeable variation in the optical properties of the actinolite from one part of the sill to the other. Differences within a sample are commonly greater than the differences among samples. A notable feature of the amphibole is that it usually contains many inclusions of exceedingly small granules of leucoxene or sphene.

Colourless clinopyroxene occurs either as relics within actinolite or more commonly as partly uralitized grains. Most pyroxene grains are charged with a fine "dust" of opaque ore in contrast to the titanium minerals enclosed in the amphibole. Few of the pyroxene grains are twinned. The following optical properties were determined by universal stage methods:

$2V_z = 53.4°$ (Average of 23 determinations)
Standard deviation: 3.3°

$Z \wedge c = 41.1°$ (Average of 20 determinations)
Standard deviation: 1.3°

With the exception of the sample collected near the base of the Lower Green Pyroxenite in which the clinopyroxene had an optic angle $2V_z = 58.5°$ (Average of 4 determinations) and an extinction angle $Z \wedge c = 41.3°$, there appears to be no significant variation in the optical properties of the pyroxene from different parts of the sill.

Brown pleochroic hornblende is a conspicuous but not abundant constituent of the Lower Green Pyroxenite. It clearly replaces clinopyroxene — a reaction which seemingly took place during the magmatic stage. The hornblende seems to have been rather stable under the prevailing conditions of regional metamorphism; in only one section was there any evidence of replacement or penetration of the hornblende by actinolite. The small size of the hornblende grains did not permit accurate determination of their optical properties. The optic axial angle, $2V_z$, ranged from 106° to 110° for four determinations from two thin sections. Determination of the extinction angle, $Z \wedge c$, was particularly poor and ranged from 13° to 23° on the same four grains.

Irregular to amoeboid or skeletal grains of leucoxene and/or sphene partly or completely replacing iron-titanium ore are common in all sections. In some, the opaque ore has a distinct remnant lamellar pattern (Widmanstätten texture).

The minerals chlorite, epidote, carbonate and albite, where present, are similar in appearance to those in basic rocks previously described.

b) The Black Pyroxenite

The typical Black Pyroxenite is distinctly different from either of the Green Pyroxenites. It is a medium-grained, greenish-grey to slate-grey granular rock composed of stumpy, slightly rounded, anhedral to euhedral grains of olive-drab to greyish augite and minor interstitial serpentine. The serpentine usually weathers to opaque whitish grains superficially resembling feldspar. The greyer varieties of pyroxenite are also the more serpentinous.

By becoming progressively more amphibolitic, the Black Pyroxenite grades downward into the Lower Green Pyroxenite and upwards into the Upper Green Pyroxenite. The change from one rock type to the other may take place within only a few inches, but more commonly it occurs over a distance that may range from a few feet to several tens of feet. Because of the gradual, almost imperceptible change, it is extremely difficult to assign outcrops in the transition zone to any particular category of pyroxenite. Such occurrences might easily be mapped quite differently by different observers and the boundaries shown on the map are therefore somewhat arbitrary.

Although coarse-grained pegmatitic phases are occasionally found in the Black pyroxenite, they are far less common than in either the Upper or Lower Green Pyroxenite. Gabbroic pegmatites, on the other hand, are altogether absent in the Black Pyroxenite. In several localities, both the Black and Lower Green Pyroxenites contain discontinuous patches of breccia which do not appear in any way to be associated with faulting. The breccias consist of fragments of relatively fresh-looking pyroxenite, generally less than 5 mm. in diameter, set in a green fine-grained, highly altered matrix. The breccias themselves are enclosed in massive pyroxenite. Their exact origin in uncertain but they may be crushed and granulated fragments of solidified pyroxenite torn from the walls of the intrusion by a later influx of magma.

The Black Pyroxenite has the following range in mineral composition: clinopyroxene, 80% to 88%; amphibole, from less than 5% to 15%; serpentine, trace to 12%; opaque ore (titaniferous (?) magnetite), 3% to 10%. Trace quantities of hornblende, chlorite and carbonate are present in some sections.

The texture of the typical Black Pyroxenite is xenomorphic granular and is determined by the clinopyroxene which occurs as more or less rounded equidimensional grains. In some sections the pyroxene is more distinctly prismatic and the texture grades toward hypidiomorphic granular.

The clinopyroxene is a colourless variety having the following optical properties:

$2V_Z = 53.3°$ (Average of 24 determinations)
Standard deviation: 1.5°

$Z \wedge c = 40.6°$ (Average of 24 determinations)
Standard deviation: 1.7°

The boundaries of the clinopyroxene grains are emphasized by a peripheral or intergranular concentration of fine magnetite. The cores of many grains are somewhat "roughened" in appearance owing to slight alteration. Within these altered patches the pyroxene is heavily charged with a very fine opaque ore "dust". Twinned grains with the 100 face as composition plane are common. They are usually composed of two individuals only but some show multilamellar twinning.

Serpentine, pseudomorphic after olivine (?), is a characteristic accessory of the typical Black Pyroxenite but it disappears in the transition zones between the Black and the Green Pyroxenites. The serpentine occurs as colourless to slightly turbid scaly aggregates in the interstices of the pyroxene grains. The patches of serpentine are commonly penetrated by or overgrown to a greater or lesser extent by fine tufts of colourless amphibole fibres based on the enclosing clinopyroxene grains. The absence of serpentine in the Green Pyroxenites is essentially due to the compelte replacement of these aggregates by the fibrous amphibole. There is generally a noticeable concentration of anhedral granular magnetite in or around the areas of serpentine. Very rarely the magnetite grains are arranged in distinct rows or patterns.

The amphibole in the Black Pyroxenite is a colourless variety (tremolite?). It is by no means as abundant as the actinolite in the Green Pyroxenites and forms largely at the expense of serpentine as described above. Locally fibrous or bladed amphibole may be found replacing pyroxene alongside small fractures crossing the section. It is obviously the result of hydrothermal alteration. The conversion of pyroxene to amphibole has led to the release of magnetite which is lodged within or alongside the fracture.

c) Serpentinite

Included in this category are both metadunite and metaperidotite. Of the two, the metaperidotite is probably the more abundant. It is not always possible to distinguish between the two varieties in the field. Both are slate grey to black on fresh surfaces and weather a characteristic rusty brown or, more rarely, grey.

The serpentinite occurs as a series of sills wholly contained within the Black Pyroxenite. The sills have a marked tendency to pinch and swell along strike and many of them can be seen to wedge out very abruptly. Because of the scarcity of outcrop it is not possible to determine whether any of the sills persist laterally for a considerable distance.

In many of the sills the transition from serpentinite to pyroxenite is gradual whereas in others the contact between the two rock types is knife-sharp. Pale-green and whitish serpentine-talc schist occurs where shearing has taken place along the contact. The gradational contacts evidently result from crystal settling and accumulation in situ of early-formed olivine during the crystallization of the ultrabasic magma. On the other hand, serpentinite sills with sharp contacts suggest an initial accumulation elsewhere of the olivine which then presumably intruded the Black Pyroxenite as a largely solid, crystalline mass. In several outcrops on the Opemiska Copper Mines property in the southwest quarter of Levy township, serpentinite sills sidestep sharply as much as 20 feet before reverting to their previous strike. It is difficult to conceive of any mechanism, other than intrusion, to account for this phenomenon.

The weathered surface on many of the metaperidotite outcrops is covered with resistant, wart-like knots of magnetite-rich material. On fresh surfaces these protuberances show up as shiny plates of dark, magnetite-bearing serpentinized and/or amphibolitized pyroxene (?) poikilitically enclosing smaller ovoid grains of serpentine pseudomorphic after olivine. Apparently the magnetite released during the serpentinization of the original olivine became lodged in the enclosing crystal of pyroxene which itself was subjected to alteration. In one exposure there was a distinct increase in the size of these magnetic excrescences towards the bottom of the serpentinite sill. This possibly suggests gravitative settling of the poikilitic pyroxene (?) grains in a liquid magma at a time when the sill was essentially in a horizontal position.

Stringers of brittle cross-fibre asbestos (picrolite), seldom more than 1 mm. in width, are common throughout the serpentinite. Although the typical serpentinite is a massive, more or less structureless rock, a banded variety was noticed in a few scattered outcrops. The banding results from the alternation of medium- and coarse-grained layers of serpentine and parallels the contacts of the sill. A poorly exposed body of whitish, massive grossularite-pyroxene rock enclosed in serpentinite occurs on the western slope of Springer mountain, on the property of Hoyle Mining Company.

Most of the metadunites consist of a mat of scaly or fibrous serpentine laced with magnetite. In some of these rocks however, the original xenomorphic granular texture of the dunite is perfectly preserved by ovoid to subhedral pseudomorphs of serpentine after olivine. The metaperidotites are characterized by a blastoporphyritic texture in which large phenocrysts, formerly pyroxene (?), now converted to tremolite (?), are set in a matrix of felty or scaly serpentine. The phenocrysts poikilitically enclose ovoid or roundish pseudomorphs of serpentine.

The following minerals are generally present in the serpentinite: serpentine, 55% to 80%; magnetite, 15% to 30%; tremolite (where present), 10% to 25%; carbonate, trace to 5%. Trace quantities of chlorite and sphene occur in some thin sections.

The serpentine is generally colourless but in many sections it is clouded by an unidentified cryptocrystalline semiopaque brownish alteration product. In some sections the fibrous or scaly serpentine is cut by narrow stringers of later serpentine.

The magnetite in the serpentinite has a two-fold origin: that which was present as a magmatic mineral and that which resulted from the breakdown of olivine to serpentine. In those serpentinites in which the original texture has not been completely obliterated and in the large poikilitic crystals of amphibole, magnetite concentrated around and between the serpentine grains faithfully outlines the shape of the original olivine grains. In most thin sections however, the magnetite is disseminated through the serpentine in irregular granules or else it occurs in elongated streaks, lenticles or trains.

The amphibole occurring in the serpentinite is a colourless, fibrous tremolitic (?) variety similar to that found in the Black Pyroxenite. Part of the amphibole resulted from the replacement of the original pyroxene (?) which formed the large phenocrysts but most of it has grown at the expense of the serpentine pseudomorphs poicilitically enclosed in the phenocrysts. The fibres of amphibole in any one phenocryst show a marked parallelism irrespective of the mineral they replace and all extinguish more or less simultaneously. In one thin section the later origin of the amphibole is clearly proved by a veinlet of serpentine cutting sharply across serpentine pseudomorphs and the encircling magnetite in a poikilitic phenocryst. In several places this veinlet is breached by needles or fibrous tufts of amphibole which replaces the other silicate minerals elsewhere in the phenocryst.

Pyroxene-bearing serpentinites (metaperidotites) are found in the transition zone where Black Pyroxenite by reduction of clinopyroxene and increase of serpentine grades into the typical serpentinite described above.

d) The Upper Green Pyroxenite

The description given previously for the Lower Green Pyroxenite is equally applicable to the Upper Green Pyroxenite.

A notable feature of the Upper Green Pyroxenite is the relative abundance of pegmatitic gabbro and pyroxenite within it. They occur as irregular lenses, patches or veins, usually conforming roughly to the layering of the pyroxenite and very rarely crosscutting it. The majority of the pegmatites appear to be concentrated at or near the top of the Upper Green Pyroxenite. The pegmatitic pyroxenite or gabbro may occur separately but more commonly, both are present in the same body.

The pegmatite is composed of uralitized and chloritized pyroxene with or without plagioclase. The average grain size is between 10 and 20 mm. but pyroxene and feldspar may attain lengths of as much as 40 mm. and 50 mm. respectively. A little magnetite is present in places. The feldspar in the gabbroic pegmatite is usually anhedral and interstitial to the prismatic pyroxene. This variety of pegmatite is readily distinguished from the Ventures Gabbro, but in outcrops in which the feldspar has a lathy habit and the texture is subophitic, the pegmatitic gabbro cannot be differentiated from the Ventures Gabbro.

The top of the Upper Green Pyroxenite is characterized by a high concentration of disseminated magnetite. In many places the pyroxenite itself is strongly foliated or lineated immediately below the Foliated Gabbro.

Seen under the microscope, the textures of the Upper and Lower Green Pyroxenites are essentially similar. Near the base of the Upper Green Pyroxenite however, the uralitization of the pyroxene proceeds more commonly along anastomosing veinlets that follow the intergrain boundaries and also cut across the grains. These veinlets connect interstitial areas of fine scaly chlorite and fibrous amphibole in which magnetite is noticeably concentrated in irregular aggregates or curving trains. There can be little doubt that these patches are the equivalent of the interstitial serpentine in the Black Pyroxenite and of similar fibrous actinolitic aggregates occurring in the upper part of the Lower Green Pyroxenite. Near the top of the Upper Green Pyroxenite the clinopyroxene and consequently the crystalloblastic actinolite have a conspicuous elongated prismatic habit. Sausseritized plagioclase, where present, is always anhedral and interstitial to the mafic minerals.

The mineralogical composition and relative abundance of constituents in the two Green Pyroxenites are also much the same. The only significant difference between the two rock types is that plagioclase is perhaps more commonly seen in the Upper Green Pyroxenite and, near the top of this same unit, magnetite is more abundant than in the Lower Green Pyroxenite. Moreover, the magnetite is not so much altered to sphene and/or leucoxene as it is in the Lower Green Pyroxenite.

The combination of fine grain and fibrous habit do not permit the determination of the optical properties of the amphibole by means of the universal stage. The optical properties of the clinopyroxene are as follows:

$2V_z$ = 51.2° (Average of 16 determinations)
Standard deviation: 1.8°

$Z \wedge c$ = 41.2° (Average of 16 determinations)
Standard deviation: 1.3°

e) Transitional Pyroxenites

The contacts between adjacent units of the pyroxenite body are almost invariably gradational. In some areas, over distances of as much as 100 feet across strike, the rock cannot be assigned with any certainty to either the Black or Green Pyroxenites. Microscopic investigation confirms the presence of these transitional pyroxenites. In mineral composition, relative abundance of constituents and texture they are intermediate in character to the main units between which they intervene.

A further complication arises from the hydrothermal (?) alteration of Black Pyroxenite alongside fractures which may be megascopically visible or detectable only under the microscope. The resulting rock types are amphibolitized to such an extent that they may be impossible to classify with any certainty in the field. Where the alteration has been particularly intense, even microscopic study fails to reveal the origin of the rock. In general, only the presence of serpentinite or greyish-white talc-serpentine bodies in the immediate vicinity of the altered rock will yield a clue as to its former composition. The Black Pyroxenite near the Levy-Daubrée township line has been affected in this way more so than elsewhere in the area.

The differences between typical Black and Green Pyroxenites are shown in Table 1.

f) The Foliated Gabbro

The Foliated Gabbro extends for only a short distance into the map area before pinching out. The composition, texture and structure of the gabbro and its relationships to the adjacent sill members are best observed in the southwest quarter of Levy township.

The Upper Green Pyroxenite usually grades by increase of feldspar into the Foliated Gabbro except where pegmatite intervenes between the two rock types. In a few localities, however, the contact between the pyroxenite and the gabbro is sharp.

Table 1

Black Pyroxenite	Green (Upper and Lower) Pyroxenite
1. Texture generally xenomorphic granular.	1. Texture generally hypidiomorphic granular.
2. Pyroxene grains mostly stumpy and rounded.	2. Pyroxene grains tend to be elongated.
3. Pyroxene exceeds 80% by volume.	3. Pyroxene less than 70%.
4. Colourless amphibole (tremolite?), less than 15%.	4. Pale blue-green amphibole (actinolite?) in excess of 15%.
5. Absence of sphene and/or leucoxene around opaque ore (magnetite).	5. Opaque ore (iron-titanium oxide) partly or completely altered to sphene and/or leucoxene.
6. Serpentine present.	6. Serpentine absent.
7. Feldspar absent.	7. Occasionally feldspathic.
8. No gabbroic pegmatites.	8. Gabbroic pegmatites common.
9. Little or no uralitization of pyroxene except along fractures.	9. Extensive uralitization of pyroxene.

As its name implies, the most characteristic feature of the Foliated Gabbro is the very conspicuous and persistent primary foliation, defined largely by the amphibole prisms and to a lesser extent by the plagioclase. The dip and strike of the foliation approximate the dip and strike of the sill, although locally there may be considerable divergence. A rhythmic segregation banding was noticed in one small group of outcrops on the Opemiska Copper Mines property.

The Foliated Gabbro is a speckled, medium-grained rock in which the original plagioclase and pyroxene have been partly or completely altered to low-grade metamorphic sausseritized albite and amphibole respectively. A small quantity of unaltered magnetite is usually present.

As seen in thin section the constituent minerals of the Foliated Gabbro are albite, 40% to 70%; amphibole, 20% to 35%; pyroxene relics (where present), as much as 8%; epidote, 5% to 20%; iron-titanium minerals (magnetite, ilmenite, sphene, leucoxene), not more than 5%. Traces of chlorite, sericite and apatite are present in a few specimens. Brown hornblende was observed in only one thin section from immediately above the Upper Green Pyroxenite.

The dominant textural feature of the Foliated Gabbro is the conspicuous subparallel alignment of the elongated amphibole prisms. Evidently the original pyroxene (now amphibole) in the rock crystallized first and was followed by plagioclase. Although many of the plagioclase grains are lathy and locally intergrown with the amphibole in subophitic fashion, the shape of the plagioclase grains is determined to a great extent by the interstices among the amphibole prisms.

Where it is not completely obscured by dense sausserite and where the composition can therefore be determined, the plagioclase is albitic in composition. In some sections the rims of the plagioclase are clear albite whereas the formerly more calcic cores are crowded with epidote (clinozoisite) granules. In addition to sausserite some albite is also replaced by scattered scales, fibres or veinlets of amphibole and chlorite.

In the Foliated Gabbro, as in the quartz metagabbro, the amphibole occurs in two very distinct habits. The first, and by far the most abundant type, forms the conspicuous elongated prisms which are clearly pseudomorphic after pyroxene. Relics of the pyroxene still occur in the amphibole of some sections. The second type of amphibole occurs as fine-grained scaly aggregates in the interstices of the plagioclase laths. Its origin in unknown. The pleochroic scheme of the amphibole is

X = Pale brown to buff
Y = Green
Z = Blue green

Z > Y > X

Although the colours are of the same hue as in the amphibole (actinolite) from the Green Pyroxenites, the shades are distinctly darker.

The remaining minerals in the Foliated Gabbro are identical to those in the other basic rocks in the area.

g) The Ventures Gabbro

A few small sills of Green Pyroxenite occur in the volcanic rocks overlying the ultrabasic complex, but within the complex itself the Ventures Gabbro is the highest stratigraphic unit. Although it is approximately 1200 feet thick on the township median line, the gabbro pinches out very rapidly to the northwest and is superseded laterally by rocks more closely resembling the coarse gabbro pegmatites of the Upper Green Pyroxenite. In the western half of range IV the Green Pyroxenite in many places is split up into a series of rather narrow sills separated by layers or tabular inclusions of volcanic rocks. Here, the pegmatitic gabbro bodies which are roughly conformable to the layering, show a definite tendency to occur at the top of these smaller pyroxenite sills.

The transition from Foliated Gabbro to Ventures Gabbro is extremely variable. It may be gradational in a particular locality, whereas only a short distance away a mixed zone of narrow, well-defined layers or lenses of Ventures Gabbro and

Foliated Gabbro, in sharp contact with one another, separates the two main bodies of gabbro. The gradational change from Foliated Gabbro to Ventures Gabbro is marked by increasing randomness in the orientation of the feldspar and also by an increase in the overall grain size of the rock, leading ultimately to the typical coarse-grained, diabasic Ventures Gabbro. The transition may take place within a distance of 12 inches or less, but more commonly, the zone ranges in width from a few to as much as 50 feet.

Because of the coarse grain size of the Ventures Gabbro, any estimates of the abundance of the component minerals based on thin section study only are subject to appreciable error. It is necessary therefore that the following proportions be considered with this limitation in mind: plagioclase, 35% to 70%; amphibole, 20% to 45%; pyroxene relics, as much as 8% but extremely rare; titanic iron oxide, sphene, leucoxene, generally less than 5% but as much as 10% in some sections; epidote, as much as 12%; chlorite, where present, less than 5%. A little quartz was noticed in two sections and hornblende in one only. Traces of carbonate, sericite, pyrite and apatite are present in most sections.

Although in hand specimen the Ventures Gabbro seems to have a uniform subophitic texture, microscopic study reveals noticeable textural variations in samples from different parts of the sill. In the Foliated Gabbro the crystallization of pyroxene generally preceded that of the plagioclase. In contrast, in the Ventures

Gabbro, these two minerals crystallized more or less contemporaneously although some of the pyroxene only crystallized after the plagioclase had solidified. The only exceptions were noticed in samples from the top and bottom of the sill. In the section from the base of the Ventures Gabbro, immediately above the Foliated Gabbro, the texture is hypidiomorphic granular. Except for a few lathy crystals, most of the plagioclase grains are subhedral equidimensional and have mutually interferent boundaries with amphibole where the two minerals are in contact. The massive amphibole occurs as stumpy, subhedral to anhedral prisms and is nowhere interstitial to the plagioclase. The texture of samples from the top of the Ventures Gabbro is essentially similar. The bulk of the rocks from the Ventures Gabbro, however, ranges in texture from imperfectly subophitic to intergranular, or hypidiomorphic granular and, in many sections elements of all three of these textures may be observed. Some of the massive amphibole forms large irregular anhedral grains elongated parallel to the c-axis. During the final stages of growth of the pyroxene crystals they were hemmed in by adjacent plagioclase grains which interfered with their unrestricted expansion and consequently the pyroxene, later pseudomorphically replaced by the amphibole, forms irregular prisms. The remainder of the amphibole is either interstitial to the plagioclase laths or else partly encloses them in subophitic fashion. The fine-grained scaly or fibrous amphibole aggregates are always interstitial to the plagioclase. Their original composition is not known. In hand specimen these angular, intergranular (intersertal?) patches help to emphasize the diabasic appearance of the Ventures Gabbro.

The constituent minerals of the Ventures Gabbro and their optical properties are similar to those in the Foliated Gabbro.

The Opémisca Batholith

The Opémisca Batholith is one of several large intrusive masses extending eastwards from Michwacho lake to Lake Chibougamau. The batholith is elliptical in outline and measures 15 miles in length and 7 miles in width. The axis of elongation is parallel, or nearly so, to the regional trend of the greenstone belts flanking it on either side.

No detailed or systematic field study was made of that part of the batholith lying outside the northwest quarter of Levy township. Owing to the scarcity of outcrop in the map area, the nature of the contact between the batholith and the surrounding rocks is not well known. It appears to be relatively smooth and even, with few, if any, apophyses extending into the country rock. However, Tolman (1932, p. 87) reports that along the eastern edge of the intrusive the contact is much more irregular owing to the presence of a number of apophyses penetrating parallel or nearly parallel to the structure of the greenstones.

The intrusion consists of an extensive core of hornblende adamellite which is markedly uniform in texture and composition. The adamellite grades by decrease in quartz into a marginal zone composed largely of monzonite and rarely granodiorite. A fringe of hybrid or contaminated rocks, considerably darker than the typical monzonite and tending towards diorite in composition, has formed along the rim of the batholith and also in and around xenoliths of country rock enclosed in it.

The exact width of the monzonitic rim is not known. During the mapping of the batholith the quartz content was estimated visually in order to differentiate the adamellite (more than 10% quartz) from the monzonite (less than 10% quartz). The estimates proved to be neither precise nor accurate and were noticeably influenced by prevailing weather conditions and the direction of traverse across the batholith. Conflicting results were also obtained on the same outcrop or hand specimen when the estimates were made by different observers. One of the main factors influencing the accuracy of the visual estimates was the very small grain size of the quartz in the peripheral zones of the batholith. Subsequent microscopic study revealed that the quartz is intensely granulated and intergrown with feldspar. The intergrowth is so fine in grain that the component minerals cannot be differentiated with a hand lens and consequently, much of the rock that was mapped as monzonite does in fact contain sufficient quartz to be classified as adamellite.

Within the map area a few small monzonitic dykes, none of which exceeds 10 feet in width, intrude the country rocks. They all occur within 2000 feet of the main intrusive mass but farther south, on the Opemiska Copper Mines property in southwest Levy township, the Black Pyroxenite is pierced by small satellitic stocks of monzonite at least 7000 feet away from the batholith.

Locally narrow, medium- to coarse-grained quartz-feldspar veins cut the adamellite or monzonite but, considering the size of the batholith, it is singularly free of pegmatitic phases. More common, but still rare, are whitish to pinkish veins or dykes of fine- to medium-grained sugary aplite and veinlets of pink feldspar. The aplites generally average about 2 to 3 inches in width although in one outcrop dykes measuring as much as 3 feet across were seen. Inclusions are rather uncommon in the central part of the intrusive but become more plentiful and also larger towards the margin. They range in size from xenoliths several thousand feet across, to mere schlieren and xenocrystic hornblende or biotite.

a. Adamellite

Typically, the adamellite is a mottled pink and white, medium-grained granular rock composed of plagioclase, quartz, potash feldspar and minor hornblende. A little yellowish-green epidote is commonly present. The mottling is caused by a slight and irregular pink hematite stain along the cleavage planes and intergrain boundaries of the feldspar. The average grain size ranges from 1 to 2 mm. A most distinctive feature of the adamellite is the presence of large microcline phenocrysts (porphyroblasts?) in which are poikilitically enclosed numerous smaller plagioclase laths. In some specimens the microcline crystals attain a length of 2.5 cm. and a width of 1.2 cm. but in general, they do not exceed 1 cm. in length. Despite their size, these microcline megacrysts are not at all conspicuous in hand specimen because they are almost invariably crowded with smaller plagioclase crystals. Only where the microcline has broken cleanly along a cleavage plane is it readily seen.

Typical porphyritic phases of the adamellite with distinct or prominent phenocrysts are rare. Where noticed, the phenocrysts in these consist of pink or white euhedral to subhedral potash feldspar crystals, devoid of any inclusions, and measuring as much as 3.5 cm. in length and 2.5 cm. in width.

In thin section, the adamellite is seen to be a hypidiomorphic granular rock composed essentially of plagioclase, 30% to 50%; quartz, 10% to 35%; perthitic microcline, 20% to 30%; and hornblende, generally less than 5%. Accessory minerals commonly present are sphene, myrmekite, opaque iron ore and apatite. Secondary epidote (pistacite) and sausserite have formed at the expense of plagioclase whereas chlorite has replaced hornblende to some extent in all sections.

Xenomorphic to idiomorphic plagioclase, ranging in composition from albite to oligoclase, is the most abundant constituent of the adamellite. The grains average about 1 1/2 mm. in diameter, but smaller euhedral to anhedral crystals are enclosed poikilitically in microcline and, more rarely, in hornblende. Multiple lamellar twinning according to the Albite law is prevalent, but in some sections a few broad, simple Albite-Carlsbad twins are found. Slight to moderate sausseritization of the plagioclase is characteristic. In some grains, zoning is defined by a sausseritized plagioclase core and a clear rim of albite. In others, narrow zones of clear and sausseritized plagioclase alternate. Less commonly, the entire plagioclase grain is sausseritized. Most of the plagioclase grains show evidence of strain by their wandering extinction and, in places, by bent twin lamellae. The small crystals of plagioclase poikilitically enclosed in some hornblende grains would imply that the plagioclase was the first of the two minerals to have started crystallizing. Moreover, the continued crystallization of plagioclase after the hornblende had solidified is evidenced elsewhere by the abutment of plagioclase laths against hornblende grains.

The hornblende shows considerable variation in its crystal shape. In most samples it occurs as well formed euhedral to subhedral, stubby to elongated prisms. In others, the grains tend to be xenomorphic and the prism faces are absent or only poorly developed. The hornblende is pleochroic from blue green (Z) to green (Y) and pale brown (X) and, in general, the grains are notably smaller in size than the felsic minerals. In all thin sections studied, the hornblende is replaced to some extent by green pleochroic chlorite. In certain sections the close association of xenomorphic hornblende, pistacite, opaque ore and sphene in irregular aggregates may represent the remains of former basic inclusions.

The bulk of the microcline present in the adamellite occurs as crystals which are considerably larger than the surrounding minerals. Individuals measuring as much as 25 mm. in length and 12 mm. in width were seen in the field, but these are exceptional. The average length of the microcline is probably less than 10 mm. It is not valid to generalize from the small number of sections studied, but it does appear as if the microcline grains from samples collected close to the border of the batholith are distinctly phenocrystic. They form rudely subhedral to euhedral crystals bounded by relatively smooth unbroken surfaces against which the surrounding plagioclase grains abut sharply. In contrast, in sections from the inner part of the batholith, the microcline grains, although as large, if not larger than those from nearer the margin, are anhedral and have highly irregular borders. Here, the microcline evidently continued to crystallize long after the plagioclase had ceased to do so. In the final stages of growth the unhindered expansion of the microcline megacrysts was impeded by the surrounding crystalline aggregate and, consequently, the outer portions of the microcline grains crystallized in the interstices of the plagioclase. The plagioclase laths are not only partly enveloped by the microcline; many have also been extensively corroded. The microcline, which is almost invariably perthitic, contains only a slight dusting of secondary alteration products. Generally, the albitic element in the perthite occurs as tiny parallel stringers or blebs which, in some grains, have coalesced to form irregular patches or anastomozing veinlets. A characteristic feature of many of the microcline crystals, especially the larger ones, are the poikilitic inclusions of tiny plagioclase tablets and, more rarely, hornblende and sphene. In some microcline grains these inclusions are haphazardly arranged, whereas in others they lie within and with their long axes parallel to definite zones or crystallographic directions. Where a sufficiently large number of such inclusions are present, they may define a distinct trapezoidal outline. The writer considers this indisputable evidence that the microcline crystals are not porphyroblasts formed by metasomatism but that they crystallized directly from a magmatic melt. Apparently, the growing microcline phenocryst exerted sufficient force on small objects in its path to rotate them into a position where they lay with their long axes parallel to the crystal faces of the microcline before it enveloped them. Reasoning along entirely different lines, Tolman (1932, p. 94) came to the same conclusion regarding the origin of the microcline. Most microcline has an undulose extinction ranging from slight to strong. Occasional grains extinguish quite sharply, however.

Quartz typically occurs in anhedral interstitial grains or mosaics. Where it has not been granulated it has about the same size as the plagioclase. Towards the margin of the batholith, however, the rocks show evidence of considerable crushing and the feldspars are surrounded by intensely granulated and recrystallized mosaics of quartz in which the grains range in size from less than 0.01 mm. to as much as 0.2 mm. The granulated quartz is intergrown with a little potash feldspar and plagioclase and all of them show pronounced strain shadows. Quartz was one of the last minerals to crystallize and in many places it corrodes and replaces the earlier formed plagioclase. Its relationship to microcline, however, is not so clear. In most thin sections the contacts between the two minerals offer inconclusive evidence as to the relative age of each. In a few sections quartz is seen to have replaced the microcline, whereas in other sections the reverse is true. It would appear therefore, that the two minerals crystallized more or less contemporaneously throughout most of the rock body. Local fluctuations may have resulted in either the one or the other solidifying first to give rise to the anomalous relationships observed.

Myrmekite in characteristic fashion occurs most commonly as partial fringes or protuberances at the contact of plagioclase and microcline. Locally, within the plane of the section, it can be seen to be completely surrounded by either plagioclase or microcline. Most typically, the feldspar component of the myrmekite outgrowth consists of one individual only. In some specimens, especially those that have been deformed, the myrmekite occurs as granular aggregates of xenomorphic grains between the larger remnant microcline and plagioclase crystals, and also within the finely crushed intergrowth of quartz and feldspar. The myrmekite does not necessarily form only at the expense of the potash feldspar. Occasionally, small euhedral tablets of polysynthetically twinned plagioclase, poikilitically enclosed in the microcline phenocrysts, and also larger plagioclase grains elsewhere in the section are seen to be penetrated by irregular wormy growths of quartz.

Epidote shows a considerable variation in colour, grain size and habit. Most of it is present as minute granules of turbid clinozoisite which makes up the bulk of the sausserite in the plagioclase. Where these tiny grains of clinozoisite have aggregated and recrystallized, large, clear xenoblastic crystals of epidote (pistacite), ranging from colourless to pale yellow, have resulted. Epidote is also found in large clusters accompanied by hornblende with or without chlorite, opaque ore and, less commonly, sphene. These aggregates probably represent the remains of basic inclusions in the adamellite.

Sphene is a universal accessory and, characteristically, occurs as wedge-shaped euhedrons.

b. Monzonite

The adamellite grades into monzonite by a decrease in its quartz content to less than 10%. In other respects, the two rock types are essentially similar except along the margin of the batholith where the monzonite has been contaminated by the country rock. In many places along the southern border of the intrusive the monzonite shows a very distinct foliation parallel, or nearly so, to the contact. Although varying in composition from one locality to the next, the contaminated monzonite differs from the normal monzonite and adamellite chiefly in its larger content of plagioclase, hornblende, chlorite, epidote and locally myrmekite. Quartz and potash feldspar are correspondingly less plentiful and consequently these marginal rocks are more closely related to the diorite and granodiorite families rather than to the monzonite-adamellite suite.

c. Hybrid Rocks

Several large but poorly exposed xenoliths of hybrid rock are enclosed within the batholith near its southern margin. Because of the great variation in mineral composition within and among these bodies, no detailed description or classification will be given.

All are characterized by a relative abundance of dark minerals - mostly amphibole and biotite and, less commonly, pyroxene. They range from reconstituted but chemically little altered basic rocks composed essentially of epidote, plagioclase, hornblende and accessory white mica to dioritic varieties which have resulted from a more extensive reaction between the magma and the inclusion. In addition to plagioclase and amphibole, these dioritic rocks also contain a little potash feldspar and myrmekite. Some pyroxene-biotite diorites seem to have had a rather complex history. The pyroxene is sieved extensively with plagioclase and, in its present state, is obviously not a primary constituent of the inclusion. It may have originated as a contact metamorphic mineral before or after being included in the adamellite. The pyroxene was subsequently partly replaced by a pale green amphibole. Still later, both pyroxene and amphibole were replaced extensively by brown biotite which locally forms coronas around pyroxene grains. The plagioclase in these pyroxene-biotite diorites is a well twinned, lathy albitic (?) variety. A little potash feldspar is present, but most of it seems to have been replaced by myrmekite. A rather unusual type of alteration noticed in these rocks was the replacement of pyroxene by scaly masses of talc, a feature also commented on by Tolman (1932, p. 98). The talc in turn is partly converted to a very pale green biotite.

d. Chemical Composition of the Opémisca Batholith and Associated Rocks.

The variation in the composition of the Opémisca Batholith and the distribution of certain elements within it were investigated by means of chemical analyses of 48 samples. Most of these were drawn from that part of the batholith lying outside the map area and of which no detailed or systematic field study was made. Time permitted only a cursory examination and description of the particular outcrop from which a sample was taken.

The area underlain by the intrusive was divided into 16 parts, approximately equal in size. From each of these subdividions 3 random samples of the granitic* rock were collected. In addition to these, a single sample of one of the rare aplite veins was also selected for analysis. To determine in what way or to what degree the chemical composition of inclusions in the batholith had been modified, three samples of hybrid rock from the xenoliths near the southern margin of the intrusive were also analysed.

The concentration of the following oxides and elements was determined: Ag, B, Ba, Be, Bi, Ca, Co, Cu, CO_2, Fe, H_2O, K_2O, Li_2O, Mo, Mn, Na_2O, Ni, P_2O_5, Pb, S, Sn, Sr, Ti, V, W and Zn. In 17 of the samples the additional oxides required to complete a standard rock analysis (SiO_2, Al_2O_3, Fe_2O_3, FeO, MgO) plus the elements F and Cl were also determined.

The 17 complete chemical analyses are shown in table 2. With the exception of NL-5 and NL-76, the specimens listed reflect the range in composition from the silica-rich adamellite in the interior of the batholith to the monzonite and more basic contaminated granodioritic and dioritic rocks along and near the margin of the intrusive. Specimen NL-5 is a porphyritic greyish-

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*Granite is used here and in the pages following in a broad sense to include adamellite, monzonite and their contaminated equivalents, that is, all the intrusive rocks making up the batholith proper. It does not include the hybrid xenolithic rocks.

pink diorite containing about 15% to 20% amphibole and is quite unlike the other rock types of the intrusive. It is considered to be part of an inclusion. Specimen NL-76 was found to have undergone secondary silicification and the oxide percentages shown should be considered to be spurious.

Table ~~3~~ 2 shows the concentration of most of the oxides and elements listed above in each of the 52 specimens collected for analyses. Ag, B, Be, Bi and Sn were not detected in any of the samples and have been omitted from the table.

Sample localities are shown on map 2.

The most characteristic feature of the batholith is its high soda content (average 6.13% Na_2O) which is more than double the potash content (average 3.02% K_2O). Although K_2O, in a very general and poorly defined way, tends to decrease with increasing Na_2O there is no noticeable regularity in the distribution pattern of either. SiO_2, as was expected, decreases progressively from the core of the intrusive to the margin, whereas Al_2O_3, CaO, MgO, Fe_2O_3 and FeO all increase. This is no doubt largely due to the contamination and desilication of the granitic magma by the more basic country rock. It seems reasonable to assume though that assimilation was not the only mechanism leading to this diversity is chemical composition. A similar variation could also result from the normal processes of differentiation as the magma solidified from the outside inward.

*Table 2

	GR-1	GR-3	GR-5	NL-5	NL-14	NL-39	NL-57	NL-59	NL-62
SiO_2	68.20	69.40	62.75	64.69	67.86	65.30	68.40	66.84	66.05
TiO_2	0.22	0.12	0.58	0.62	0.18	0.20	0.12	0.28	0.33
Al_2O_3	16.30	15.74	16.46	17.10	16.41	17.56	15.87	16.80	16.94
Fe_2O_3	1.30	1.08	1.77	1.93	1.14	1.47	1.25	1.28	1.38
FeO	0.58	0.56	2.30	1.12	0.67	0.85	0.57	0.86	1.00
MnO	0.01	0.02	0.07	0.05	0.03	0.03	0.02	0.04	0.04
MgO	0.96	0.79	2.80	1.23	1.00	0.98	0.91	1.12	1.33
CaO	2.45	1.93	2.74	3.53	2.09	2.66	1.76	2.27	2.56
Na_2O	5.99	6.01	5.96	5.84	6.18	6.57	6.28	6.66	6.63
K_2O	2.84	2.94	3.44	2.52	2.93	2.96	3.07	2.80	2.78
**P_2O_5	----	----	----	----	----	----	----	----	----
H_2O+	0.40	0.46	0.97	0.65	0.57	0.33	0.54	0.45	0.50
H_2O-	0.02	0.01	0.03	0.03	0.01	0.05	0.01	0.01	0.02
CO_2	0.01	0.01	0.03	0.03	0.04	0.03	0.05	0.03	0.02
F	0.11	0.09	0.11	0.14	0.11	0.11	0.11	0.12	0.11
Cl	0.02	0.02	0.12	0.03	0.02	0.03	0.02	0.01	0.03
	99.41	99.18	100.13	99.51	99.24	99.13	98.98	99.57	99.72

	NL-63	NL-66	NL-68	NL-72	NL-76	NL-77	NL-79	NL-82
SiO_2	70.31	68.61	67.94	67.70	68.87	59.98	63.48	59.90
TiO_2	0.12	0.18	0.10	0.20	0.22	0.53	0.50	0.52
Al_2O_3	15.75	16.23	16.34	16.37	15.90	16.80	17.38	16.16
Fe_2O_3	1.13	1.22	1.30	1.27	1.25	1.98	1.80	1.92
FeO	0.36	0.50	0.49	0.53	0.53	2.22	1.22	2.34
MnO	0.03	0.03	0.04	0.04	0.05	0.06	0.07	0.06
MgO	0.22	0.97	1.04	1.08	0.56	3.22	1.09	3.71
CaO	1.16	1.86	1.84	2.13	2.14	4.36	3.17	4.46
Na_2O	6.16	6.00	6.05	6.03	5.61	5.72	5.74	5.45
K_2O	3.40	3.22	3.04	3.02	3.14	2.89	3.18	3.34
**P_2O_5	----	----	----	----	----	----	----	----
H_2O+	0.53	0.47	0.53	0.44	0.32	0.77	0.68	0.89
H_2O-	0.02	0.01	0.04	0.02	0.03	0.01	0.01	0.02
CO_2	0.02	0.00	0.00	0.00	0.00	0.02	0.02	0.03
F	0.08	0.11	0.10	0.12	0.10	0.13	0.12	0.14
Cl	0.02	0.02	0.01	0.02	0.01	0.04	0.07	0.04
	99.31	99.43	98.86	98.97	98.73	98.73	98.53	98.98

* All analyses by Quebec Department of Natural Resources

** P_2O_5 not determined

[1]Table 3

		GR-1	GR-3	GR-4	GR-5	NL-2	NL-5	NL-7	NL-8
Na_2O	%	5.99	6.01	----	5.96	6.03	5.84	3.65	5.90
K_2O	%	2.84	2.94	----	3.44	3.20	2.52	5.08	2.78
Li_2O	%	0.002	0.00	----	0.00	0.006	0.003	0.00	0.003
Ca	%	1.75	1.38	----	1.96	3.4	2.52	0.46	1.9
Fe	%	1.36	1.20	----	3.03	3.7	2.22	0.44	1.3
Ti	%	0.13	0.07	----	0.35	0.33	0.37	0.025	0.07
P_2O_5	%	[2]----	----	----	----	0.14	----	0.01	----
S	%	0.009	0.009	----	0.012	0.055	0.006	0.004	----
H_2O+	%	0.40	0.46	----	0.97	1.50	0.65	0.03	----
H_2O-	%	0.02	0.01	----	0.03	0.08	0.03	0.01	----
Ba	ppm	1060	1025	----	990	750	1015	280	1330
Co	ppm	3.8	2.5	3.1	2.5	11.3	3.8	3.1	4.4
Cu	ppm	2.5	[4]tr	8.0	33.0	63.0	2.5	tr	tr
Mo	ppm	[3]nd	2	4	2	2	2	nd	3
Mn	ppm	110	170	----	520	655	385	120	397
Ni	ppm	12.5]	8.8	8.8	37.5	25.0	11.3	7.5	10.0
Pb	ppm	15	15	5	15	30	12.5	15	nd
Sr	ppm	1030	1050	----	680	900	1115	285	1030
V	ppm	38	44	----	95	82	70	nd	24
W	ppm	nd	nd	nd	4	nd	nd	nd	nd
Zn	ppm	6.3	3.8	10.0	10.0	32.5	16.3	6.0	7.5

1 All analyses by the Department of Natural Resources, Quebec, except for Co, Cu, Mo, Ni, Pb, W and Zn, which were determined by the writer. The techniques used are described by Gilbert(1959) and in Technical Communications 14, 15, 28 and 37 of the Geochemical Prospecting Research Centre, Imperial College of Science, London.
2 A dashed line denotes element not determined.
3 nd indicates element was sought but not detected.
4 tr denotes detectable quantities of Cu, but less than 1.5 ppm.

Table 3 (continued)

		NL-9	NL-12	NL-14	NL-15	NL-16	NL-18	NL-23	NL-27
Na_2O	%	5.84	5.65	6.18	6.15	6.39	6.08	6.27	5.83
K_2O	%	2.83	3.26	2.93	2.86	2.86	3.06	2.83	3.34
Li_2O	%	0.003	0.00	0.00	0.003	0.004	0.002	0.001	0.001
Ca	%	1.6	1.3	1.49	1.8	1.6	1.5	1.8	1.5
Fe	%	0.99	0.89	1.32	1.0	1.0	1.0	1.4	1.2
Ti	%	0.075	0.07	0.11	0.06	0.09	0.08	0.17	0.15
P_2O_5	%	----	0.015	----	0.04	0.025	0.04	0.04	0.03
S	%	----	0.023	0.001	0.023	0.027	0.023	0.029	0.024
H_2O+	%	----	0.51	0.57	0.30	0.40	0.50	0.45	0.52
H_2O-	%	----	0.07	0.01	0.06	0.06	0.08	0.07	0.07
CO_2	%	----	0.02	0.04	0.00	0.01	0.00	0.03	0.05
Ba	ppm	1210	1080	1235	1335	1235	1175	1190	990
Co	ppm	5.0	2.5	3.8	2.5	5.0	3.1	1.3	3.8
Cu	ppm	4.0	4.0	2.5	2.5	3.5	10.0	tr	2.5
Mo	ppm	4	3	1	4	4	1	2	2
Mn	ppm	200	225	205	170	280	300	350	420
Ni	ppm	10.0	12.5	16.3	10.0	10.0	10.0	15.0	8.8
Pb	ppm	5	5	12.5	15	5	15	nd	12.5
Sr	ppm	3300	740	940	940	790	840	850	830
V	ppm	41	41	42	41	43	41	42	43
W	ppm	nd	nd	nd	nd	nd	nd	nd	nd
Zn	ppm	15.0	12.5	6.0	12.5	10.0	6.0	7.5	15.0

Table 3 (continued)

		NL-29	NL-39	NL-40	NL-50	NL-51	NL-53	NL-54	NL-55
Na_2O	%	4.85	6.57	3.02	5.73	6.60	5.98	6.25	6.14
K_2O	%	2.13	2.96	2.51	3.77	2.70	2.87	2.82	2.86
Li_2O	%	0.007	0.00	0.005	0.00	0.003	0.002	0.002	0.003
Ca	%	5.4	1.90	5.3	2.1	2.1	1.7	1.9	1.6
Fe	%	5.8	1.69	5.2	1.9	1.5	1.1	1.1	0.93
Ti	%	0.34	0.12	0.34	0.20	0.14	0.05	0.088	0.14
P_2O_5	%	0.11	----	0.28	0.08	0.08	0.04	----	0.02
S	%	0.027	0.009	0.035	0.034	0.027	0.023	----	0.027
H_2O+	%	1.51	0.33	1.44	0.58	0.30	0.45	----	0.48
H_2O-	%	0.04	0.05	0.04	0.08	0.06	0.09	----	0.07
CO_2	%	0.14	0.03	0.04	0.00	0.03	0.02	----	0.01
Ba	ppm	505	1565	485	1460	1190	1470	1295	1090
Co	ppm	6.3	3.1	21.3	3.1	3.1	3.8	3.8	3.8
Cu	ppm	27.5	2.5	93	5.5	3.0	3.5	2.5	5.0
Mo	ppm	1	1	2	2	2	3	4	nd
Mn	ppm	780	235	1450	600	410	320	305	365
Ni	ppm	16.3	10.0	18.8	16.3	11.3	10.0	8.8	10.0
Pb	ppm	27.5	17.5	10.0	5.0	20.0	25.0	12.5	12.5
Sr	ppm	930	1700	750	1160	1350	880	980	790
V	ppm	195	35	179	47	47	47	41	51
W	ppm	nd	nd	nd	nd	nd	nd	4	nd
Zn	ppm	14.0	7.5	22.0	6.3	5.0	10.0	8.0	7.5

Table 3 (continued)

		NL-56	NL-57	NL-58	NL-59	NL-60	NL-61	NL-62	NL-63
Na_2O	%	6.14	6.28	7.00	6.66	6.94	6.46	6.63	6.16
K_2O	%	3.13	3.07	2.75	2.80	2.59	3.26	2.78	3.40
Li_2O	%	0.002	0.00	0.002	0.00	0.00	0.00	0.00	0.00
Ca	%	1.2	1.26	1.7	1.62	1.4	2.5	1.83	0.83
Fe	%	0.91	1.32	2.0	1.57	1.3	2.1	1.75	1.07
Ti	%	0.10	0.07	0.10	0.17	0.175	0.205	0.20	0.07
P_2O_5	%	----	----	0.10	----	0.045	0.12	----	----
S	%	----	0.005	0.013	0.019	0.034	0.037	0.001	0.015
H_2O+	%	----	0.54	0.49	0.45	0.62	0.53	0.50	0.53
H_2O-	%	----	0.01	0.05	0.01	0.03	0.05	0.02	0.02
CO_2	%	----	0.05	0.02	0.03	0.02	0.01	0.02	0.02
Ba	ppm	1010	1285	----	1155	1175	1205	1150	1090
Co	ppm	2.5	----	3.8	3.1	5.0	5.0	3.8	2.5
Cu	ppm	3.0	5.0	2.5	1.5	1.5	2.5	tr	1.5
Mo	ppm	1	nd	3	3	1	2	3	3
Mn	ppm	240	175	----	280	495	420	285	235
Ni	ppm	12.5	15.0	10.0	12.5	10.0	12.5	8.8	15.0
Pb	ppm	nd	5.0	10.0	10.0	10.0	17.5	5.0	50.0
Sr	ppm	700	700	870	1030	880	1000	1350	600
V	ppm	46	36	47	45	41	46	50	38
W	ppm	nd	nd	nd	nd	nd	nd	nd	nd
Zn	ppm	12.5	12.5	5.0	7.5	17.5	5.0	5.0	17.5

Table 3 (continued)

		NL-64	NL-65	NL-66	NL-67	NL-68	NL-69	NL-70	NL-71
Na_2O	%	6.22	5.87	6.00	6.34	6.05	6.01	6.14	6.22
K_2O	%	2.92	3.27	3.22	2.80	3.04	3.00	2.84	3.00
Li_2O	%	0.005	0.002	0.00	0.002	0.00	0.006	0.003	0.005
Ca	%	1.5	1.4	1.33	2.0	1.31	1.6	1.9	1.4
Fe	%	0.82	0.97	1.24	1.2	1.29	1.2	1.1	1.2
Ti	%	0.083	0.13	0.11	0.22	0.06	0.20	0.14	0.17
P_2O_5	%	0.05	0.05	----	0.06	----	0.07	0.07	0.08
S	%	0.029	0.027	0.009	0.029	0.008	0.018	0.023	0.035
H_2O+	%	0.53	0.43	0.47	0.44	0.53	0.29	0.47	0.55
H_2O-	%	0.06	0.07	0.01	0.07	0.04	0.04	0.07	0.06
CO_2	%	0.02	0.02	0.00	0.02	0.00	0.03	0.04	0.03
Ba	ppm	980	1265	1160	1370	1145	1225	1300	1410
Co	ppm	3.1	3.1	3.8	7.5	3.1	3.1	3.8	5.0
Cu	ppm	2.5	5.0	3.0	2.5	1.0	2.5	2.5	2.5
Mo	ppm	1	1	4	3	4	5	3	5
Mn	ppm	330	470	250	420	325	440	310	340
Ni	ppm	8.8	10.0	10.0	10.0	16.3	8.8	8.8	17.5
Pb	ppm	5.0	nd	5.0	10.0	5.0	12.5	10.0	nd
Sr	ppm	800	760	940	1310	850	1210	1550	850
V	ppm	63	48	33	44	33	54	43	52
W	ppm	nd	nd	nd	nd	nd	nd	nd	nd
Zn	ppm	8.3	10.0	7.5	7.0	12.5	6.3	7.0	12.5

Table 3 (continued)

		NL-72	NL-73	NL-74	NL-75	NL-76	NL-77	NL-78	NL-79
Na_2O	%	6.03	6.12	6.14	5.81	5.61	5.72	6.11	5.74
K_2O	%	3.02	3.34	3.18	3.42	3.14	2.89	2.91	3.18
Li_2O	%	0.003	0.002	0.002	0.004	0.003	0.003	0.001	0.002
Ca	%	1.52	1.8	2.1	2.1	1.53	3.11	2.1	2.26
Fe	%	1.30	1.5	1.8	2.3	1.29	3.12	1.3	2.21
Ti	%	0.12	0.17	0.16	0.28	0.13	0.32	0.10	0.30
P_2O_5	%	----	0.10	0.11	----	----	----	0.09	----
S	%	0.009	0.032	0.035	----	0.007	0.012	0.031	0.038
H_2O+	%	0.44	0.41	0.43	----	0.32	0.77	0.34	0.68
H_2O-	%	0.02	0.06	0.06	----	0.03	0.01	0.05	0.01
CO_2	%	0.00	0.01	0.02	----	0.00	0.02	0.05	0.02
Ba	ppm	1225	1280	1225	970	870	1400	1225	1025
Co	ppm	5.0	2.5	5.0	3.8	5.0	5.0	2.5	7.5
Cu	ppm	12.5	3.5	7.5	tr	2.0	5.5	5.0	15.0
Mo	ppm	nd	2	2	3	6	2.5	nd	3
Mn	ppm	345	445	450	715	375	465	470	535
Ni	ppm	10.0	15.0	11.3	22.5	7.5	22.5	15.0	10.0
Pb	ppm	12.5	12.5	nd	7.5	15.0	5.0	12.5	17.5
Sr	ppm	1115	1400	1280	1000	930	1800	1400	1350
V	ppm	45	39	44	61	44	89	36	62
W	ppm	nd	nd	nd	nd	nd	nd	4	4
Zn	ppm	8.3	15.0	5.0	15.0	12.5	15.0	10.0	15.5

Table 3 (continued)

		NL-80	NL-81	NL-82	NL-83
Na_2O	%	5.93	5.59	5.45	6.85
K_2O	%	2.69	3.56	3.34	2.26
Li_2O	%	0.003	0.00	0.00	0.002
Ca	%	1.7	2.6	3.19	1.4
Fe	%	1.1	1.7	3.16	1.1
Ti	%	0.053	0.17	0.31	0.14
P_2O_5	%	----	0.07	----	0.11
S	%	----	0.035	0.013	0.024
H_2O+	%	----	0.56	0.89	0.69
H_2O-	%	----	0.04	0.02	0.05
CO_2	%	----	0.01	0.03	0.85
Ba	ppm	1200	1150	1255	1035
Co	ppm	5.0	5.0	2.5	7.5
Cu	ppm	5.0	2.5	5.0	10.0
Mo	ppm	2	2	16	3
Mn	ppm	495	510	510	300
Ni	ppm	8.8	10.0	21.3	16.3
Pb	ppm	15.0	12.5	5.0	nd
Sr	ppm	980	900	1250	690
V	ppm	18	57	89	46
W	ppm	nd	nd	4	nd
Zn	ppm	12.5	7.5	11.3	20.0

The analyses in tables 2 and 3 show that it is possible to outline within the batholith a core of distinctive chemical composition. On the map this core shows up as an elongated area, possibly elliptical in outline and offset slightly to the northeast of the centre of the intrusive. It may measure as much as 7 miles in length and 3 miles in width and its axes seem roughly parallel to those of the batholith. The position and composition of this core are inferred from the complete chemical analyses of samples GR-3, NL-57 and NL-63, but the partial analyses of NL-12, NL-64 and NL-65, also within the outlined area, seem to confirm these deductions. The most notable features of the core are: a silica content of more than 68%, less than 16% Al_2O_3, less than 1.5% Ca (or about 2% CaO), less than 1.4% Fe (or less than 1.3% Fe_2O_3 and 0.6% FeO respectively) and less than 1% MgO. Nowhere else in the batholith can all these conditions be satisfied.

Water is most plentiful in those rocks containing abundant hydrous minerals such as biotite and amphibole. Consequently, the highest water content is found in the contaminated granitic and hybrid rocks around the edges of the intrusive. This is also generally true for P_2O_5 but it must be emphasized that there is no direct correlation between P_2O_5 and water.

Compared to the major elements and oxides, most of the trace and minor elements appear to be very unsystematically distributed. Ti increases irregularly with increasing Fe and so does V with increasing Fe_2O_3 and FeO. There is no noticeable correlation between such pairs as K and Sr, K and Ba, Ca and Sr, and Fe^{++} and Mn. Cu and Zn have a fairly uniform concentration throughout the batholith. Specimens from the hybrid xenoliths and the contaminated granitic rocks along the southeastern border of the intrusive have the highest Cu content. Ni too is seemingly more abundant towards or in the marginal zone of the batholith rather than in the interior. Here, however, the Ni content of the xenoliths appears to be somewhat lower than that of the more mafic rich granitic rocks. Judge purely on a visual inspection of the data, the distribution of the remaining trace elements seems rather erratic.

Metamorphism

Although the entire pre-granitic sequence has been folded, faulted and metamorphosed, the mineral assemblage in many of the rock types did not reach equilibrium. This is especially noticeable in the pyroxenite members of the Opemiska Ultrabasic Complex where much original magmatic pyroxene co-exists with low grade metamorphic amphibole. The metamorphic minerals which are present in the pre-granitic rocks are characteristic of the quartz-albite-muscovite-chlorite and quartz-albite-epidote-biotite subfacies of Turner and Verhoogen's (1960, p. 533) greenschist facies.

Compared to the Presqu' Île Batholith 5 miles south, there is a singular absence of any collar or aureole of contact metamorphic rocks around the Opemisca Batholith. The contact between the monzonite and the country rock is nowhere exposed except in one outcrop about 1000 feet west of the south end of Knife lake. Here a dyke-like body of monzonite, about 200 feet in width, intrudes pyroxenites of the Opemiska Ultrabasic Complex. It is not known whether the monzonite is merely an apophysis extending from the batholith for some short distance into the pyroxenites or whether it actually is the outer margin of the batholith and the pyroxenite to the east of it, a xenolith. Even here, samples of Black Pyroxenite taken close to the contact of the monzonite and from inclusions within it have the same mineralogical composition as they do elsewhere in the area. The only exposure in which conclusive evidence of alteration of the country rock by the monzonite was seen is on the property of Canamisca Copper Mines Limited. Here, an outcrop of pyroxenite is cut by tiny leucocratic acid stringers and veinlets alongside which the pyroxenite has been feldspathized and converted to a dioritic-looking rock.

The inability of the Opemisca Batholith to raise the country rock immediately adjacent to a higher grade of metamorphism than the regional greenschist facies implies perhaps that by the time it had intruded to its present level it was already in a relatively cool and possibly dry state.

STRUCTURAL GEOLOGY

Regional Setting

In southwestern Quebec three irregular easterly trending greenstone belts are generally recognized (Dresser and Denis, 1944, p. 73). They extend from the Ontario border in the west to the Grenville Front in the east. The northern belt, also known as the Waswanipi-Chibougamau belt, lies very approximately along and to the south of the fiftieth parallel. It has been further subdivided into three smaller, subparallel, coalescing belts, separated by discontinuous bodies of granitic and minor basic rocks. The northernmost of these minor belts is known as the Mattagami-Waconichi belt. The map area is situated in the eastern section of this belt along the south limb of a major anticlinal fold. The Opémisca Batholith and the Chibougamau Intrusive Complex farther to the east occupy the core of this fold.

Attitude of the pre-granitic rocks

The volcanic and layered intrusive rocks form a steeply dipping conformable sequence. The strike, which is just about due west on the Daubrée-Levy township line, curves around gradually to the northwest in the Springer mountain area. Along the northern side of Springer mountain, where it slopes down towards

Springer creek, the strike of the volcanic rocks changes rather rapidly from northwest to north and then to northeast near the contact of the batholith.

The tops of the formations on Springer mountain face southwest. Unfortunately, the pillows in the lava have been much distorted and only one reliable top determination could be made. However, these beds continue southeastward into the southwest quarter of Levy township where the structure and attitude have been worked out in much greater detail and there can be no doubt about the validity of the interpretation. No reliable criteria could be obtained as to the attitude of the layered rocks west of Springer mountain. The general sequence is not much disturbed, and is known with reasonable certainty to within 7000 feet of the western boundary. Beyond this point the combination of deep sand, drift and swampy lowland obliterate almost all outcrop in range V and the structure can not be confidently interpreted from the meagre field data.

Schistosity

The coarser-grained rocks are usually massive except in the vicinity of shear zones where they have been converted to schists and semischists. In contrast, the fine-grained rocks are schistose almost without exception. The reasons for this have been discussed in some detail on page 12. Where both bedding and schistosity can be observed they are almost invariably parallel.

Folding

In the eastern half of range V the layered rocks show several large but rather gentle contortions or changes in strike. North of range line V, between Knife lake and the Lévy-Daubrée line, the strike apparently remains fairly constant although the mapping has outlined a few small contortions locally. Unfortunately, the absence of reliable marker beds in this heterogeneous sequence does not facilitate correlation across the sand covered gaps between the areas of outcrop.

The writer believes that the presence of Black Pyroxenite and serpentinite along the Levy-Daubrée township line, about 700 feet south of range line IV, and Green Pyroxenite in the extreme southwestern corner of the area results from several easterly plunging tight isoclinal folds. The estimated positions of the traces of the axial planes are shown on the map. The continuity of the Black Pyroxenite and serpentinite for several thousand feet to the southeast has been very clearly defined by a series of high magnetic anomalies. Unfortunately, the paucity of outcrop in this part of the area permits many alternative interpretations to be made. The final determination of the structure must await a more detailed knowledge of the geology in neighbouring northeast Daubrée township.

Faulting

Faulting is rarely exposed at surface. Because of the very nature of the crushed or sheared rocks in the faults or fault zones and their susceptibility to alteration, direct evidence of faulting is usually soon obliterated by erosion. Underground mapping at Opemiska Copper Mines and closely spaced diamond drilling on the Chiboug Copper property in southwest Levy township confirm that the rocks are much fractured and displaced along many more faults than are ever recognized at surface. Although these faults generally conform to more or less regular patterns, the different ages of the various sets of faults greatly complicate the structural picture. At present, two sets of faults have been recognized in the map area: a set striking northwest and a set striking north-northeast.

The prominent northwesterly fault cutting across the eastern part of the Coniska Copper Mines claim group has been intersected in several diamond drill holes. It is the extension of a well-defined fault on the property of Opemiska Copper Mines farther south. The strong shear zone between the acid and basic volcanics on the claims of Hoyle Mining Limited has already been described in some detail on page 22. It is also considered to belong to the northwesterly set of faults.

Faults of the north-northeasterly set in the southwestern corner of the map area are inferred from geophysical data, diamond drilling and the lack of continuity along strike of the various rock types. Here again the absence of any marker beds and the poorness of rock exposures make a correct interpretation of the structure extremely difficult, and the information shown on the map should be assessed with these limitations in mind.

ECONOMIC GEOLOGY

General Statement

The discovery and exploitation of substantial copper deposits in adjoining southwest Levy township stimulated considerable exploration in the map-area. Unfortunately, the greater part of northwest Levy is underlain by granitic rocks and the area considered suitable for exploration is therefore rather small - less than 5 square miles. Despite a great deal of activity during the past decade no economical deposits have been discovered to date. The most encouraging results so far have been obtained on the property of Coniska Copper Mines Limited, where pyrite, pyrrhotite, chalcopyrite and sphalerite mineralization have been intersected in diamond drill holes.

Tiny seams of brittle cross-fibre asbestos have been noticed in the serpentinites which also contain much disseminated magnetite. Neither mineral occurs in workable concentrations. Chromite is not known to be associated with ultrabasic rocks in the Opémisca region but the likelihood of its presence should not be disregarded.

An almost unlimited quantity of sand and gravel is available.

Description of Properties

At the time of mapping only three companies held claims under option in the northwest quarter of Levy township. The approximate location of these properties is shown on map No. 1.

Canamisca Copper Mines Limited

The company holds a block of 17 claims numbered: 33013 claims 4 and 5, 33017 claims 1 to 5, 33021 claims 1 to 5 and 33022 claims 1 to 5.

The property is underlain almost entirely by granitic rocks of the Opèmisca Batholith. The pre-granitic rocks occupy a long narrow strip along the southern boundary of the block. To the east of Grandpére Marais creek they are made up of acid and basic volcanic rocks, and to the west of the creek, mostly of the various pyroxenites and serpentinite of the Opemiska Ultrabasic Complex.

The property was idle during the summer of 1962 but 6 years previously the company completed more than 6000 feet of diamond drilling. Of the ten holes drilled, none encountered any significant concentration of sulphide minerals.

Coniska Copper Mines Limited

The property of Coniska Copper Mines Limited comprises 48 claims of which 8 are situated in the adjoining southwest quarter of Levy township. The 40 claims in the northwest quarter are numbered as follows: 33011 claims 1 to 5, 33013 claims 1 to 3, 33020 claims 1 to 5, 37913 claims 1 to 5, 37918 claims 2 and 3, 63787 claims 1 to 5, 63788 claims 1 to 5, 63789 claims 1 to 5, and 63790 claims 1 to 5.

Work on the property was discontinued in 1960, but prior to that the company had completed an extensive program of exploration involving geological mapping, magnetic, electromagnetic and resistivity surveys and diamond drilling. It is believed that upwards of 15,000 feet of diamond drilling had been done, but the true figure is not known. Vandals have emptied and destroyed many of the boxes of drill core left on the property and to date, the writer has been unable to obtain any records of drilling from the company.

Practically all the rock types described in the main body of this report occur on the property. Unfortunately, most of the outcrops lie buried under a deep cover of glacial sand. The eastern claims are underlain by the Opémisca Batholith in the north and by rocks of the Opemiska Ultrabasic Complex in the south. In the south central and southwestern parts, the epidiorite and quartz gabbro predominate. The remainder of the property is occupied by basaltic and gabbroic greenstones, rhyolite and minor ultrabasic rocks.

At least one of the major northwesterly faults is known to cross the eastern end of the claim group. It is paralleled by a set of quartz veins in the epidiorite-quartz gabbro complex and the metabasalt. Many quartz and carbonate veins have also been intersected in the diamond drill holes in this part of the property. The faults show up as zones of carbonate-chlorite schist in the basic rocks and as carbonate-chlorite-talc (?) schists in the ultrabasic rocks. Nowhere else in the area are these shear zones found on such a grand scale as in the eastern end of the Coniska claims lying in southwest Levy township. The rather scanty exposures on these two claims (37917 claims 4 and 5) offer few clues to the subsurface structure. The severity of shearing in the underlying bedrock only became known through diamond drilling. Although the currently available data are still too inadequate to permit interpretation of such a complex structure, and a final determination awaits more detailed investigation, the following statements are offered to provide a necessary geological setting for the discussion of the sulphide mineralization. The attitude of minor structures in the outcrops and the known trend of faulting in the surrounding region suggest that the area lies at the intersection of two sets of faults, one set striking northwest and the other northeast. Evidence was also found that a third set of faults striking east or east-northeast may be involved. Moreover, the area is also situated on the nose of a steeply plunging syncline, at a point where the trend of the axial plane was deflected from northeast to southeast by folding and the northwestern set of faults. The sulphide deposits are considered to be structurally associated with these northwesterly faults.

Generally speaking, the sulphide minerals occur in one of two ways:

a) As disseminated grains and also tiny stringers and blebs of pyrite, pyrrhotite and rarely chalcopyrite in virtually all rocks, but most of all in the metabasalt. These sulphides are not uncommon in massive rock where there is no evidence of shearing nearby.

b) As fracture fillings, veins and irregular replacements in smaller shears. These deposits appear to be in subsidiary or closely related structures of the major shear zones which are, for the most part, rather barren. The sulphides are largely pyrite, chalcopyrite, pyrrhotite and, to a lesser extent, sphalerite. In many places they are accompanied by one or more of the minerals quartz, carbonate, chlorite, axinite, jasper and epidote.

Concentrations of sulphide have been intersected in many of the diamond drill holes but none of these deposits has been large enough to be exploited economically.

Hoyle Mining Company Limited

The company has under option 20 claims of which only eight are located in northwest Levy township. They are numbered: 37035 claims 1 to 5 and 37034 claims 2 to 4.

The property was idle at the time of the writer's visit in 1962 but a few years previously the company had undertaken a program of geophysical exploration involving electromagnetic resistivity and self potential methods. This was followed up by diamond drilling to test anomalies outlined by the geophysical survey. No significant sulphide deposits were found.

The larger part of the eight claims in northwest Levy is occupied by volcanic rocks. The two westernmost claims are underlain by the Opemiska Ultrabasic Complex. The entire range of rock types in the complex, from Lower Green Pyroxenite to Ventures Gabbro, is present.

The structure appears to be fairly simple. The various formations strike northwest except in the northeastern part of the property where the strike curves around from northwest to north to northeast as the contact with the Opémisca Batholith is approached. A major shear zone, parallel to the strike of the beds, intervenes between the acid and basic volcanic rocks near the top of the volcanic succession. No significant sulphide deposits are known to be associated with it.

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