CANADA

DEPARTMENT OF MINES

HON. W. A. GORDON, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

GEOLOGICAL SURVEY

W. H. COLLINS, DIRECTOR

Summary Report, 1932, Part D

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OTTAWA

J. O. PATENAUDE, ACTING KING'S PRINTER

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MICHIPICOTEN RIVER AREA, ONTARIO

By A. F. Matheson

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INTRODUCTION

Michipicoten River quadrangle borders the northeast coast of Lake Superior. It is about 350 square miles in extent and lies between latitudes 47° 45′ and 48° and longitudes 84° 30′ and 85°.

The coast and principal streams were surveyed in 1927 by H. N. Spence of the Topographical Division of the Geological Survey. Further additions were made to the geographical mapping in 1928 by L. J. Weeks who also geologically surveyed considerable parts of the area. The present writer continued this work throughout the summer season of 1930 and part of that of 1931. Vertical aerial photographs of the area were taken in 1931 by the Ontario Forestry Department. A geographical and geological sheet, on one inch to the mile, has been compiled by the Geological Survey from these sources of information. It is not yet published, but advance photographic copies are obtainable.

The writer's field work was done under the supervision of T. L. Tanton who was present in the field during June, 1930. Courtesies and aid were received from the residents everywhere throughout the area and were greatly appreciated. Officials of the Algoma Power Company, Messrs. Lang and Ross, and the Algoma Central Railway, also helped. Mr. Gavin Young was field assistant in 1930 and Mr. William Neeland in 1931. The office and laboratory work was done at the University of Minnesota under Dr. F. F. Grout, Department of Geology, who gave much assistance. Other members of the faculty also gave helpful criticism.

GENERAL CHARACTER OF THE AREA

The surface of Lake Superior is 602 feet above sea-level. Along the shore steep cliffs rise to several hundred feet above this level. Inland the country is rugged and many hills rise to 800 feet above Lake Superior, but a northeastern section is rolling and without much relief.

The only extensive plains are those occupied by the glacial lake deposits in Michipicoten and Magpie River Valleys and in the vicinity of Lake Anjigami. They lie at elevations up to about 1,085 feet above the sea and are dissected and terraced by the streams.

The whole area drains to Lake Superior. There is a marked increase in the gradient of all the streams within 5 and 10 miles of the lake. Lakes and streams commonly lie in rocky basins and valleys that strike northeast. Fewer rocky basins strike northwest. The 13-mile westward course of Michipicoten River is somewhat at variance with the general drainage pattern.

Some of the forest north of Michipicoten River and east of Anjigami is burned. All the area south of Michipicoten River and west of Lake Anjigami is still covered with forest. The predominant tree is spruce, but white pine, red pine, jackpine, tamarack, canoe birch, silver birch, mountain ash, balsam, and cedar are present. Open groves of hard maple cover the high range of hills between Great Lake and Lake Anjigami. Very little commercial timber is being cut now.

GENERAL GEOLOGY

The general geology of Michipicoten River area is similar to that of Michipicoten area as described by Collins (Memoir 147). The oldest division consists of siliceous and basic volcanic flows and fragmentals interbedded with less common, local sediments, stratified tuffs, greywackes, conglomerates, and banded iron formation. This complex, commonly, but somewhat loosely, called the Keewatin, has been divided by Collins into two parts by an especially thick conglomerate and greywacke series called the Dore. The complex is invaded by large bodies of granite and gneiss, presumably Algoman. Diabase dykes cut the rocks of the two preceding groups. They are differentiated as older diabase and younger diabase. The older dykes are commonly sheared and appear highly altered. As in Michipicoten area, they occupy the sites of major faults. The younger dykes are in most places fresh and unsheared, and only minor displacements are evident along them. Youngest of all are sand and gravel and other loose deposits of Glacial and Recent age.

Table of Formations

Pleistocene and Recent		Boulder clay; gravel, silt, clay
Late Precambrian	"Younger" dykes	Diabase
	"Older" dykes	Diabase
Early Precambrian		Granite, granite-gneiss, etc.
	Post-Dore	Volcanics, clastics, iron formation
	Dore	Conglomerate, greywacke, pyroclastics
	Pre-Dore	Volcanics; sediments

Pre-Dore

The Dore occurs only in the northwest where it forms a belt extending east from Dore Point. The pre-Dore rocks lie north of this belt and are confined to a band 400 yards or less wide between the Dore strata and a body of younger granite and granite-gneiss. Of this band only the part west of Dore River was examined. The pre-Dore rocks include highly siliceous, grey, banded quartz-sericite schists, hornblende schists, fine-grained chlorite schists, and, less abundantly, garnetiferous schists and greenish, greywacke-like rocks. The several rock varieties occur in bands that appear to have considerable continuity along the strike. In several places the quartz-sericite schists carry what appear to be pebbles or fragments of other rocks. The larger part of the pre-Dore rocks are seemingly of sedimentary origin.

The granite and granite-gneiss bordering this strip of pre-Dore strata are younger, for narrow dykelets of granite and aplite cut the schists and the inclusions of the schists lie in the granite. The pre-Dore rocks of the limited area examined appear to be conformable with the bordering, overlying Dore conglomerate, and might be considered as representing a zone of the Dore series severely sheared and otherwise metamorphosed. The area examined is, however, too limited to warrant drawing any such conclusions, especially since Collins has presented evidence that in areas to the east and northeast the pre-Dore rocks are older than the Dore conglomerate and are invaded by granitic rocks, also of pre-Dore age.

Dore Series

In Michipicoten River area the Dore series occurs only in the northwest corner of the map-area, where it forms a belt 5½ miles long by between 1 and 2 miles wide. This belt commences at Dore Point, on the Lake Superior shore, and runs a little north of east. In both directions it is terminated by faults. The general strike of the Dore strata is about north 70 degrees east and the dip is southeast. Along the Lake Superior shore the strata are vertical or very steeply inclined. Along the northern margin the angle of dip is not so steep, but is 60 degrees or higher.

Good exposures of the Dore strata occur along the Lake Superior shore and in places across the northern part of the band. The southern exposures are of a conglomerate belt at least one-half mile wide. A second conglomerate belt, 1,000 to 1,500 feet wide, forms the northern margin of the western part of the band. The northern belt of conglomerate shows less diversity of pebbles than the southern belt. Commonly the pebbles are light coloured, but some are of greenstone and dark granitoid rocks. Most of the pebbles are considerably elongated. The granite boulders, cobbles, etc., are similar to granites present to the north and also may be matched by the granites west of the Dore along the shore of Lake Superior. In this northern belt of conglomerate the pebbles increase in amount and size as the northern margin is approached, the matrix is commonly a green, micaceous, chlorite schist. The strata between the northern and southern conglomerate belts are not well exposed. They include greywacke, chlorite schist, and, possibly, tuffaceous beds.

Post-Dore

The post-Dore rocks underlie about one-third of the whole map-area. They are commonly severely folded, faulted, and metamorphosed, and only the main structural features are known. These rocks strike for the most part either northeastward or northwestward and dip vertically or very steeply.

On the west side of Gros Cap peninsula two distinctive bands of carbonaceous iron formation occur about a half mile apart and disposed in a manner such as to suggest that they may be on the opposite limbs of an anticlinal fold overturned toward the north and pitching west.

The post-Dore rocks are mostly fine or medium grained, and grey to dull green is the characteristic colour. Many different kinds of rocks are included. The commonest are andesitic or basaltic lavas and tuffs, but carbonate rocks, local sediments, porphyrite, and recrystallized contact phases of the division are present also. Pyroclastics are probably as abundant or more abundant than the flows. They are present everywhere and appear to be especially abundant southwest of Island Lake and southwest of Fenton Lake, and also on the west end of Bridget Lake. In some places they are well banded and are probably water sorted. Some are very fine grained, others very coarse; some are breccias or agglomerates containing fragments a foot or more in diameter.

Practically all the post-Dore rocks contain 5 per cent or more of carbonate. Commonly this carbonate is disseminated, but it also occurs in veins and in the interstices of pillow lavas. The disseminated carbonates are replacements of the original minerals of the greenstones.

Bands of clastic sedimentary rocks occur at a number of places. The sediments are mostly fine or medium grained, banded grey and green, laminated rocks. The bands are one-eighth to one-quarter inch wide. In many places these rocks are highly siliceous. Where the rocks show a greater than average proportion of magnetite and carbonate they may possibly be referred to as iron formation, but they are not the typical Keewatin iron formation. The sediments include some conglomerates, between Twomile Lake and the creek out of Deep Lake to Great Lake. The pebbles of the conglomerate are fine-grained, light-coloured felsites, slightly elongated and not over 2 inches in diameter. The matrix is siliceous chlorite schist. The conglomerate does not resemble the Dore.

Porphyry is an abundant rock in several places. West of Firesand River there are a number of occurrences of this rock, but exposures here are not good and the relation of the porphyry to the other rocks is obscure. In several places there appear to be, however, gradations between a porphyry and a massive greenstone. The porphyry is commonly crossed by reddish brown veinlets one-sixteenth inch or less in width. The porphyry is grey or greenish grey and has a fine-grained groundmass. The phenocrysts, which are not over one-quarter inch, average about one-eighth inch in longest dimension. They are commonly rectangular or irregular feldspars and less commonly dark bluish quartz. Fine-grained chlorite is present along slight shears or joints. The porphyry of this part of the area appears to be very similar to some of the porphyrite described by Dr. Gledhill, as a phase of the Algoman granite intrusives.

Porphyry outcrops on Antoine Lake and on the east end of Bridget Lake. It intrudes volcanics and iron formation. The rock is grey or grey-green, commonly massive but in places slightly sheared. The groundmass is fine grained and the phenocrysts are not larger than one-quarter inch.

Many of the porphyries may be genetically related to the intrusive granite, but this is not readily proved either in the field or by petrographic study. Porphyries that occur near a granite contact or in other close association with granite are probably related to the granite, but many are far from any exposed granites.

Granite and Granite-gneiss

Granite and gneiss and related rocks underlie about two-thirds of Michipicoten River area. All the south, southeast, and eastern part is a continuous mass of granite and gneiss, part of a granite mass to the east that is continuous for 100 miles from north to south. The granite mass in the extreme northwest corner of the area is also part of a much larger mass that extends northwestward. The Wawa Lake mass and the small stock on Magpie River are relatively isolated granite areas within the post-Dore.

The large eastern mass, the Wawa Lake batholith, and the small stock on Magpie River intrude post-Dore rocks. The Dore Lake mass intruded pre-Dore rock and is probably also intrusive into the Dore. Commonly the contacts with older rocks are distinct. In some places, however, for example in Township 30, Range 22, and about the Wawa Lake batholith, there is a zone of mixed rocks, where granite outcrops alternate with Keewatin outcrops. At several places near the contacts with schists, granite dykes lie within the schists and dip and strike with the schistosity. The granites are intruded by older and younger diabase dykes and aplites, pegmatites, and quartz veins are common.

The main granite masses are commonly massive or slightly gneissoid, equigranular, and of medium grain. The general colour is light grey with variations to darker grey near contacts. The mineral composition, as estimated from about thirty thin sections, is 60 per cent acidic plagioclase, 12 per cent orthoclase, 26 per cent quartz, and 2 per cent biotite. Microcline and some medium plagioclase are also present but nowhere abundant.

Red granites are present near Anjigami on the Algoma Central Railway, on Tabor Creek near the east edge of the map-area, between Brûlé Bay and Old Woman Bay, and on the Lake Superior shore west of the Dore sediments. At Anjigami the red granite is intermingled with grey granite. Some contacts are sharp, whereas others appear to be gradational. West of Dore Point the red granite is also in contact with grey granite and the change from red to grey occurs within from 1 to 10 feet.

The red granites are massive, of medium to coarse grain, but very similar in texture to the grey granite with which they are in contact. The red colour is due to the feldspar. The rock consists of plagioclase near oligoclase, orthoclase, a little microcline, and 25 to 30 per cent quartz. There are few accessories, and the alteration products kaolin, epidote, sericite, chlorite, and leucoxene form not over 7 per cent of the rock. The following contrast may be made with the ordinary grey granite.

Red Granite	*Grey Granite*
Everywhere very fresh looking.	Some places considerably altered.
Very little dark mineral.	Biotite or other dark mineral common.
Few accessories	Accessories common.
Few observed pegmatites and these are irregular.	Pegmatites and aplites are common and have very distinct walls.

Analyses of Red Granite from Anjigami

	Per cent of oxides
SiO_2	77·74
Al_2O_3	13·26
Fe_2O_3	0·30
FeO	0·28
MgO	0·18
CaO	1·08
Na_2O	5·82
K_2O	0·81
H_2O	0·32
CO_2	0·05
TiO_2	0·07
	99·91

Several partial analyses are brought together in the following table:

—	I	II	III	IV	V	VI
Fe_2O_3	0·30	0·11	0·25	1·24	....	....
FeO	0·28	0·37	1·00	1·33	....	....
Na_2O	5·82	4·39	4·23	3·08	5·66	4·61
K_2O	0·81	3·62	3·93	1·70	0·77	0·57

(I) Red granite from Anjigami. (II) Red granite from Brûlé Bay, Lake Superior. (III) Red granite ½ mile west of Dore Point, Lake Superior. (IV) Grey granite from southwest corner Township 28, Range 23. (V) Grey granite ½ mile northeast of Sand Lake. (VI) Grey granite ½ mile west of Dore Point, Lake Superior.

Analyses done in the Rockefeller Foundation Laboratory for Rock Analyses, by A. F. Matheson, except No. IV, which is taken from Dr. Gledhill's report on Michipicoten gold area.

The field relations indicate that there may be some difference in age between the red and grey granite, but the exact relation is not clear. Red and grey granite occur together in many areas, and commonly the red granite is the younger.[1]

North of Mile 141 on the Algoma Central Railway, a small outcrop of a dark red, porphyritic syenite occurs. The rock appears to grade into granite. Phenocrysts of feldspar are present, but not abundant. The groundmass is fine to medium grained and shows flashing blades of feldspar and some dark mineral. The texture of the rock has some resemblance to a porphyritic diabase. Microscopic examination shows siliceous plagioclase and probably some orthoclase, in elongated subhedral crystals, both heavily coated with hematite. These minerals form over 80 per cent of the rock. Biotite (partly altered to chlorite), magnetite, apatite, leucoxene, and pyrite lie in the interstices between the feldspar grains. Red hornblende syenite is included in the granitoid rocks along the north side of the pre-Dore belt. The rock is very fresh looking in hand specimen and microscopic section. A specimen taken north of Deer Lake near the fault has an average grain size of 2 to 3 mm. The edges of the feldspar grains are granulated. Orthoclase and albite are present in almost equal amounts, there is about 10 per cent of blue-green hornblende, and apatite, tourmaline, and magnetite are the accessories. A little introduced pyrite is partly altered to hematite.

[1] Moore, E. S., and Charlewood, G. H.: "Two Granite Batholiths in the Pre-Cambrian"; Roy. Soc. Canada, 3rd ser., vol. 24, pt. 1, sec. 4 (May, 1930).

Porphyritic granites or granite porphyries are uncommon within the main granite masses. A few occur near contacts, but they are especially abundant where arms of the main granite masses extend into the Keewatin.

East of Lake Anjigami siliceous plagioclase porphyry occurs at the contact of granite and post-Dore rocks near the end of the post-Dore belt. The Keewatin rocks at this point are mostly banded and laminated, fine-grained, chloritic tuffs of green or grey-green colour with coarser phases in small lenses. Approaching the granite these tuffs change to more dingy looking, less distinctly banded rocks. Well-formed crystals of feldspar appear and become increasingly abundant until a distinct, light pinkish porphyry with a schistose groundmass is the result. Such gradations from tuffs to porphyry take place both along the strike and across the strike of the tuffs in a distance of 50 to 60 feet. The tuffs and the porphyry are cut by dykes with sharp walls, of grey and light pink granite, felsite, and felsite porphyry. The schistose porphyry at this point may be due to the introduction of feldspars as metacrysts in the tuffs. Its occurrence near the granite and the gradation from tuff to porphyry toward the granite suggest this origin. Microscopic examination of the rock leaves the origin inconclusive.

Inclusions of the hornblende schist or hornblende biotite schist are numerous along the contacts between granite and Keewatin. Commonly the schist inclusions have the same strike and dip as the neighbouring Keewatin, but in some cases, at least, this schistosity was probably induced after the inclusion was caught up in the granite. Inclusions also occur within the interior of the large granite masses and are especially numerous southeast of Pickerel and Anjigami Lakes toward Sand Lake. In this area they are also hornblendic or biotitic or both, and without orientation in any one direction. Many lenticular, schlieren-like inclusions, 6 inches to 1 foot wide, also occur and give the rocks a banded appearance. This banding strikes a little south of east and is the usual direction of banding or gneissose structure in the eastern granite mass. Some of these inclusions are so thoroughly soaked with granitic material that they are quartz diorites or nearly related rocks. Some of the granites show contamination by the inclusions. Small amounts of pink garnets occur in the granites and biotite is present in some in very irregular distribution.

Aplite borders the granite on the contact with post-Dore rocks at Brûlé Bay. The aplite is dark grey and fine grained. Some of the quartz grains are bluish and opalescent. This mineral forms about 12 per cent of the rock. Oligoclase and orthoclase make up almost all the rest. A little biotite is present, especially along slight shears. Darker grey, granodiorite phases of the granite occur along the contact from Moon Lake to Michipicoten Falls. The contacts with the post-Dore are sharp, but are gradational with light grey granite. The rocks are medium grained, texturally similar to the granite, with a tendency for the feldspars to be porphyritic. The rock is essentially composed of 75 per cent feldspar, 20 per cent quartz (in many places bluish and opalescent), and 5 per cent biotite. The alteration although not excessive is slightly greater than that of the average granite. The darker colour, slightly more basic plagioclase, greater alteration, and larger amount of biotite are the most prominent features that differentiate the granodiorite from the ordinary granite.

The Wawa Lake batholith has been described by Collins and by Gledhill.[1] The boundaries of this batholith are nowhere, apparently, sharply defined, and many apophyses extend into the post-Dore area. The petrography of the mass is especially characterized by variations in texture. Porphyritic textures are common, and fine and coarse varieties occur, some of which are difficult to distinguish from certain acid volcanics. The rocks are in most places medium dark to dark granodiorite and diorite. The small stock on Magpie River is a quartz porphyry. The groundmass is ash grey and fine grained.

The western contact of the large eastern granite and gneiss mass in Michipicoten River area strikes northeast and very roughly parallels the axes of the major folds of the area, as if the position of the folds and the granites were dependent upon one another. Along this contact any schistosity in the intruded rock, and in places a gneissose structure in the invading rock, are parallel to the contact. That the intrusion of the granite is later than these major folds is shown by the extensions of the main granite mass that strikes northwest. Here the development of schistosity in the invaded rock parallel to the contact of the intrusive and at a high angle to the major folds suggests that the granite pushed aside the invaded rocks to make room for itself. Commonly the contacts with inclusions in the granite mass do not suggest a large amount of assimilation, although some of the granites are undoubtedly contaminated.

The granite and gneiss are believed to be younger than all the Keewatin rocks, although in this area they are not found intruding the Dore sediments. Outside of the area, however, granites continuous with them do intrude the Dore. Collins (Memoir 147) has discussed the evidence for the presence of two granites, and north of Michipicoten Harbour mapped older granite as part of the pre-Dore rocks. North of the Dore series there is a great variety of granitoid rocks; some are very old looking and others remarkably fresh, but it was not found possible to differentiate an older and younger granite. Probably the younger granite, intrusive into the same areas as the older, has obliterated most of the older. The granite and granite-gneiss masses of the other parts of northern Ontario showing relations to the Keewatin volcanics and associated sediments similar to the granite and gneiss of Michipicoten River area are commonly classed as Algoman.

Older Diabase

The Older Diabase is widely though relatively sparsely distributed throughout the area. The Older Diabase cuts both the Keewatin and the granites. The common strike is northwest and the dip is vertical or very steep. Between 30 and 100 feet is a common width. On the north side of Old Woman Bay, Lake Superior, a porphyritic older diabase is cut by a fresh, fine-grained dyke 2 feet wide, probably Younger Diabase. This is the only example of this relation seen in the area. Many dykes are intersected by veinlets of epidote, and some also by quartz-calcite veinlets 3 to 6 inches wide. The quartz-calcite veinlets are especially abundant in the diabase but less abundant in the wall. The most westerly of the Older Diabase dykes on Dore Point is cut by dull red, aplitic dykelets.

[1] Ont. Dept. of Mines, Ann. Rept., vol. 36, pt. 2 (1927).

The Older Diabase is dark green, medium or fine grained, massive or slightly sheared. The edges of dykes are commonly fine grained and in sharp contact with the older rocks. Some of these dykes are porphyritic and the phenocrysts are light-coloured, rectangular or irregular feldspars up to one-half inch in diameter. The dykes are crystalline throughout, but even away from the chilled edges the average grain size of the sections microscopically examined is a millimetre or less. Due to alteration the diabasic texture is not prominent. Probably the original minerals are 50 to 70 per cent basic plagioclase, 35 to 50 per cent augite, with accessory ilmenite, quartz, and apatite. The rock is now, however, very considerably altered.

The quartz-calcite veinlets have apparently a genetical relation to the diabase. They occupy vertical or near vertical joints in the dykes or nearby wall-rocks. Their greater abundance in the diabase is due to the complex jointing and consequent abundant paths for solutions. Many quartz veins and stringers are present everywhere in the area, but veins with much coarse, crystalline, white or light pink calcite are seemingly present only in association with diabase. Similar calcite veins are common at other places in Lake Superior region and occur, too, in other parts of northern Ontario. In many places they are of large size and in some places they are economically important, principally for their silver content. The small veins described here do not show any mineralization.

The red aplite dykelets that occur in the Older Diabase on Dore Point have also, probably, a genetical relation to the diabase. The dykelets are 3 to 4 inches wide and follow vertical or gently dipping joints. Contacts with the diabase are sharp. Left hand faults striking 160 to 170 degrees offset some of them a foot or more. As dykelets they are entirely confined to the diabase. Some pink felsites gradational into the Dore sediments nearby are somewhat similar in appearance, but much finer grained. The rock of the dykelets is dull red on the exposed surface, but much lighter coloured on the fresh surface. It is hard, dense, felsitic, and fresh looking in the field. Under the microscope the texture is aplitic and the average grain size is 0·5 mm. or less. The aplite consists of 87 per cent albite, 8 per cent carbonate (calcite?), 5 per cent epidote, and traces of apatite, biotite, and chlorite. It looks fresh and the epidote and carbonate are interstitial. The carbonate in places, however, ramifies through the albite. The interstitial position of the epidote and its fresh appearance suggest a primary mineral. The same is true for most of the carbonate, but the ramifying veinlets in the albite indicate introduction. Such aplites, showing similar relations to dykes and sills of diabase, are found commonly in northern Ontario. They are most likely differentiates of the magma from which the diabase also came.

Younger Diabase

Younger Diabase dykes are abundant in all parts of the area. The field and structural relations are similar to those of the Older Diabase. The majority of the dykes strike northwesterly and dip vertically. The width varies from 1 or 2 feet to 100 feet or more. Commonly they are 20 to 60 feet wide. Three types have been recognized, namely, quartz diabase, normal diabase, and olivine diabase.

Quartz diabase is the commonest variety. The rock is dark green, slightly roughened on the weathered surface and speckled with white-weathering plagioclase. Some dykes contain phenocrysts of plagioclase which may be as much as 5 inches across and many are an inch or more. The phenocrysts of many dykes are in bunches unevenly distributed, but no phenocrysts are closer to the wall than 4 or 5 inches. Most of the phenocrysts show crystal form, but commonly with rounded edges, and many are practically equidimensional. Some are broken or show little faults not continuous into the immediately adjacent phenocrysts. Specimens taken from the edge of the dyke are very fine grained. Away from the edge the grain is coarser and those specimens microscopically examined have an average grain size of 1 mm. In some dykes the grain is coarser. The diabasic texture is prominent and the rocks are relatively fresh microscopically as well as megascopically. The mineral composition is, essentially, 40 to 50 per cent plagioclase, 40 to 50 per cent pyroxene, 4 to 7 per cent magnetite or ilmenite, and 2 to 4 per cent quartz. The chief plagioclase is andesine or silicic labradorite. The pyroxene varies slightly in character and may be augite, diopside, or diallage. In several sections it is surrounded by very fresh-looking, coarse hornblende. The iron oxides commonly show skeletal crystal forms and reaction rims of biotite and a green fibrous amphibole (?) at the contacts with plagioclase. An interstitial micrographic intergrowth of quartz and plagioclase is present in all the sections examined. The plagioclase of the intergrowth is silicic andesine or basic oligoclase. These intergrowths consist of about 43 per cent quartz and 57 per cent plagioclase in most places.

The normal diabase forms only narrow dykes and, consequently, is fine grained. The grain size varies from 0·05 to 0·2 mm. The diabasic texture is evident under the microscope. The main constituents are: 30 to 40 per cent basic plagioclase, 55 to 65 per cent pale green pyroxene, and 2·5 to 10 per cent iron oxide (ilmenite?). The composition, except for the lack of quartz, is similar to that of the quartz diabase, although the proportions of the minerals are different.

Olivine diabase dykes are relatively few but are widespread. All the recognized olivine-bearing dykes are porphyritic. The phenocrysts are very fresh, narrow, lath-shaped, plagioclase crystals $\frac{1}{4}$ to 3 inches long showing sharp contacts with the groundmass, which is black and characteristically fine grained. The sharp contacts and fresh character of the phenocrysts help to distinguish the olivine diabase from the quartz diabase. The average grain size of the groundmass of one specimen is 0·5 mm. and the rock shows a fresh, porphyritic, diabasic texture. The specimen contains 57 per cent plagioclase, 24 per cent augite, and 13 per cent iron oxide (magnetite and ilmenite). Only about 1 per cent of olivine (fayalite) is present and there is less than 1 per cent of quartz. The plagioclase of the groundmass is likely silicic andesine. Although relatively fresh in appearance it shows more alteration than the phenocrysts. The plagioclase of the phenocrysts shows faint zones; the outer zone of some crystals has an index less than quartz. Refractive oil determinations indicate that most of the plagioclase of the phenocrysts has a composition of Ab_{50} An_{50}. These phenocrysts are very fresh looking, but in a few places are crossed by veinlets of chlorite and there is some slight alteration to sericite and biotite. Near their outer edges, especially near the ends, they have inclusions of augite, fayalite, a needle-like mineral, and black opaque particles (iron oxide?). The borders of some phenocrysts appear to be an intergrowth with a more silicic plagioclase. The intergrowth is of irregular rods that lie at right angles to the crystal boundary. The augite is fresh looking and pale green. Fayalite is brownish in colour and has an abundance of oriented dark inclusions. Alteration along cracks to magnetite, and also a little hematite, is very advanced in some crystals. Rosiwal analyses indicate the mineral composition of the three varieties of Younger Diabase to be as follows:

Grain size	Plagioclase	Pyroxene	Ilmenite or magnetite	Quartz intergrowth	Alteration products	Olivine
Quartz Diabase						
1 mm.	40	48	5·7	3·1	3	
1 "	45	42	6·8	2·0	3·5	
1 "	48	39	4·0	3·3	5·0	
	49·4	42·1	3·7	2·4	2·2	
1 "	40·4	41·4	5·8	3·6	8·6	
	48	41·5	4·5	4	2	
Normal Diabase						
0·1 mm.	31·2	66·3	2·5	....	Minor amounts of very fine grain	
0·1–2 mm.	37·4	58·5	4·1	....		
0·05–1 mm.	32	57	10			
Olivine Diabase						
0·5 mm.	57	24	13 Includes sec. mag.	1–	4	1

The field relations show that the diabase dykes are younger than the granite and gneiss. They are placed in the Keweenawan period because of their petrographic similarities to Keweenawan diabase dykes in other parts of northern Ontario. It is quite probable, however, that some of the dykes may be older than Keweenawan. Diabase dykes of similar lithology have in many places been shown to be of widely separated ages. The division into older and younger diabase is based both on structural relations and petrography. The younger normal diabase is found cutting the older diabase. The younger set is characteristically fresh, whereas the older set is much altered.

Lamprophyre Dykes

The lamprophyre dykes appear to be most abundant about Wawa Lake batholith, where many are revealed by stripping and especially in underground development of the mines. They occur elsewhere but are relatively few. The dykes are narrow; the few noted are from 2 or 3 inches to about 1 foot wide, but some up to 5 feet wide are known. They were seen to cut the Keewatin and the granite and granite-gneiss. The rocks are almost black or dull grey-green. They are fine grained and some are porphyritic. Intense alteration along the walls gives some of them a banded appearance, and all look highly altered.

Gledhill has described the lamprophyres from the gold area in more detail. He classifies them as mica and non-mica varieties. Some dykes have olivine as an abundant phenocryst; others have biotite. Frohberg[1] has described kersantites containing abundant biotite and a plagioclase near andesine, a small amount of quartz, and some orthoclase. Secondary products are chlorite and carbonate. Other dykes with primary olivine, biotite, augite, apatite, and iron ore he has classified as picrites. The picrites cut the kersantites.

Most of the few lamprophyres noted by the writer cut granodiorite or granite; and such dykes are believed to have formed toward the end of the magmatic process that gave rise also to the granite. Their age in Michipicoten River area is, therefore, probably Algoman. Gledhill writes that "The probability is that they are a late facies of the dioritic intrusions." Frohberg has found, however, that in the vicinity of the Grace mine the lamprophyres are the youngest intrusive rocks, cutting even the younger quartz diabase of supposedly Keweenawan age. According to this evidence either the diabase is much older than Keweenawan or the lamprophyres are not related to Algoman intrusives.

Glacial Lake Deposits

Some small sand terraces are present along the Lake Superior shore just west of Gros Cap and for one-half mile west of Dore Point. From the latter place a sand-bottomed valley extends north a mile, and is also continuous northeast. The sand and silt are commonly light grey or buff coloured. This sand-plain is dissected by the valleys of small, intermittent streams flowing to Lake Superior. The terraced lake deposits that occupy the valleys of Magpie and Michipicoten Rivers are described by Collins. The most extensive areas are those extending inland from Michipicoten Bay for about 5 miles up the two river valleys. Similar deposits occupy the valley of Firesand River entering Michipicoten River three-quarters mile above Michipicoten Falls. They occur up Michipicoten River from this point in a narrow belt for about 5½ miles, then spread over a strip about 1½ miles wide along Michipicoten River to the north boundary of the map. Continuous with this area they occupy a broken plain lying mostly east of Anjigami River and Anjigami Lake, and extending as far south as Mile 144 on the Algoma Central Railway.

Lake deposits on the Algoma Central Railway one-half mile south of Michipicoten River consist of fine-grained sand, coarse sand, and gravel, interbedded and heavily crossbedded. Varved clays outcrop near the point where the Anjigami trail crosses Anjigami River. Large, irregular, smoothed boulders up to 10 feet in diameter lie scattered at intervals over the gravel plain east of Miles 154 and 155 on the Algoma Central Railway and over the gravel plain to the south.

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[1] Frohberg, M. H.: Ein Beitrag zur Kenntnis der turmalinfuhrenden Goldquartzgange des Michipicoten. Distriktes, Ont. Dissertation, Freiberg, Feb., 1932.

At Michipicoten Falls the first terrace above the river shows the following section, measured from the top down:

(1) A few inches of sandy soil.

(2) Ten feet of gravel consisting of cobbles averaging 3 to 4 inches and showing a rude stratification. The upper part is coarser than the lower and the lower part is crossbedded. The pebbles and cobbles are of grey granite, grey granite-gneiss, and some schist.

(3) Fifteen feet of interlayered, fine-grained, grey sand and silt beds. The sandy layers are crossbedded, 3 to 4 inches thick; the silty layers are $\frac{1}{8}$ to $\frac{1}{4}$ inch.

In the terrace above this the upper beds are finely laminated, fine-grained sand and silt beds. These overlie interstratified sand and gravel layers 1 to 3 inches thick and these beds overlie coarse gravel.

Commonly in the upper part of Michipicoten River Valley in the map-area and at the higher elevations in the Anjigami basin the deposits are largely coarse sand and gravel. Farther down stream, as at Michipicoten Falls, there is an abundance of both fine and coarse material. At lower levels near Lake Superior fine-grained sand and silt predominate. There is a gradation corresponding to the difference in elevation. All the lake deposits are probably the result of deposition of one period when the lake stood at its highest level.

On the portage trail to the mouth of Noisy River, which empties into Lake Superior 3 miles northeast of Brûlé Bay, lake beaches are exposed. From the lake shore, at 602 feet above sea-level, to an elevation of 618 feet are well-rounded beach boulders washed clean by the waves. At 650 feet elevation there are indications of another beach, but the ground from 618 feet to 650 feet is mostly tree covered. From 684 feet to 706 feet a continuous succession of lichen-covered beach boulders, stepping up on six well-defined beaches, strike parallel to the present shore. The boulders are from a few inches to 2 feet in diameter and are moderately well rounded, but not as well as the present Lake Superior beach boulders.

Glacial Deposits

The glacial deposits lie at elevation above that of the glacial lake deposits. The thickness is variable but commonly slight, and in places glacial deposits are entirely lacking. Some gravelly hills and boulder ridges occur, particularly in the east and southeast. From Great Lake east to Lake Anjigami the high hills south of the Anjigami trail are rather heavily covered with sandy soil and boulders. Maple groves are characteristic of these high hills.

Recent Deposits

Concretions are forming along the shores of some of the lakes at the present time. Some are sandstone concretions cemented by iron oxide; others are thin, discoidal, argillaceous concretions confined to a certain lamina in the clay. In many places they grow horizontally from a tiny vertical rootlet which constitutes a centre. In advanced stages this centre is entirely removed.

Structural Geology

In the area to the north, Collins has shown that the axes of the major folds strike east or northeast. The same structural trends characterize Michipicoten River area as shown by the distribution of the Dore sediments, the iron formations of Island Lake, Fenton Lake, and Gibson Range, and also by developments of agglomerates, sediments, and bedded tuffs. The available data are not, however, sufficient to locate accurately the position of the axes of the folds or even to determine which are anticlinal and which are synclinal. It is suggested on a former page that in the vicinity of Gros Cap Peninsula there may be an overturned anticlinal fold pitching west and that the Dore sediments may lie in a syncline.

The large faults in the western part of the map-area strike north or northwest and in most places form sharp ravines. In the central and eastern part of the area, the major faults strike a little east of north. Faults with a northeast strike are present also in the western part of the map-area, as for example on Gros Cap, but the displacement where known is small.

The movement along the large faults has been, apparently, mostly horizontal and is well illustrated by the offsetting of the Dore sediments. The fault terminating the Dore band at its east end might be expected to extend for a considerable distance south, but was not there recognized. A fault passing south through Deer Lake into the western part of the Dore band strikes in an almost perfectly straight line about 5 degrees east of south for about $1\frac{1}{4}$ miles. Its northern extension is not known. The fault plane is marked by a gully 30 to 150 feet wide and, especially where the fault passes through granite, the walls on either side rise perpendicularly. The fault causes a left hand offset of about 200 feet at the north boundary of the Dore conglomerate.

West of Island Lake the faults strike northwest, but are relatively small and are not represented in the topography. Diabase occupies two of the fault planes. The offset is right handed.

On the Lake Superior shore, in the extreme southwest corner of the map-area, a slickensided fault plane, with an apparent strike of about north 7 degrees east, dips west. The slickensides indicate both vertical and horizontal movement. The granite at this point is brecciated; some fragments are over 6 inches in diameter. Volcanics to the east form a steep cliff striking about parallel to the fault plane. From this point north to Old Woman Bay and Brûlé Bay there is evidence of much shearing and steep cliffs rise above the lake. They probably owe their origin, at least in part, to faulting.

Two faults offset the Deep Lake iron range. The faults strike east of north and both occupy depressions.

Between Miles 147 and 148 on the Algoma Central Railway east of Lake Anjigami two strong shear zones strike northeast. Many of the lakes, lake bays, and streams have their long axes northeast and probably indicate faults.

A north-striking fault that follows McVeigh Creek, and has a measured horizontal displacement of about 2 miles, probably continues south through Michipicoten River area following the valley occupied by the Algoma

Central Railway. The presence of this fault in Michipicoten River area is not proved, but is suggested by the large displacement found to the north, and the existence of a pronounced valley on the strike.

ECONOMIC GEOLOGY

Gold and iron deposits are of chief economic interest in Michipicoten River area. Some molybdenite float is reported to have been found near the outlet of Dore Lake.

Gold

Most of the gold discoveries of the area are confined to the region about the Wawa Lake batholith. They are fully described by Gledhill. During the season of 1931 the most active work was carried on at the Minto and Parkhill mines. A 75-ton mill, previously erected on the Minto property, was in operation and gold was milled and shipped.

South of Michipicoten River, in Township 30, Range 22, several prospects have been staked in recent years. A prospect near Twin Lakes and another south of Round Lake have been described by Weeks. Another prospect is almost one-half mile east of the portage landing on the east side of Round Lake and a number of claims were recently staked in this vicinity. At the point where some stripping and trenching have been done, a quartz vein strikes east and dips north 80 degrees. It is 3 feet wide in places, but varies to lesser widths. The exposed length is about 230 feet. The vein is in grey, gneissic, granitoid rocks, but is not far from the contact of the granite and post-Dore rocks to the west. The country rock also carries several small quartz stringers. The quartz is milky or smoky blue and contains visible pyrite, galena, and chalcopyrite. The best mineralization appears near the centre of the vein and hanging-wall. The small stringers are also mineralized.

Many quartz veins, ranging from tiny stringers to veins 4 feet in width, are scattered throughout the post-Dore rocks, but in almost all cases quartz is the only mineral present. North of Deep Lake many lens-shaped quartz veins occur. A few carry iron carbonate and a still smaller number pyrite. Rarely a little chalcopyrite is present. Some barren quartz veins also occur in the Dore sediments but are not numerous. Quartz veins with tourmaline are common in the narrow belt of pre-Dore rocks along the contact with granite.

Iron Formation

Keewatin iron formation is characteristic of the post-Dore rocks of Michipicoten River area. It is folded and dips vertically or very steeply. Some iron formations are lenses 3 feet wide and not over 50 feet long. The most extensive range is north of Deep Lake and as mapped is from 60 to 400 feet wide and almost 2½ miles long, with some offsets by faults. The iron formations apparently occur at several horizons in the post-Dore rocks.

Most of the iron formations contain sufficient magnetite in the banded-silica member to attract the dip needle. In exploring the post-Dore rocks for iron formation, therefore, the dip needle was used extensively because in most places the rocks were drift covered and their continuity or width could hardly be inferred from outcrops. While doing this work it was found that the following phenomena gave high local dips not attributable to iron formation: (1) diabase dykes, the attraction varying considerably over different parts of any one dyke; (2) shear zones mineralized with pyrrhotite; (3) recrystallized hornblende schists with octahedral crystals of magnetite; (4) fine-grained, finely laminated sediments carrying an especially high concentration of magnetite.

GROS CAP IRON FORMATION

Iron formation occurs on Gros Cap just west of Michipicoten Harbour. Two bands of iron formation, each with a maximum width of 3 feet, outcrop 50 feet apart "just around the east point near the beacon." On the lake shore these bands strike south 65 degrees east and south 45 degrees east, but a few feet inland swing toward the north. Both bands dip southwest at 45 degrees or higher. One of the bands may be discontinuously traced 150 feet northward to a point immediately behind the boathouse. At this point it branches and fingers out into pillow lavas. The iron formation contains lenses of banded silica with magnetite, a little hematite, and limonite. Pyrite occurs disseminated and in cubic crystals up to one-quarter inch.

Between the beacon and the southwest point of Gros Cap, iron formation outcrops at six places. In succession from east to west these are as follows.

(1) A band 50 feet wide strikes south 50 degrees east and dips southwest at 47 degrees. This is exposed inland for about 600 feet. The overlying rock is a light grey tuff or lava and slickensided along the contact with the banded silica. The underlying rock is similar but more fissile. The band consists of finely granular silica and alternating layers of siliceous hematite.

(2) A band 10 feet wide of grey, finely laminated chert, with magnetite and unevenly distributed pyrite, strikes south 45 degrees east and dips 50 degrees southwestward. It lies between schistose and massive andesitic lavas. The upper contact is smooth and slickensided.

(3) Two chains west of No. 2, a band 8 inches wide at the water's edge widens to several feet in the sloping cliff. Near water-level it strikes south 75 degrees east and dips vertically. It contains silica banded with siliceous magnetite, disseminated pyrite, and pyrite crystals up to 1 inch.

(4) The fourth occurrence is a small, white silica lens just west of No. 3.

(5) An old dump and shaft are present at the next outcrop. The iron formation here is about 60 feet wide and at the shaft, 160 feet inland, strikes south 50 degrees east and dips 35 degrees southwestward. It contains silica and dark blue-black hematite in layers $\frac{1}{4}$ to 4 inches wide. A little magnetite is also present.

(6) The sixth outcrop is over 100 feet wide, strikes south 70 degrees east, and dips vertically. It is exposed just below the water and on shore is traceable across the southwest point, so that the same band outcrops on the west shore of Gros Cap. At this point it is faulted, the fault being followed by a quartz diabase dyke 100 feet wide that strikes north 55

degrees east and dips southeast 67 degrees. On the south shore a series of quartz veins at 50 degrees crosses the iron formation and coarse vein quartz is present along the strike. The iron formation consists of fine-grained silica layered with thin bands of hematite.

On the west shore of Gros Cap, iron formation outcrops at five places north of the diabase dyke. In succession from south to north these are as follows.

(1) The first band is over 100 feet wide and the south wall strikes east and dips 85 degrees south. The band is composed of silica and hematite and in alternating layers.

(2) A band 4 feet wide which strikes south 70 degrees east in the face of the hill and dips southwestward. North along shore the strike is south 30 degrees east. The band is formed of silica with layers of hematite.

(3) This band is only 6 inches wide. It consists of silica and hematite in alternating layers.

(4) This is about 30 feet wide. It strikes south 40 degrees east and dips southwestward 57 to 60 degrees. Part of the iron formation band consists of 3- to 8-inch bands of grey, finely laminated silica interbedded with $\frac{1}{4}$- to $\frac{1}{2}$-inch bands of dense, blue hematite. Another part consists of dark green, siliceous, carbonate rocks with octahedra of magnetite and martite.

(5) Immediately north of the No. 4 band of iron formation, a band of iron formation strikes northwest and dips southwest at a high angle. It is heavily charged with pyrite and the silica is dense, hard, coaly looking, and soils the fingers. Part is covered with water, but appears to be banded silica heavily hematite stained. Offshore from the pyrite-bearing part the iron formation is under water, but there is a broad band apparently of silica and magnetite. This band is on the strike of No. 4, but is wider and quite unlike it in character. It can be followed beneath the water to within a short distance of No. 4. A fault striking about north 70 degrees east probably intervenes.

North of the peninsula there are three more bands of iron formation of which the south band is about 55 feet wide, strikes north 60 degrees to 65 degrees east, and dips steeply southeastward. This band from south to north consists of: (1) 6 feet of light-coloured lenses of banded silica and magnetite heavily stained by pyrite; (2) 6 feet of lenses of banded silica and magnetite with very little pyrite; (3) 35 feet of stained (due to abundant pyrite), banded silica and magnetite. The silica is dark and coaly looking. The other bands are similar in strike and dip and petrographic character. The black, dense, carbonaceous silica is characteristic.

As early as 1866 there were attempts to mine the iron formations on Gros Cap, but these operations were soon discontinued. All the bands are relatively small and since they consist largely of silica have no possibilities as a source of iron ore.

IRON FORMATION NEAR MICHIPICOTEN HARBOUR AND NEAR THE MISSION

Two small bands of iron formation south of the Algoma Central Railway near Michipicoten Harbour and another that crosses the railway about 3 miles from the harbour have been described by Collins, who also has described the occurrence near The Mission.

ANTOINE AND BRIDGET LAKE IRON FORMATION

Iron formation outcrops on the portage between Antoine and Bridget Lake and can be followed for about one-quarter mile southwestward. The area is covered by two fractional claims. At the outlet of Bridget Lake, also on the south side near the east end of a long bay to the southwest, also along the north shore, and on several islands in the same lake, further outcrops of iron formation are present. Occurrences are also reported immediately south of Bridget Lake.

The outcrops of iron formation between Antoine and Bridget Lake are interrupted by a porphyry body intruding the iron formation. At most points the iron formation is nearly horizontal on top of the porphyry or as in a few places forms inclusions in the porphyry. The iron formation consists of magnetite interbanded with silica or with fibrous, green, silky amphibole. In many places the silica is coarse. Pyrite veins one-quarter to one-half inch wide cut the formation in a number of places. In places magnetite forms as much as 80 per cent of the rock over a width of 3 feet. At other places it forms 20 per cent or less. This occurrence though relatively small has a greater concentration of magnetite than is usual. A number of old trenches in the iron formation are still evident, but some in good ore probably do not go deeper than a few feet before striking the underlying porphyry. There does not appear to be any large quantity of rich ore.

The several outcrops present on Bridget Lake are not large. Most of them are contorted, but the general trend is between north 45 degrees east and east. They are banded and contain a small proportion of magnetite with silica and fibrous amphibole or green, siliceous, chlorite schist.

Southwest of Bridget Lake on the shore of Lake Superior a short distance north of Smoky Point, a much contorted band of iron formation strikes north 15 degrees west and dips west 70 degrees. A dip needle traverse parallel to the west boundary of Township 30, Range XXII, and about 8 to 12 chains west, and another a short distance inland and parallel tc the Lake Superior shore in the vicinity of the iron formation failed to find any extension of the band outcropping on the lake shore.

IRON FORMATION WEST OF ISLAND LAKE

A band of iron formation, slightly over one-half mile long and having a maximum width of 275 feet, is present west of Island Lake. It crosses the township line between Townships 30 and 31, Range XXII. The average strike of the formation is northeast and the rocks dip vertically. The band is horizontally displaced by three faults that strike northwestward. The displacement on the north fault is very small; on the south fault it is about 1,200 feet and in each place the displacement is right handed. Diabase dykes occupy the middle and north faults. The best exposures are near the ends of the faulted segments. On the south end of the largest segment, the outcrop is about 30 feet wide and consists of lenticularly or very indefinitely banded, dark grey, fine-grained silica with a small proportion of magnetite. In places the banding is more distinct and there white silica, in layers one-half to three-quarters inch wide, alternates with dark, magnetite-bearing layers. None of the outcrops seen has a high proportion of magnetite.

Another small band of iron formation occurs on the south side of a small lake (Line Lake) slightly over one-quarter mile west of the outlet of Island Lake. It is about one-quarter mile long and 60 feet or less in width. The average strike is northeast and the dip is vertical or very steeply northwest. A small, right hand offset occurs near the middle of the band along the creek flowing from the lake. On the lake shore at the creek, the west section is crumpled. Slightly rusty looking outcrops are present at several places and these show alternating layers of fine-grained, light-coloured silica, magnetite, and chlorite.

Small, abnormal dips were obtained at several points between this band and the small lake between Island Lake and Fenton Lake, but could not be traced beyond a few feet. At one point the magnetic attraction was due to a very small lens of lean iron formation.

FENTON LAKE IRON FORMATION

The iron formation of Fenton Lake begins a few chains west of the south end of the small lake between Island Lake and Fenton Lake. It runs southwestward to Fenton Lake and follows the shore for 25 chains. Farther southwest it occurs on two small islands less than 2 chains offshore. It crosses the lake and extends southwestward for about 50 chains. It is 200 feet or less in width, but, at least north of Fenton Lake, it is probably wider, from 330 to 525 feet, which widths include some greenstone. The northern part of the range forms a small ridge. Southwest of the lake the iron-range ridge is more prominent, but it is nowhere an outstanding topographic feature. The average strike is north 30 degrees east, but the northern end turns more eastward, and in places, also, the rocks are considerably contorted. The formation at all observed outcrops dips 85 degrees or more northwest or southeast. About one-half mile south of Fenton Lake the succession across the iron range from east to west is dark green, fissile, chlorite schist, banded silica and magnetite, banded carbonate with amphibole and silica, a dark green quartz porphyry schist, a drift-covered interval, a second banded-silica member, and, farther west, volcanic fragmental rocks. Outcrops of slightly rusty, banded silica and magnetite are present at various points along the range. The bands are commonly $\frac{1}{8}$ to 1 inch wide and quite regular up to lengths of 6 or 7 feet. The silica bands are usually grey or white and fine grained, granular. Grey, siliceous, chlorite schist also occurs with magnetite-rich, siliceous layers. The magnetite is fine grained and the proportion is variable; some parts of the range show little magnetic attraction. At several points carbonate mixed with light-coloured amphibole is banded with silica layers. Pyrite is sparingly present in the banded silica. North of Fenton Lake, near the north end of the range, fine-grained, light buff, carbonate rock forms two outcrops. At this point, apparently, banded silica and magnetite form two members separated by rocks of different character. This range was mapped largely by dip needle traverses. Dip needle traverses were also made west of the range to Noisy River and the trail from Fenton

Lake to Lake Superior was also surveyed with a dip needle, but no indications of iron formation were obtained.

There are several old test pits along the range, especially south of Fenton Lake, but nothing other than banded silica and magnetite is exposed in any of them and this member is not rich enough in iron to be of commercial value. Only the ridge-forming, banded-silica member forms readily observed outcrops. Some iron carbonate occurs along the west side of the range near the north end.

DEEP LAKE IRON FORMATION, TOWNSHIP 29, RANGE XXII

The average strike of this range is about south 60 degrees east and the dip is vertical or in a few places 80 degrees northeast. The range is offset along two faults that strike northeastward. The range forms part of a high ridge. Deep gullies striking northeastward cut across it along the two faults, at the outlet of Cabin Lake and at the middle bay on the north side of Deep Lake. Banded silica with magnetite forms most of the outcrops. The amount of magnetite in the layers is variable; at the outlet of Cabin Lake magnetite is relatively abundant, whereas the outcrops on the east bay of Deep Lake have only a very little magnetite in layers within the silica. Near where the middle section of the iron range crosses Deep Lake Creek, on the south side of the creek, the iron formation and associated rocks are slightly contorted and consist of indefinitely banded, rusty-weathering silica and magnetite with some fine-grained, radiating, light brown amphibole. About 15 chains southeast of where the range crosses the creek, banded white silica and medium-grained magnetite outcrop on the southwest side of the range, which is over 400 feet wide and dips 80 to 85 degrees northeastward at this point. Some pyrite is present and parts of the exposure are leached and have a cellular, porous structure. A dark brown limonite crust up to one-third inch thick forms a secondary coating over some of the iron formation. Farther east silica is banded with very narrow layers of carbonate largely changed to limonite.

A large part of the range is drift covered, but it is traceable by means of the dip needle; the eastern extension of the range is still unmapped. The exposures are not rich enough in iron minerals to be commercially valuable, but a range of this size may possibly have a carbonate member at some point, most likely along the middle section on the northeast side.

IRON FORMATION NEAR MILE 4 ON THE EAST BOUNDARY OF TOWNSHIP 29, RANGE XXII

This iron formation outcrops close to three small lakes and along the creek out of the western lake. It extends almost one-quarter mile in a direction slightly west of north, but the few outcrops noted have strikes more toward the west than the apparent general trend. The formation dips steeply and in places is contorted. It may be a continuation of the Deep Lake iron range, but little is known about it. Iron formation with an apparent northwest trend occurs about one-quarter mile south of the above. The outcrops are brown and consist of very irregular banded silica with magnetite in variable quantity. In a few places carbonate layers are present with the silica, and small crystals of an elongated, light-coloured amphibole crosscut the banding. There is a small outcrop of banded silica and magnetite on the power line to Goudreau near where it crosses the north boundary of Township 29, Range XXII.

IRON FORMATION EAST OF LAKE ANJIGAMI

Banded iron formation is exposed on the Algoma Central Railway near Mile 147 east of Anjigami Lake. It extends about 15 chains eastward from the railway cut and is present again about three-quarters mile to the northeast. The formation is folded with the associated volcanics which, striking northwest at the railway cut, turn northeastward when traced easterly. In places, as at the railway, part of the formation is contorted. It dips vertically. Silica layers banded with chlorite, hornblende schist, or, in some places, layers rich in magnetite make up the iron formation. It contains pyrrhotite and pyrite and weathers brown and rusty. Several old trenches and pits are present, but the whole belt is very small and of little commercial value.

GIBSON IRON FORMATION

The Gibson iron formation is near the northwest corner of Township 29, Range XXIII. From the distribution of the outcrops it appears to strike northeastward. Most of the area is drift covered. The only rock of the iron formation exposed is a ferruginous dolomite not much like most of the carbonate rock of the other iron ranges. On the surface it weathers a deep red and is soft and earthy. The iron content appears to be low.

OTHER OCCURRENCES OF IRON FORMATION

In Michipicoten River area, iron formation has been reported by Coleman and Moore[1] at the following localities:

(1) North of Peter Lake. The formation is 350 yards long, 20 yards wide, and strikes 105 degrees.

(2) Near the southwest end of Peter Lake.

(3) At each end of Island Lake. The occurrence near the portage at the south end of Island Lake may possibly be a continuation of the Fenton Lake iron formation.

(4) On the old "tote" road from The Mission to Great Lake.

(5)

> "A quarter of a mile from the west end of Lake Mishewawa (Deep Lake) there is a band of iron range rock, a continuation of the band which Dr. Coleman had already examined for some distance. The strike is directly northwest and the dip 90 degrees. It holds an average width of about one-quarter of a mile, cutting across the country to Magpie River. It crosses Michipicoten River just below High Falls and passes The Mission in Simon's Hill just north of the village. Some parts show little iron, while in others banded silica and carbonates are found."

This band was examined by the present writer. It consists largely of bedded tuffs and other sediments, commonly without the dense silica layers of the iron formation; at a few places it contains considerable magnetite or carbonate but much less than the poorest typical Keewatin iron formation.

[1] Coleman, A. P.: Iron Ranges of Eastern Michipicoten with Additional Notes by Dr. E. S. Moore; Ont. Bureau of Mines, vol. 15, pt. 1 (1906).

PALMAROLLE AND TASCHEREAU MAP-AREAS, ABITIBI COUNTY, QUEBEC[1]

By A. H. Lang

CONTENTS

INTRODUCTION

Palmarolle and Taschereau maps form part of a series of maps of Rouyn-Harricanaw region published on a scale of one inch to one mile. Palmarolle area extends from the interprovincial boundary to longitude 79°00′ between latitudes 48°30′ and 48°45′. Taschereau area adjoins and lies east of Palmarolle area, being bounded by longitudes 78°30′ and 79°00′, and latitudes 48°30′ and 48°45′. Taschereau area is traversed by the Canadian National (National Transcontinental) Railway and by the branch line from Taschereau Station to Rouyn. The village of Makamik is in the northeast corner of Palmarolle area and the northwest corner of Taschereau area. The Makamik highway, extending from Noranda to Makamik, lies close to the junction of the two areas, and a good automobile road extends, close to the railroad, from Makamik to Amos and Senneterre situated east of Taschereau area. The northern parts of both areas, where farming is important, are well served with roads, most of which are gravelled and over which an automobile can travel.

The vicinity of the Beattie mine, which is at present the most active mining section in the areas under discussion, may be reached in several ways. A good water route suitable for canoes, launches, and scows extends southward from La Sarre on the Canadian National Railway via La Sarre River, Lake Abitibi, Duparquet River, and Lake Duparquet. Only one short portage occurs on this route, at Dancing Rapids where a track and push truck are maintained. A road leads from the landing at Lake Duparquet to the Beattie mine, a distance of about one mile. A winter road extends from the settled district around the village of Palmarolle to the mine. A motor road from the Makamik highway to the mine was commenced in 1932 and should be completed early in 1933. A railway to the mine is now under construction from Destor Station on the Rouyn branch of the Canadian National Railway, and is expected shortly to be in condition for temporary service. Excellent airplane transportation is maintained from bases at Rouyn and Amos.

[1] The Palmarolle and Taschereau map sheets are now in process of reproduction. Meanwhile photographic copies of that part of the Palmarolle sheet covering parts of Duparquet and Dester Townships can be supplied at a nominal price to cover cost of colouring by hand, etc.

Geological reconnaissances were made in the district in general by Walter McOuat in 1872, J. F. E. Johnson in 1909, W. J. Wilson in 1910, M. E. Wilson in 1910 and 1911, and T. L. Tanton in 1914 and 1915. Messrs. Wright and Segsworth made a private reconnaissance in 1924 and suggested, in a paper published that year, the extension of the Porcupine type of mineralization into Quebec. In 1925 and 1926, B. S. W. Buffam mapped the geology of Palmarolle and Taschereau areas in considerable detail, and some work was done in these areas by W. F. James and J. B. Mawdsley. Some of the results of this work were published in the form of a report on Destor area, and some were incorporated in a memoir on Rouyn-Harricanaw region and the accompanying 4-mile map.

The base maps available at the time of Mr. Buffam's work were very incomplete. Since that time vertical air photographs were taken by the Royal Canadian Air Force, additional land surveys were made, and a new base map was complied by the Geological Survey from all available information. Before entering the field, the writer made a stereoscopic study of the air photographs and plotted the position and shape of rock exposures on the base map. The field work done by the writer in these areas during 1932 consisted in adjusting previous traverses to the new base, which necessitated re-examining many of the exposures, examining additional exposures found on air photographs, and in studying the critical region adjacent to the Beattie mine. In this work he was ably assisted by Messrs. B. C. Freeman, J. R. Bridger, and A. W. Johnston.

Since detailed descriptions of the general features, physiography, and geology of the district are contained in the report by Buffam and in the memoir dealing with the Rouyn-Harricanaw region, the purpose of the present report is merely to give a general description of these subjects, and to present such additional information as was obtained in 1932.

The writer desires to give full credit to the work of Mr. Buffam, to which his own field work was purely supplementary. For information and many courtesies he is greatly indebted to Mr. A. J. Keast, manager of the Beattie mine, to members of Mr. Keast's staff, to Messrs. W. F. James, B. S. W. Buffam, and R. H. Taschereau, and to Professor J. J. O'Neill, who was making a detailed study of the Beattie property for the Quebec Bureau of Mines.

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PHYSICAL FEATURES

Palmarolle and Taschereau areas lie within the clay belt, and are somewhat below the general level of the Canadian Shield. These areas and the district in general may be divided into three main physiographical divisions: the clay lowlands; sand-plains and morainal hills and ridges; and the rocky uplands. The lowlands comprise at least three-quarters of the areas and have a general elevation of about 1,000 feet above sea-level with a gently rolling slope to the northwest. They form the settled sections in the northern and central parts of the two map-areas, where mixed farming is pursued, principally in the townships of La Reine, La Sarre, Royal-Roussillon, Languedoc, Roquemaure, Palmarolle, Poularìès, Privat, and that part of Launay not covered by sand. In these townships rock outcrops are generally scarce, being found only along the shores of the large lakes and as small, rocky knolls protruding from the clay.

The most extensive deposit of sand, ground moraine, and eskers is in the northeastern part of Taschereau area, including parts of Privat, Languedoc, Guyenne, Launay, and Manneville Townships, and continuing north of the map-area. Very few rock exposures are found in these sections. Considerable parts of Roquemaure and Hébécourt Townships are covered by these deposits. A series of beach deposits at successive levels occurs in the southern part of Poularìès Township. Small hills and ridges composed of sand, gravel, and boulders occur at various points within the general areas of clay lowlands, in many places surrounding rock outcrops, and parts of the general area of the rocky uplands are covered with gravel and boulders.

The rocky uplands are represented by a range of relatively high rock hills extending along the southern boundaries of both map-areas, being known as Destor Hills in Palmarolle area and Abijevis Hills in Taschereau area. The elevations of these hills have not been precisely determined, but they vary up to 500, or in some cases 700, feet above the lowlands. In general they have abrupt, rugged slopes and many have glacially rounded summits. They present large exposures of bare rock, particularly since recent fires have removed much of the vegetation. Besides the general east-west trend of the whole range, those individual hills and ridges that are composed of Keewatin or Timiskaming rocks have a decided east-west elongation parallel to the strike of these formations.

An interesting physiographical feature is the Robertson-Vaudray depression, a narrow gorge extending from Lake Robertson due south in an almost straight line to Lake Vaudray, some 30 miles south of the map-area. This gorge cuts across Abijevis Hills, and contains several, small, narrow lakes. This depression suggests an origin due to erosion along a fault zone, and there is some evidence of faulting along the line south of Taschereau map-area. Within the area a well-defined band of tuffs crosses the depression without any apparent displacement, so that the faulting seems to have died out to the north, making the northern end of the depression resemble a fracture zone rather than a fault zone.

The following elevations of several points in the areas are taken from various authorities. Precise levels: Launay 1,067 feet; Taschereau 1,015;

Robertson Lake, high water 1,005; Authier 1,005; Makamik 933; Bassiguac siding 954; Lois siding 1,029. Subject to revision: Lake Abitibi 865; Lake Hébécourt 890; Lake Duparquet 885; Lois Lake 995.

The height of land crosses the southern and eastern boundaries of Taschereau area, therefore only a small part of the area, including parts of Destor, Aiguebelle, Manneville, and Launay Townships, is tributary to the St. Lawrence system. The remainder of both areas is tributary to Hudson Bay via the Abitibi drainage system. Since most of the streams flow through the soft clay lowlands they consist of long, sluggish, meandering sections interrupted by occasional falls and rapids.

Most of the lakes occupy flat depressions in the lowlands, and, therefore, are exceedingly shallow. The larger of these are Lakes Abitibi, Duparquet, Hébécourt, Lois, and Robertson. The shoreline of Lois Lake is drowned, owing to a dam on Lois River. Lakes of different types are represented by the small, narrow lakes in the Robertson-Vaudray depression, of which Lakes Genest and Saulx are examples.

GENERAL GEOLOGY

All of the rocks in Palmarolle and Taschereau areas, with the possible exception of some of the later gabbro dykes, are of early Precambrian (pre-Huronian) age. Altered volcanic rocks of the Keewatin series underlie about two-thirds of both map-areas. These are dominantly flows originally of andesitic composition, now generally chlorite schists in various stages of alteration and schistosity. Tuffs and breccias are found occasionally in beds up to 10 feet wide interbedded with the flows. In addition, what is believed to be a younger formation of the Keewatin series, consisting chiefly of tuffaceous sediments, occurs as synclinal remnants apparently conformable with the older, dominantly extrusive, Keewatin rocks. A band, consisting chiefly of conglomerate including greenstone pebbles, occurs apparently as a synclinal remnant along the southern boundary of Palmarolle area. These rocks rest unconformably on the greenstones and are believed to be younger than the tuffaceous sediments. For this reason and on lithological grounds they are correlated with rocks occurring south of Rouyn which are grouped with the Timiskaming series.

A few, small, irregular masses of quartz diorite form what are believed to be the oldest intrusives in the area. The greenstones are intruded by composite batholiths consisting chiefly of hornblende syenite, grey granite, and pink porphyritic granite, with minor amounts of more basic rocks resembling diorite and granodiorite but too altered for accurate determination. These batholiths are surrounded by broad, transitional zones of highly metamorphosed "hybrid" rocks. A fairly large body of feldspar porphyry and several smaller intrusions of both feldspar and quartz porphyries occur in the southern part of Palmarolle area. The larger body is in contact with the Timiskaming sediments, and it has previously been considered that the conglomerate contained boulders of the porphyry, and, therefore, that the porphyry was older than the sediments. As explained below, the writer is of the opinion that the porphyry replaced the conglomerate, and hence is younger than the Timiskaming sediments. The relationship of the porphyry to the granitic rocks is not known, since they occur in separate localities. The volcanic and granitic rocks are cut by dykes of basalt and lamprophyre, and the youngest rocks in the areas are quartz gabbro (later diabase) dykes.

Table of Formations

—	Series	Description
Quaternary..........	Post-Pleistocene.........	Lacustrine clays and sands
	Pleistocene..............	Morainal material
Great unconformity		
Precambrian.........	Probably pre-Huronian...	Quartz gabbro dykes
	Pre-Huronian intrusives	Basalt and lamprophyre dykes Quartz porphyry Feldspar porphyry Porphyritic granite Granite and granite-gneiss Hornblende syenite Peridotite and dunite Older gabbro (quartz diorite)
		Intrusive contacts
	Timiskaming series......	Chiefly conglomerate, with some slate, arkose, and quartzite
	Keewatin series..........	Chiefly tuffaceous sediments
		Chiefly altered andesite, with some altered rhyolite, dacite or trachyte, basalt, and minor amounts of tuffs and breccias

KEEWATIN GREENSTONES

Most of the Keewatin rocks of Palmarolle and Taschereau areas are much folded lavas, most of which show evidence of an originally andesitic composition. The individual flows vary in thickness from about 3 to 300 feet. Pillow structure is common, individual pillows being up to 7 feet long. A band of porphyritic andesite about 300 feet wide and containing phenocrysts of saussuritized feldspar can be traced for about 14 miles in Destor and Aiguebelle Townships, and lies about 2 miles south of Lois Lake. Altered rocks which appear to have been rhyolites, trachytes or dacites, and basalts are much less common than the altered andesites. In some cases it has not yet been possible to determine whether some outcrops of quartz porphyry and rhyolite are flows or small intrusives, and the same applies to certain more basic rocks which may be either flows or sills. Volcanic breccias containing angular fragments of andesitic composition are common in Launay Township. Banded iron formation is not common, but a few, narrow bands of chert and jasper interbedded in andesite occur on the south shore of Lake Abitibi near the interprovincial boundary.

UPPER KEEWATIN TUFFACEOUS FORMATION

Bands of altered, fine-grained, thinly bedded tuffs occur at several places in the areas. The strike of the beds is generally northwest-southeast, with steep or vertical dips. They conform to the strike of the lavas as well as the latter can be determined in the vicinity of the tuffs, and there is no evidence of an unconformity between the lavas and the tuffaceous formation, therefore the latter is considered to be the upper member of the Keewatin series, most of which has been removed by erosion and which is now represented only by these synclinal infolds.

The chief occurrence, known as the Privat band, extends from the Desmeloizes map-area through the village of Makamik, continuing diagonally across the townships of Royal-Roussillon, Poulariès, Privat, and Manneville, a distance of some 25 miles in Taschereau area. The band has an average width of one-half mile, is very finely bedded, and consists chiefly of fine fragments of chlorite, epidote, and plagioclase. The rocks are often replaced by ferruginous dolomite and show various stages of schistosity.

Altered tuffs having the same general composition as those of the Privat band outcrop in places in Languedoc and Guyenne Townships, but are not sufficiently well exposed to be traced definitely. In the western part of Languedoc Township these beds strike in a southeasterly direction roughly parallel to the Privat band, but some outcrops were found in the eastern part of the township striking northeasterly. The few outcrops of tuffs in Guyenne Township strike southeasterly. This information suggests the presence of a major drag-fold.

Two small bodies of altered tuffs occur along the northern boundary of Palmarolle area. Of these the western one, which occurs in La Reine Township, is metamorphosed and deformed by the La Reine granite, and was mapped as hybrid rock.

A poorly exposed band of altered sediments lies between the mouth of Duparquet River and the Beattie mine. These rocks are exposed in places along the north shore of Lake Duparquet, but exceedingly few outcrops are found north of the shore, the land being very flat and heavily covered with overburden. This unit consists of schistose and carbonatized tuffs and altered rocks resembling phyllites, and includes an exposure of deformed conglomerate just at the mouth of Duparquet River. This conglomerate is at the position where a synclinal axis is thought to occur, so that it may represent an infolded remnant of the Timiskaming series. On the other hand, the conglomerate may be a member of the main body of sediments, but in any case its presence is not considered sufficient reason for classifying the whole body of sediments as Timiskaming, and because of their lithological similarity they are correlated with the Keewatin tuffaceous sediments. The relationship of these rocks to the nearby band of Timiskaming sediments is obscured by the intervention of the porphyry intrusion with its altering effect on the surrounding rocks, and by the limited number of outcrops. The width of the band of supposedly Keewatin sediments becomes narrow at the mouth of Duparquet River. The nearest outcrops across the lake are altered lava, but no outcrops are found immediately opposite the sediments. The available information suggests that the strata lie in the nose of a southeastward pitching syncline, but, on the other hand, it is possible that faulting has occurred along the course of Duparquet River.

In the single crosscut existing in 1932 at the Beattie mine the north wall of the ore-body consists of highly altered, banded rock believed to be part of the tuffaceous formation. These rocks are not found at the surface at this point because of overburden. A few outcrops of highly altered sediments occur south of the porphyry, and in some cases are so altered that it is not known whether they are Keewatin or Timiskaming.

TIMISKAMING SERIES

A band consisting chiefly of conglomerate extends along the southern boundary of Palmarolle area from the vicinity of the Beattie mine eastward. Near the Makamik highway it branches and continues a short distance into Taschereau area. The band is ½ to 1 mile wide, only part of this width being in the areas under discussion. A band of slate 15 to 100 feet wide occurs south of the Duparquet mine, forming a natural boundary between the sediments much replaced by porphyry and the relatively unaltered sediments lying to the south. The latter consist chiefly of coarse conglomerate, but also contain some arkose grading in places into quartzite.

"OLDER GABBRO"

Small, irregular bodies of quartz diorite, generally known in the district as "Older Gabbro," occur, particularly near Duparquet Lake and in Hébécourt Township. There are probably more of these small bodies than are shown on the map, because the rocks are poorly exposed in Hébécourt and Roquemaure Townships, and the boundaries are probably more irregular than the limited exposures allow to be mapped. These intrusives are part of a swarm of Older Gabbro bodies extending northward from the Nipissing Central Railway to Hébécourt and Duparquet Townships, dying out to the north and to the east. In other areas these rocks have been found to be the oldest of the pre-Huronian intrusives.

BASIC INTRUSIVES

A body of serpentinized dunite occurs at the southern edge of Taschereau area about 1½ miles east of the north-south centre-line of Destor Township. This consists almost entirely of serpentine, which is apparently secondary after olivine. Buffam states that the rock is "strongly magnetic, and when tested from chromium gave a negative result." A small body of peridotite consisting essentially of hornblende is found in Lots 37 to 40, Range II, Poulariès Township, and a somewhat similar occurrence is in Lot 29, Range I, Roquemaure Township.

No definite information regarding the ages of the basic rocks having been found in the map-area, Buffam correlated them tentatively with similar rocks in Ontario which are younger than the Older Gabbro and which are generally supposed to be older than the granites.

GRANITIC AND SYENITIC INTRUSIVES

About one-third of the total area of both map-areas is underlain by syenite and granites of several types. The oldest of these is hornblende syenite, which is followed by the older granites. A fresher-appearing, porphyritic granite is considered to be the youngest major intrusive in the areas. Because these rocks occur together in complex assemblages they will be described according to their geographical distribution instead of in chronological order.

The La Reine batholith is a relatively small, poorly exposed body of granite-gneiss occurring in the northwestern corner of Palmarolle area north of Lake Abitibi. The rock has a pronounced gneissic structure and consists of quartz, orthoclase, microcline, plagioclase, and biotite, the feldspars being much altered. Similar rocks are exposed at the northwest end of Nepawa Island, at the narrows between this island and the mainland, and on La Sarre River in the northwest corner of Palmarolle Township.

A small quantity of hornblende granite occurs in a narrow zone at the west side of Nepawa Island.

The Palmarolle composite batholith forms the largest area of intrusives, but is in general poorly exposed. It stretches from Lake Abitibi across the Makamik highway and extends for about 4 miles into Taschereau area. Because the contacts are mantled by overburden it has not been possible to determine whether all of the members of this complex are separate intrusions cutting one another or whether some of them are gradational phases of the same magma. Hornblende syenite occurring in the northern part of Palmarolle area, chiefly in La Sarre and Royal-Roussillon Townships, is considered to be the oldest member of the complex, since it is cut by stringers of granite. It is an even-grained rock having a grain size of 2 to 3 mm., consisting chiefly of albite and oligoclase-andesine with a relatively large amount of hornblende.

A grey granite (grain size, 2 to 4 mm.) is poorly exposed across much of Palmarolle and Poulariès Townships, and is probably the largest component of the Palmarolle batholith. The rock consists of quartz, orthoclase, albite-oligoclase, hornblende, and biotite. The southeastern part of the batholith, near the Makamik highway, contains much pinkish, porphyritic granite, stringers of which cut the grey granite. At the southern edge of the batholith are bodies of dioritic or granodioritic rocks and peridotite, in which the percentage of hornblende is greatly increased, as well as dykes of quartz porphyry and feldspar porphyry. To the south the batholith grades into the greenstones through a broad, transitional zone of schistose hybrid rocks.

The Robertson Lake batholith occupies a large area surrounding the town of Taschereau. It consists chiefly of porphyritic granite with phenocrysts of glassy quartz up to one inch in diameter, pinkish orthoclase, microcline, albite-oligoclase, biotite, and hornblende, the latter increasing toward the margin of the batholith. This granite is probably to be correlated with the porphyritic granite of the Palmarolle batholith, and is believed to be the youngest of the major granitic intrusives. The Robertson Lake batholith is bordered by a broad, transitional zone of highly altered volcanics intruded by granite, syenite, gabbro, amphibolite, and quartz veins.

FELDSPAR PORPHYRY

The principal body of feldspar porphyry occurs near the centre of the southern boundary of Palmarolle map-area, extending for nearly 3 miles between the Beattie mine and the Duparquet mine. The rock has a purplish red colour and varies in grain from aphanitic through various phases to augen porphyry and lath porphyry with feldspar phenocrysts up to 1 inch in length having parallel orientation. In places these phases seem to grade into one another, whereas in others the lath porphyry appears to cut the finer-grained phases. The constituents are altered orthoclase and plagioclase. According to Buffam's determination, the phenocrysts are anorthoclase. The rock is both altered to sericite and kaolin, and silicified by the mineralizing solutions that formed the Beattie ore-body.

This porphyry body was intruded along what is considered to be a synclinal axis, and at least along the margins of the intrusive it appears to have replaced the sediments rather than to have forced them aside. To the north it is bounded by the silicified zone forming the ore-body. Elsewhere the tuffs and conglomerate near the margin of the mass appear to have been soaked and replaced by feldspathic solutions, forming hybrid rocks having the general appearance of the porphyry and yet displaying some of the characters of the original sediments. Buffam believed that a band of altered Timiskaming conglomerate near the Duparquet mine, and lying immediately north of the band of slate already described, contained boulders of the porphyry. He called this the "porphyry conglomerate," and considered that it was deposited on the eroded surface of the porphyry, and, therefore, that the porphyry was of pre-Timiskaming age. In 1932 some stripping gave rather good exposures of this zone, and the writer was unable to find any definite boulders of the porphyry. He is of the opinion that the matrix and some of the boulders of the conglomerate have been replaced by porphyry. This hypothesis was supported by the discovery of a dyke of the porphyry cutting these hybrid rocks. Therefore, both the feldspar and quartz porphyries are believed to be post-Timiskaming in age, but their relationships to one another and to the granitic intrusives are unknown.

QUARTZ PORPHYRY

Small dykes and bosses of quartz porphyry occur at various places in the southern parts of the map-areas, principally near the syncline of Timiskaming sediments. These rocks consist of quartz phenocrysts up to ½ inch in diameter in a fine-grained, greenish grey, feldspathic groundmass.

BASALT AND LAMPROPHYRE DYKES

These dykes occur at various localities, cutting both volcanic and granitic rocks. They are particularly common in the western part of Poulariès Township, and are in all cases too small to indicate on the map.

LATER GABBRO DYKES

Quartz gabbro dykes, often referred to as the later diabase, occur at various localities in the area and can sometimes be traced for considerable distances. In other districts these dykes have been divided into quartz gabbro and olivine gabbro (diabase) dykes, some of pre-Huronian age and some of post-Huronian (Nipissing) age. No definite olivine diabase dykes have been found in Palmarolle and Taschereau areas, and since no Huronian sediments occur in these areas, the age of the existing quartz gabbro dykes is not known definitely, but they are undoubtedly the youngest rocks in the areas.

ECONOMIC GEOLOGY

To date there have been no producing mines in either Palmarolle area or Taschereau area, but being situated within the general belt of early Precambrian volcanic and sedimentary rocks in this part of Ontario and Quebec where gold, copper, and other mineral deposits have been discovered and mined, and lying only some 25 miles north of the Noranda mine, considerable prospecting and development work has been performed in recent years, particularly in the southern part of Palmarolle area. The Beattie mine, located near Duparquet Lake, has recently been the scene of extensive development which has indicated a large, low-grade, gold ore-body, and the mine is expected soon to be producing.

The mineral deposits discovered to date are gold-quartz veins, shear zones, and replacements, containing disseminated sulphides. No massive sulphide replacements have been discovered. What are at present the most important of the gold-quartz deposits are located in or near the synclinal infold of sedimentary rocks at the southern edge of Palmarolle area, and are associated with intrusions of porphyry. Most of the remaining mineral occurrences are veins and shear zones located in or near the transitional zones bordering the granitic complexes. Development work on these latter types appears to have been disappointing, but these transitional zones would seem to be favourable prospecting localities, although probably not as favourable as the vicinities of the porphyries. The following localities and considerations are thought to be worthy of the attention of prospectors.

(1) *Duparquet Syncline.* The vicinities of the known bodies of porphyry are the most obvious localities for prospecting. The feldspar porphyry seems to be more favourable than the quartz porphyry, but any fair-sized bodies of the latter might repay investigation. Since the porphyry occurrences are generally small, and since much of the area is covered with soil and vegetation, it is probable that there is more porphyry than is now known. Therefore, prospecting might be directed toward the discovery of additional porphyry, and though this might occur anywhere, the most likely locality is in or near the syncline in Destor and Duparquet Townships, and its possible continuation into Hébécourt Township.

(2) *Synclines of Tuffs in Northern Parts of Palmarolle and Taschereau Areas.* Since the Duparquet syncline appears to be a zone of weakness favourable for porphyry intrusions and mineralizing solutions, it might

not be unreasonable to expect these phenomena along the other synclines. This point is mentioned, although no porphyry is known to have been found in these belts.

(3) *Borders of Granitic Masses.* If veins or replacements are associated with granitic bodies, mineralization is most commonly found near the boundaries of the intrusives. Though veins are associated with any type of granitic rock, those containing metals are most likely to be associated with the more basic types such as granodiorite and diorite. Therefore, at or near the contacts of these types with volcanic rocks would seem to be the most favourable places for sulphide replacement deposits, and quartz veins containing metals might be found near the boundaries of such intrusives, either in the intrusives themselves or in the older intrusives or other rocks which they cut.

MINERAL OCCURRENCES

Since the Beattie mine was the subject of a special study by Prof. J. J. O'Neill for the Quebec Bureau of Mines, this property was not studied in detail by the writer. However, it seems advisable to describe it briefly in order to show its relationship to the geology and mineral possibilities of the district. Many claims have been staked in Palmarolle and Taschereau areas, but only those on which most development work has been done will be described, these being listed according to the townships in which they occur. In the cases of properties now idle, where workings could not be examined because of water and debris, information has been obtained from the annual reports of the Quebec Bureau of Mines.

Duparquet Township

Beattie Mine. The property of the Beattie Gold Mines, Limited, is located about 1 mile northeast of Duparquet Lake and approximately 9 miles east of the Makamik highway. The means of communication have already been described. The claims include the western part of the main feldspar porphyry mass, the ore-body consisting of a siliceous replacement zone along the northern boundary of the porphyry, containing finely disseminated pyrite, a little arsenopyrite, and evenly distributed gold, which is practically always invisible to the naked eye.

The original claims were staked by John Beattie in 1910, about the time of the construction of the National Transcontinental Railway. Surface work was done in 1924 when the property was optioned by the Victoria Syndicate. Diamond drilling was done in 1928 and 1929 when the property was under option to the Consolidated Mining and Smelting Company. In 1930 John Beattie made a new discovery 1,000 feet west of the old workings. The property was later optioned by Ventures, Limited, who conducted an extensive program of diamond drilling. This indicated an ore-body at least 1,158 feet long having an average width of 107·9 feet; estimated to contain 5,000,000 tons above the 500-foot horizon averaging \$3.07 a ton in gold, 3,000,000 tons of which averaged \$3.50 a ton.[1]

[1] Ann. Rept. Quebec Bureau of Mines, 1931.
Robinson, A. H. A.: "Gold in Canada"; Mines Branch, Dept. of Mines, Canada, 1932.

Beattie Gold Mines, Limited, was incorporated late in 1931, Ventures, Limited, holding 50 per cent of the stock and Nipissing Mines Company, Limited, holding 40 per cent. A development shaft was sunk on the ore-body and crosscuts were driven to each wall on the 220-foot level. Sampling of these crosscuts indicated that at least for these sections the grade of the ore was considerably higher than the average calculated from drilling. During the summer of 1932 a 5-compartment shaft was commenced in the foot-wall of the ore-body, and was at a depth of 350 feet in January, 1933. Excellent mine buildings have been constructed, the mill is nearly completed, and the mine is expected soon to be producing on a large tonnage-low cost basis.

Beattie Island. Beattie Island, a small island in Duparquet Lake, was staked about 1910 by John Beattie. Most of the island consists of Older Gabbro cut by fine-grained, basic dykes and numerous faults. At the northern end of the island a sheared zone in altered greenstone contains quartz, pyrite, and some chalcopyrite, accompanied by much carbonate alteration. Some gold values are said to occur. The zone strikes about north 15 degrees west, dipping steeply to the south. It is exposed by test pits, and some drilling was done during the winter of 1931-32. The main part of the zone where most of the work has been done is about 10 feet wide. The shearing extends over a greater width which could not be determined definitely, but mineralization appears to occur irregularly.

Rochester-Springer Group. This group of claims is situated immediately east of the Beattie property, and geological conditions are in general similar to those on the Beattie, mineralization occurring at the northern boundary of the porphyry. The property was optioned to Aconda Mines in 1929, when 1,721 feet of drilling was done. Further drilling and surface work were done in 1931.

Duparquet Mining Company. This company owns a large block of claims at the eastern extremity of the porphyry mass. A good deal of development work was done in 1929, but the workings could not be examined because they were filled with water. A small, inclined shaft was sunk to about 50 feet on quartz veins or lenses said to have contained some gold. A 2-compartment shaft situated 250 feet northeast of the former was sunk to a depth of 195 feet and 2,400 feet of lateral work was done on the 175-foot level. "Several small lenses of quartz, some fairly well mineralized, were encountered, but as a whole, results were disappointing, and operations were discontinued in the fall of 1921".[1] Some diamond drilling was done in 1931.

Hugh Park Claims. Mr. Park controls a large block of claims to the south of the three above-mentioned properties. Most of this ground lies south of Palmarolle map-area. Stripping and diamond drilling were done in 1932 at a point just south of the map-area where some quartz-pyrite mineralization is associated with porphyry and conglomerate.

Corbett-Bergeron Group. These claims are located in the northeast quarter of the township, in and near the transitional belt between the

[1] Ann. Rept., Quebec Bureau of Mines, 1929, p. 130.

Palmarolle batholith and the greenstones. The property is reached by a wagon road from the Makamik highway, a distance of about 6 miles. In 1931, 2,000 feet of drilling was done on a silicified and carbonatized zone in sericite schist containing fine-grained pyrite and chalcopyrite. The gold content is unknown to the writer.

Dugoss Mines, Limited. Some drilling was done by the Consolidated Mining and Smelting Company in 1931 on these claims, which are situated near the Corbett-Bergeron group in and near the transitional rocks bordering the Palmarolle batholith.

Paragon Gold Syndicate. These claims adjoin the Corbett-Bergeron and Dugoss groups. Three drill holes, totalling 1,955 feet, have been drilled in a shear zone in altered greenstone containing pyrite and some chalcopyrite. The gold content is unknown.

Destor Township

Makamik Mines, Limited. This company did development work in 1927 on a large group of claims situated near the Makamik highway in and near the transitional zone south of the Palmarolle batholith. The claims include several quartz veins, lenses, and shear zones in deformed rock, the quartz containing small quantities of pyrite, pyrrhotite, and chalcopyrite. As far as the writer was able to learn, gold values were very low. Over 2,000 feet of diamond drilling is reported to have been done, and a 30-foot test pit was sunk on the largest vein. These claims are now registered in the names of various individuals. Granite and an altered rock resembling granodiorite are exposed on the northern claims of this group.

Dussault Group. This group is located about 2 miles east of the Makamik highway, in the transitional zone at the southeastern end of the Palmarolle batholith. Underground work was done in 1930 by the Abacourt Mining Corporation, Limited, a subsidiary of the Duparquet Mining Company. This consisted of a 2-compartment shaft 120 feet deep with lateral work at the 112-foot level on a quartz vein or shear zone containing some chalcopyrite. These workings could not be examined because of water, and the values are unknown.

Destor Mines, Limited. The claims developed in previous years by this company lie west of Lois Lake, and are reached by a wagon road from the Makamik highway, a distance of about 3½ miles. The claims are situated in a broad, transitional zone of altered greenstones at the southeastern margin of the Palmarolle batholith. Trenching in 1926 is reported to have exposed a lenticular body of quartz for a distance of 42 feet, this body being about 7 feet wide, containing some pyrite and chalcopyrite. Five holes, totalling 1,231 feet, are reported to have been drilled in 1928.

Launay Township

L. Bergeron's Claims. These claims are located in Lot 4, Range 7, on granitic rocks of the Robertson Lake batholith. A vertical quartz vein averaging 20 feet in width, striking north 12 degrees east, is exposed for about 200 feet, and was stated to have been traced to other outcrops. The quartz contains a small quantity of disseminated pyrite and molybdenite, together with low gold values.

Lots 17 to 24, Range I; Lots 21 to 24, Range II. Wendt-Wriedt Consolidated Mines, Limited, in 1928, performed surface work on claims having the above location. Quartz veins and stringers containing disseminated pyrite are reported to occur in a shear zone about 150 feet wide in altered volcanic rocks.

Privat Township

J. A. Dubreuil's Claims. These claims are situated in and near the band of tuffs referred to in this report as the Privat band. The claims are located west of Lake Genest, in Lots 45 to 51, Range III. Some quartz-pyrite-tourmaline-carbonate mineralization occurs irregularly in altered tuffaceous rocks. The gold content is unknown.

Languedoc Township

"Philitot Mine." This property consists of thirteen claims staked by F. and R. Clement in Range II, Languedoc Township. The mineralization consists of irregular replacements of pyrite and some chalcopyrite in much sheared and altered volcanic rocks. The mineralization had not been sufficiently uncovered at the time to permit of a systematic examination.

WASWANIPI LAKE AREA, QUEBEC[1]

By A. H. Lang

CONTENTS

INTRODUCTION

This report is based on field work done during the summer of 1931. Waswanipi area includes 5,500 square miles in Abitibi Territory, between latitudes 49 degrees and 50 degrees, and longitudes 76 degrees and 78 degrees. The southern boundary is approximately 45 miles north of Senneterre on the Canadian National Railway some 200 miles east of Cochrane. The northwestern corner is about 100 miles southeast of James Bay. Bell or Nottaway River, which crosses the railroad at Senneterre, flows northward through Waswanipi area, draining all of it. Owing to recent attempts to establish a fish industry at Mattagami, Gull, and Waswanipi Lakes, a launch service has been operated sporadically between Senneterre and Mattagami Lake and the fishing companies have built iron-shod tracks equipped with push-trucks at the eleven portages on the route. An excellent water route extends from Mattagami Lake to Waswanipi Lake. The only portage that must always be made is at the Red Chute, at the outlet of Lake Olga. In high water a shorter route to Waswanipi Lake is via Wedding River, from the headwaters of which a long portage extends to Otter Creek. Instead of descending Bell River from Senneterre, Laflamme River may be followed from Barraute, joining the Bell at Kanikwanika Island.

Within the last few years seaplanes have been used to a considerable extent for transportation into Waswanipi area from bases at Senneterre and Amos. The flight from Senneterre to Waswanipi Post required about an hour. The area contains numerous lakes suitable for landing, and landings can be made at several places on Bell River.

Previous geological work in Waswanipi area has consisted of reconnaissances along the principal waterways, the present mapping being the first attempt to examine the smaller lakes and streams or to make land traverses. During the course of the work, the shores of all lakes and streams navigable by canoe were examined in so far as time permitted, but land traverses were made only in strategic places. Seaplanes were used very successfully from time to time for transporting personnel and

[1] Hand-coloured photographic copies of the map of Waswanipi area, on a scale of 4 miles to 1 inch, can be supplied at a nominal charge covering cost of production.

supplies, and for reconnaissance. By this means lakes and streams were sketched, prominent outcrops were located approximately, and areas of drift and muskeg were eliminated. Thus, not only was time saved in travelling, but the ground work was controlled more intelligently than would otherwise have been possible. A number of very small lakes, unconnected by navigable streams, were visited with a Bellanca seaplane capable of taking-off in very short distances, a rubber air-raft being used for examining the shores.

The work was greatly facilitated by the Royal Canadian Air Force, the writer acknowledging most gratefully the courtesies and co-operation extended by several of its officers, and in particular by the pilot, Flying Officer R. K. Rose. He also wishes to acknowledge courtesies rendered by Fortin Frères and other residents of Senneterre, officials of the Hudson's Bay Company at Senneterre and Waswanipi, and employees of Commercial Fisheries, Limited. Officials of the Quebec Bureau of Mines and Department of Lands and Forests generously supplied maps and information, and Dr. John A. Dresser was kind enough to give data on the mineral occurrence at Mount Laurier. It is a pleasure to record the efficient service of the field assistants, M. H. Haycock, C. Riley, J. R. Bridger, and C. S. Longley.

GENERAL CHARACTER OF THE DISTRICT

In general the area is one of very low relief sloping gently to the northwest, the average elevation being between 650 and 700 feet above sea-level. A belt of much higher relief occurs near the centre of the area, and is composed of Mount Laurier and adjacent hills south of Mattagami Lake, hills south of Lake Olga, and Dalhousie Mountains south of Gull Lake. Mount Laurier, the highest point in the area, is approximately 550 feet above Mattagami Lake, and about 1,150 feet above the sea; Dalhousie Mountains are slightly lower. The only other hills of any prominence are some between Kamshigama Lake and O'Sullivan River, one near Coldbrook Creek, and Buck Hill, a rather high prominence just north of the map-area, near Maikasagi River. Except in the case of Mount Laurier, the underlying rock seems to have had little bearing upon relief, for the country has been reduced to a fairly uniform level by long-continued erosion, with only odd promontories remaining, and the flatness has been accentuated by extensive deposits of clay and sand.

The area is at the eastern edge of the clay belt, the boundary of which passes from the northeast corner of the area to Kamshigama Lake. To the east, in the vicinity of Waswanipi Lake, and Waswanipi River, the country is overlain by sands, gravels, and boulders, of glacial origin, with some clay. The lakes and streams of this eastern region are comparatively clear. To the westward there is a gradual transition to the clay belt, the lakes becoming increasingly muddy. Bell River and Mattagami Lake are particularly dirty. All of the region west of Bell River is extremely flat and covered with a thick deposit of clay. This part of the area is very poorly drained, with a great deal of muskeg, practically no rock exposures, and numerous distributaries to the streams. All the lakes are very shallow, and being in flat, drift-covered country, their shorelines have but slight geological significance. An exception to this latter statement occurs in the case of the northeastern arms of Lake Olga, which follow the trend of the schistosity of the greenstones and parallel a granite-greenstone contact. The streams are generally characterized by sluggish, meandering stretches separated at intervals by rapids.

GENERAL GEOLOGY

Waswanipi area consists of over 5,000 square miles of relatively flat country, the greater part of which is heavily drift-covered and contains few rock exposures. About one-half of the area is underlain by greenstones, chlorite schists, and other alteration products of volcanic rocks generally classed as belonging to the Keewatin series. Associated with these rocks are minor quantities of altered sediments, the relationships of which have not as yet been clearly demonstrated. The volcanic series is intruded by a large batholith of oligoclase anorthosite and a minor amount of gabbro believed to be a phase of the anorthosite. There are also small, stock-like intrusions of diabase and diorite whose relation to the anorthosite is unknown. Much of the area is underlain by granites, with some syenite and granodiorite, of which at least the major part is younger than the anorthosite. The granite-greenstone and granite-anorthosite contacts are generally transitional, with zones of hybrid rocks possessing some of the characteristics of both types. Besides dykes of dioritic type and pegmatite, associated with the granitic rocks, a few diabasic dykes were observed which are probably correlatives of the later gabbro dykes of Rouyn district. Surficial deposits of Quaternary age consist of clays, sands, and morainal material.

Table of Formations

Quaternary..........	Clay, sand, and morainal material
....	Later diabase
	Chiefly pink granite, with some pegmatite, syenite, and granodiorite; also a complex of grey, possibly older, granite, granite-gneiss, migmatites, and altered inclusions
Pre-Huronian.........	Diabase and diorite of Mount Laurier
	Oligoclase anorthosite with some gabbro
	Volcanic series: chiefly metamorphosed lavas, with some associated tuffs and other sediments and hybrid phases transitional between volcanics and intrusives

VOLCANIC SERIES

The volcanic series forms part of an interrupted belt of Keewatin rocks extending from Rouyn district to Chibougamau region. Since the volcanics of Waswanipi area are essentially similar to those, many times described, of adjacent regions, they are not described in detail in this report. Most of the volcanics occur in two principal belts, a northern belt in the vicinity of Allard River and Mattagami, Olga, and Gull Lakes, and a southern belt near Laflamme and Wedding Rivers and Kamshigama Lake.

A few occurrences of sedimentary rocks associated with the altered volcanics were found. They consist of bands or lenses of fine-grained argillite, quartzite, and tuff. Lean, banded iron formation occurs near Allard River and elsewhere. Two small bodies on the north shore of Mattagami Lake are shown on the Nottaway sheet as belonging to the Timiskaming series. These consist of a complex of conglomerate-like rocks and other highly altered rocks of sedimentary appearance, with granitic material and hybrid rocks. No definite evidence that these rocks are of Timiskaming age was observed by the writer and, therefore, they are included with the sediments and hybrids associated with the volcanic series.

Two conditions prevail near the contacts of intrusives with the volcanic series. Tongues, dykes, and stringers of granitic rock intrude the greenstone in the most irregular manner and in many cases boundaries between the two classes of rocks could be drawn only by estimating whether a given outcrop contained more or less than 50 per cent intrusive rock. In addition, the contacts in many cases are zones of hybrid rocks. The zones vary in width and in places are a mile or more broad, but in such instances granite may not be so far below the surface.

The most noteworthy examples of these altered zones are: near the eastern end of Mattagami Lake; at Red Chute on Lake Olga; along the western shore of Gull Lake from the outlet of Waswanipi River to Ramsay Bay; and in the vicinity of Iserhoff River. As a contact is approached from the intrusive side an increasing number of altered inclusions occur, and eventually the country rock grades into varieties belonging to three main types of "hybrids". (1) Fine-grained, massive to schistose, more or less banded types. These in many instances resemble sediments, but though they may include some altered sediments they are believed to be mostly altered volcanics. They consist of secondary feldspar and quartz, with some biotite and chlorite. Any banding or schistosity is parallel to the trend of the contact, as is well shown on the western shore of Gull Lake. (2) More coarsely banded types, containing fine stringers of more or less pure granitic or feldspathic material, and best described as injection gneisses or migmatites. (3) Rocks containing abundant metacrysts of feldspar of the same appearance as that in the granites. Such metacrysts are seldom more than 1 cm. in size and lie in a more or less schistose matrix of biotite, chlorite, and quartz, most of the matrix apparently representing original greenstone. Some rocks, assumed to have been originally greenstone, have been partly replaced and recrystallized so as to form a massive rock almost resembling a diorite. Lenses of quartz, with segregations of chlorite at the tips, are in places associated with these hybrid rocks. The original nature of the rock is generally completely destroyed.

DIABASIC INTRUSION NEAR MOUNT LAURIER

Mount Laurier is formed of a massive, rather fine-grained, black rock resembling diabase or gabbro. Its texture is diabasic, with phenocrysts of feldspar up to 3 mm. in length. The rock consists essentially of what seems to be altered andesine-labradorite feldspar and hornblende, the latter considerably altered to chlorite. A definite contact with the volcanics was not found, but the diabase is assumed to be a stock. A similar rock occurs in places on the south shore of Mattagami Lake. On the west side of Mount Laurier the diabase is cut by a tongue of granite. This so-called diabase bears considerable resemblance to the gabbro occurring near Bell River, which is believed to be a differentiate of the anorthosite intrusive.

DIORITE INTRUSION NEAR MOUNT LAURIER

An irregular body of dioritic rock about 1 mile in diameter occurs to the north of Mount Laurier, one outcrop at the base of the mountain apparently cutting the diabase. It is a fairly coarse-grained, somewhat porphyritic rock mottled greenish to black, and weathering to a light grey. The rock consists essentially of somewhat parallel, lath-shaped crystals of what is judged to be altered labradorite. There is considerable hornblende, and some biotite and magnetite, but practically no quartz.

ANORTHOSITE AND GABBRO

The term " anorthosite " is generally restricted to the familiar type composed of labradorite. Batholiths in Chibougamau and Waswanipi districts composed essentially of oligoclase were classed as anorthosite by early investigators, but in order to avoid confusion with the labradorite type Mawdsley gave the name " oligoclase anorthosite " to the Chibougamau occurrence.[1] A large mass of somewhat similar rock occurs near the centre of Waswanipi area, and the writer, having spent a season in Chibougamau with Mawdsley, feels no hesitation in correlating this with the Chibougamau occurrence. The pure oligoclase anorthosite of Waswanipi area is generally fine to medium grained, fairly hard, massive, and, in many places, recrystallized. The rock is cream or faintly greenish, often soapy in appearance, and weathers white or grey. It consists of rather small, altered grains of oligoclase that give the impression of having been crushed and recrystallized. Much of the pure oligoclase anorthosite in Chibougamau contains large feldspar crystals several inches in length. This type was not found in the present map-area, but may occur since only a few outcrops were found.

The relatively pure oligoclase anorthosite appears to grade into three different types. First, varieties in which chlorite increases up to a maximum of about 50 per cent of the rock. Some of this chlorite may have resulted from the alteration of ferromagnesian constituents, but most of it was probably introduced hydrothermally. The second type consists of hybrid phases developed near the contacts of later intrusions of granite and pegmatites, where the anorthosite appears to have been replaced by varying amounts of granitic material, chiefly feldspar and hornblende. The third type is gabbroic and in general similar to the contact phases found in Chibougamau district. Gabbroic rocks occur near the boundary of the Waswanipi anorthosite, notably along the lower reaches of Bell River. These are medium to coarse-grained, black rocks consisting of altered labradorite, with hornblende, pyroxene, and magnetite.

[1] Geol. Surv., Canada, Sum. Rept. 1927, pt. C, p. 8.

Some of the occurrences on Bell River, notably at Channel Rapids, are banded, with narrow zones of feldspathic material interspersed with indistinct bands in which ferromagnesian minerals predominate. Because outcrops are small and scattered, the gabbroic phases could not be definitely traced into anorthosite, but the former is believed to be a differentiate of the main oligoclase anorthosite intrusion.

Outcrops of oligoclase anorthosite occur sparingly over a distance of some 16 miles along the lower part of Bell River, where they are associated with the above-mentioned, gabbroic rock. The most westerly exposure was found on Coldbrook Creek. The country here is particularly flat and drift covered, so that the position of the boundary west of Bell River is purely hypothetical. An outcrop of hybrid anorthosite was found near the mouth of a creek at the western end of Elizabeth Bay, and a somewhat similar exposure occurs on an island near the mouth of Opaoka River. These two outcrops and one outcrop of massive, pure oligoclase anorthosite about 6 miles up Opaoka River constitute the only information concerning the anorthosite found between Bell River and Dalhousie Mountains. The anorthosite outcropping on Opaoka River is the purest that was found, and is interpreted as being in the heart of the batholith. Numerous exposures were found in Dalhousie Mountains south of Gull Lake. Here the anorthosite is intruded by pegmatite dykes and tongues of granite, and is altered near the granite contacts to a hybrid type possessing some of the characteristics of both granite and anorthosite, and having in many places a banded, gneiss-like structure. Virtually no information is available as to the position of the southern contact. From the information available it appears that the intrusive is a linear body about 6 miles wide, extending in an east-west direction for about 40 miles, and roughly on the strike of the Chibougamau occurrence. These two batholiths are approximately 100 miles apart but, nevertheless, the fact that they strike towards one another may indicate an important feature of the regional structure of central Quebec.

GRANITES AND ASSOCIATED ROCKS

About one-half of Waswanipi area is underlain by granitic rocks. Massive, pink granite is the prevailing type, but grey granite, syenite, and granodiorite occur in minor amounts, pegmatite is abundant, and one district is occupied by a complex of granite, granite-gneiss, and altered inclusions. All these rocks, with the possible exception of some of the grey granite and gneiss, are believed to belong to one general period of intrusion.

The characteristic pink granite is massive, medium grained, and much of it is porphyritic or pegmatitic. The chief mineral is altered microcline, which constitutes 60 or 70 per cent of the rock. Plagioclase, generally about oligoclase in composition, occurs in minor quantities. The amount of quartz varies from as high as 25 per cent in some granites to little or nothing in syenitic phases. Hornblende, biotite, and in some places white mica occur as minor constituents. A grey syenite from Iserhoff River consists essentially of orthoclase and microcline, with some plagioclase. The rock contains a moderate amount of hornblende and a little quartz.

The pegmatites are found chiefly around the southern parts of Lake Olga and Gull Lake, and in Dalhousie Mountains. The pegmatites range in grain size from medium to coarse grained, with crystals of pink feldspar up to 6 inches in length. The feldspar is generally pink microcline or pink orthoclase, but white microcline is also common. The amount of quartz varies greatly. Some types contain no mica, whereas others carry biotite and white mica in knots up to one inch in size. A small quantity of graphite was found in one dyke.

Granodiorite was found in some localities, notably near Carol Creek, and occurs in isolated outcrops. The relationship to the granites could not be determined, but the granodiorites are believed to be phases of the general granitic invasion. They are massive, medium grained, greenish grey to pink, and consist of about 30 per cent orthoclase and microcline, 25 to 40 per cent oligoclase-andesine, and 25 to 40 per cent quartz. Hornblende and biotite occur as minor constituents.

A complex of generally grey granites, banded gneissic rocks that are lit-par-lit injections or migmatites, and granitized inclusions of what were once probably volcanics and interbedded sediments occupies practically all the area north of Mattagami Lake and extends north of Lake Olga and Gull Lake. On some of the islands, and in places along the shore, the complex is cut by dykes of gabbroic or diabasic composition. So far as can be learned, this complex is the prevailing formation for great distances north of the map-area. The grey granite appears to be distinct from the types described in previous paragraphs, and is believed to be older, but whether or not it is older than the anorthosite is unknown.

ECONOMIC GEOLOGY

During 1928 a number of claims were staked between Mount Laurier and Mattagami Lake, and five diamond drill holes, totalling 2,000 feet, were drilled on the property of Dunlap Consolidated Mines, Limited. There was no activity here in 1931 and the writer was unable to find the mineralized zone. The camp is situated about one mile southeast of Laurier Bay on Mattagami Lake. Much of the country in the vicinity of the claims is drift covered. The rocks consist of altered lavas and irregular intrusives of diabase, diorite, and granite. It has been stated that the mineralization is found near the contact of volcanics and dioritic rock, and that the drilling showed several bands 10 to 25 feet wide impregnated with pyrrhotite and marcasite, with some chalcopyrite.

At Ramsay Bay, on Gull Lake, some pyrite and a little chalcopyrite occur over a width of at least 3 feet near a contact of granite and altered rocks of the volcanic series. An assay for gold gave negative results.

A ridge immediately south of Iserhoff River, about 1½ miles from its mouth, contains a mineralized zone about 3 feet wide, in banded schists and hybrid rocks. The zone is highly sheared, contains some pyrite, and is cut by numerous quartz lenses and stringers. A grab sample of material from several places in the zone showed no gold when assayed.

Considerable pyrite and iron stain were found on a ridge just south of Rose Lake near the contact of volcanic rocks, particularly around the boundaries of pillows in the volcanics. An assay of this material gave negative results for gold.

The area contains numerous veins and stringers of white, glassy quartz, with no visible mineralization. A sample from one of these veins, from an island in Lake Olga, showed no gold when assayed.

It is felt that the most likely regions for prospecting are in the vicinity of Mount Laurier, in the country between Rose Lake and Wedding River, and near Iserhoff River. From the air it was seen that a good deal of rock is exposed in the country between Kamshigama Lake and O'Sullivan River. This territory is rather inaccessible, but might prove worthy of prospecting. In any of these regions prospectors are recommended to search for the combination of greenstone with rocks of dioritic nature.

THETFORD DISTRICT, 1932

By H. C. Cooke

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Illustrations

CORRELATIONS BETWEEN THETFORD AND CHAUDIÈRE AREAS

During the past two field seasons the rock formations of Thetford map-area, north latitude 46° to 46°15′, west longitude 71° to 71°30′, were mapped, and have been described in the Summary Reports of the Geological Survey for 1930 and 1931. In these reports a correlation was assumed between Thetford area and Chaudière map-area about 6 miles to the east, and the names Caldwell series and Beauceville series used in Chaudière area for the supposedly Cambrian and Ordovician formations were applied to similar rocks in Thetford area. It seemed desirable, however, to determine this correlation more definitely, and, accordingly, in 1932 the Caldwell-Beauceville contact was traced eastward from Thetford area as far as the western edge of Chaudière area. All the roads, spaced about three-quarters of a mile apart, were traversed, and the position of the contact determined on each; a determination rendered easy by the pronounced petrographic difference between the two series. In addition, the distinctive basal conglomerate of the Beauceville series was found along almost all the sections. The contact of the two series trends northeast in a slightly curving line to connect with the contact as mapped in Chaudière area. The correlation of the two areas is, therefore, definitely established.

During the course of this work a large dyke of serpentinized peridotite, varying in width from 100 to 300 feet, was traced for more than 3 miles before being lost beneath drift at both ends. Throughout this distance it lies within the Beauceville series, from 500 to 1,600 feet south of the

Caldwell-Beauceville contact. Instances of peridotite cutting the Beauceville series are very uncommon; so that this occurrence is important as furnishing direct evidence that the peridotite intrusions took place after deposition of the Beauceville series.

Fossils were found this year in the Beauceville series by the writer's assistants, M. S. Hedley and A. R. Byers. The fossils, mainly of graptolites, occur in several places along the strike of some beds of a rather fine-grained blackish sandstone in Lots 11 and 12, Ranges VIII to IX, Adstock Township, about one-half mile southeast of Lac Rocheux. They were submitted to Dr. R. Ruedemann of the New York State Museum for examination. Dr. Ruedemann reports as follows:

"The faunule from Adstock Township, Beauce County, Quebec, seems to consist of only one species, presenting various shapes by compression in different angles. It is not very well preserved, but in its dimensions and thecal aspect is best comparable to *Diplograptus (Glyptograptus) euglyphus* Lapworth which occurs in our Normanskill shale. It is, however, also possible that the form is a narrow type of the *Diplograptus recurrens* Ruedemann, occurring in our Lorraine. The concavo-convex cross-section of some specimens is especially suggestive of the latter species which resembles a narrow *D. amplexicaulis* (*See* Bull. 262, p. 57). It also agrees with this species in the close arrangement of the thecae (11-12 in 10 mm.)."

Dr. Ruedemann's determinations, therefore, place the formation either in the Middle Ordovician (Normanskill, Chazy), or in the Upper Ordovician (Lorraine).

The fossil occurrences lie far within the mass of Beauceville series. The northwestern boundary of the formation is about 6 miles away, and, though the southeastern boundary is not yet mapped, Beauceville rocks are known to extend more than 3 miles southeast of the fossil localities. Unless more discoveries are made, therefore, there can be no means of knowing how much of the Ordovician system is represented in the Beauceville series; but the fossils, nevertheless, have a special value in that they are the first to be discovered in this series, and mark it definitely as Ordovician; whereas previously it could be classed as only probably of that age.

MAGNETIC INVESTIGATIONS

The months of July and August were devoted mainly to an investigation of the possibilities of discovering deposits of asbestos or chromite by prospecting with a dip needle or magnetometer. Preliminary experimental work during two weeks in 1931 had shown that asbestos-bearing areas are highly magnetic, whereas ordinary serpentinized peridotite, and also the slates, quartzites, and other country rocks of the region, are either slightly magnetic or non-magnetic. These observations suggested that the dip needle or magnetometer might be used, in drift-covered areas, to determine where asbestos-bearing areas lie.

The instrumental work of the investigation was done by Mr. A. H. Miller of the Dominion Observatory, assisted during July by Professor Lachlan Gilchrist and Mr. A. A. Brant of the University of Toronto. The principal instruments used were Askania magnetometers, and they were employed to determine both the horizontal and the vertical components of the magnetic field. In places duplicate observations were made with the ordinary dip needle and with the Hotchkiss Super-Dip. Either instrument, it was concluded, could be satisfactorily used instead of the more expensive Askania, for prospecting purposes.

The ground selected for study was the former Union Asbestos pits, now part of the property of Black Lake Consolidated Asbestos Company, which in 1926 was absorbed by the Asbestos Corporation, Limited. The property lies near the summit of Murphy Hill, on the northeast slope, in Lots 27 and 28, Range B, Coleraine Township. This locality was selected because the deposit is comparatively isolated, being approximately 2,000 feet from the nearest working, a small pit to the east, and about three-quarters mile from the nearest of the large Black Lake pits to the west; to the south no deposits are known. If, therefore, an asbestos deposit is more magnetic than the surrounding ground, this locality should have demonstrated the fact excellently.

The pits on this property include: one large excavation about 900 feet long and 400 feet wide; a smaller, adjoining one, 500 feet long and 300 feet wide; and two others of lesser size. The whole set of excavations occupy an area about 1,500 feet long, trending northeast, and 1,000 feet wide. Around these pits a rectangular area was surveyed, 3,000 feet from north to south and 2,400 feet from east to west. This area, which extended from 300 to 800 feet east, west, and south of the boundaries of the pits, and 1,500 feet north of them, was accurately subdivided into squares 300 feet to the side, and the corners of the squares were marked by pegs over which the magnetometers were later set up.

The results, which will be published in detail by A. H. Miller, showed: (1) that the whole area has a high local attraction; (2) that the local attraction varies within wide limits from station to station; (3) that in general the pit areas, where commercial asbestos occurs, do not display higher attractions than the areas outside. Apparently, therefore, the whole body of serpentinized peridotite is so magnetic, for a considerable distance at least from the deposit, that magnetic methods would fail to locate the deposit.

It was then thought that perhaps the area examined was too small, that if a deposit is a magnetic centre it might affect a considerable surrounding area, so that it might be necessary to go farther away than had been done to secure the relationships sought. Accordingly, a course southward, away from the known deposits, was surveyed, with stations about 300 feet apart, to Caribou Lake, 1½ miles distant. This course gives a section across the peridotite mass to the south boundary. It was found that throughout this distance the mass maintains the same high magnetic attraction, with the same local iregularities observed around the pits. It became evident, therefore, that the magnetic method is useless for locating asbestos deposits beneath areas of drift.

Some further experiments were made to determine, if possible, the causes of the irregularities noted. Some well-exposed areas of rock, where pronounced irregularities had been observed, were surveyed in detail and stations established 25 feet apart. The results of these studies may be summarized as follows.

(1) Certain faults possess high magnetic attraction, others do not. No visible difference between the two types is evident.

(2) Serpentine bands or belts that have flowed under differential pressure, so as to form the so-called "fish-meat" texture, commonly have very high local attractions, whether slip fibre is present or not. One locality was found, however, at the west end of Nadeau Ridge, where a belt of this type, carrying a little slip fibre, gave results no higher than usual.

(3) The blackish bands flanking granite dykes in general exert about the same attraction as the surrounding serpentinized peridotites. In places, however, they register very powerful attractions, and the rock, to the eye, is no different from the rock with ordinary attraction.

(4) The attitude of an asbestos vein or set of veins determines largely the amount of attraction it exerts. Vertical veins yield high results, horizontal veins low results, and veins of intermediate attitude, intermediate results. With vertical or nearly vertical veins, again, the attraction differs if the vein strikes north and south, east and west, or in some intermediate direction.

(5) Large variations in local attraction were also observed in places where no structural or other cause could be found to account for them.

(6) Dunites or peridotites, now so completely serpentinized that they weather to a light grey tint, almost invariably exert high attractions. These dunites are most commonly found interbanded with pyroxenites, which exert little or no attraction.

It is evident, therefore, that not only the asbestos veins, but also the serpentines under certain conditions of alteration or shearing, exert very powerful local attractions. Further, these attractions are by no means everywhere the same, but what looks like the same material may exert a strong attraction in one place, and a small attraction in another. Conditions being thus complex, there appears to be little hope of ever using magnetic methods for detecting the presence of asbestos bodies beneath drift, because there could be no means, other than by trenching or drilling, of distinguishing the attractions exerted by the different serpentines from those exerted by asbestos veins; and the areas over which attractions are generally high are too large, and the strong attractions too numerous, to make trenching or drilling economically possible.

Some further experiments were carried on at the chromite mine at the west end of Caribou Lake, one of the few known chromite occurrences where any notable quantity of the mineral still remains in the ground. Six sections were surveyed across the body, which has a known length of about 1,000 feet; and stations established 25 feet apart. The magnetic study showed the surrounding serpentine to have, in general, a fairly high attraction, but the chromite, on the other hand, exerts little or no attraction. It might be possible, therefore, to use magnetic methods to locate bodies of chromite; but the examination would have to be extremely detailed, with stations about 25 feet apart, and would be correspondingly expensive to carry out.

ASBESTOS DEPOSITS

A fairly detailed study was made of the various asbestos deposits around Black Lake, to determine whether it would be profitable to make a large-scale survey of any. The principal result of the study was the accumulation of a body of facts demonstrating the close connexion existing between faulting and asbestos deposition. Many, perhaps most, of the deposits are elongated along some large fault that runs down the centre or along one edge of the deposit. Associated with this main fault are a large number of minor faults; and instance after instance was observed, of sets of veins running off from the downthrow sides of these minor thrusts.

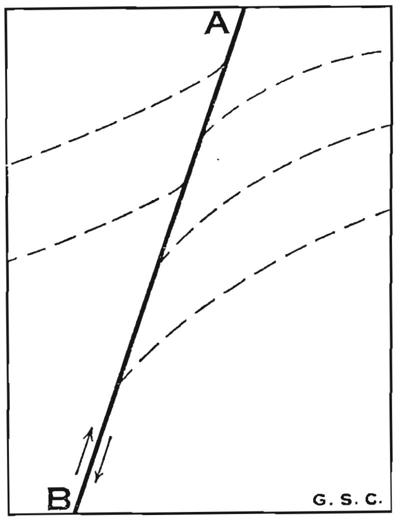

Figure 1. Development of tension cracks in wall of a fault. Lines of pecks indicate directions of tension cracks that would tend to form in walls of fault AB; it is considered that only those on the right-hand side would actually develop.

The reason that the veins appear only on the downthrow side is suggested to be as follows. A thrust movement along the fault plane AB (Figure 1) would tend to produce tension cracks in the walls in the directions indicated by the dotted lines.[1] On the right-hand side of the fault the frictional pull is upward, and as relief is possible in this direction, this set could develop. On the left-hand side the frictional pull is *downward*, so that the tendency would be toward compression of the rocks; consequently, few, if any, tension cracks would develop on this side. The fissures that later became filled with asbestos, therefore, are found almost entirely on the downthrow sides of the faults.

Perhaps the clearest example of the relation between faults and veins is afforded by a small deposit just west of the town of Black Lake. The

[1] Willis, Bailey: "Geologic Structures"; 1st ed., p. 64; 2nd ed., p. 143.

pit is small, approximately 200 feet long and 30 to 40 feet wide, and is entered from the provincial highway through a short tunnel beneath the railway track. The pit extends northeasterly along a curving course somewhat like that of a reversed " S ". The southeast side of the pit is bounded by a single thrust fault, and the pit, the boundaries of which are fairly closely those of the deposit, faithfully follows the curves of the fault. The fault dips southeast and the southeast side has been upthrust, so that the deposit occurs on the downthrow side in which tension cracks, with a tendency to open, would naturally be developed. No other faults are present to obscure the simplicity of the relations. The manner in which the deposit follows the curves of the fault, and the uniform width of the deposit, indicate that the faulting has in some way controlled deposition; and the occurrence of the deposit on the downthrow side, the side under tension, suggests that the veins have been formed in tension cracks. This deposit is of particular interest because of the lack of those phenomena which, in other deposits, tend to obscure the main relations.

A very detailed survey was made of the Vimy Ridge pit. This pit was selected because the walls, the only places where much bare rock is visible, are more accessible than in others. It was also hoped that some data might be obtained on the origin of the ribbon structure, which is extraordinarily well developed in this pit but is only rarely seen elsewhere.

The pit has been quarried into the side of a north-sloping hill for a distance of about 550 feet, and has a length of about 900 feet in a direction 15 degrees south of east. The south wall has a maximum height of 100 feet.

Looking at the south wall, one sees it filled with the great ribbon veins of asbestos. These dip gently eastward at the east end of the pit, and westward at the west end; in the middle of the pit wall they appear horizontal; so that their arrangement gives the impression of an open anticline. This structure has long been thought significant, but its cause has never previously been determined.

The walls are cut by a multitude of joints and faults, as is also the case in most of the other pits. It is not often, within the peridotite masses, that an horizon marker can be found by which the displacement along a fault can be determined; but when one is present, it commonly proves that what looks like a fault of some magnitude has really a displacement of only a few inches. Thus, faults that crush a band of peridotite 4 to 8 inches wide prove to have displacements of about 6 inches. A throw of an inch or two will produce beautifully slickensided fault faces, with possibly a good development of fibrous material in the fault. These facts, and the great number of such small faults, indicate both that the serpentinized peridotite was extremely incompetent to resist shearing stresses, and also that it was very brittle. It may further be inferred that the rock lay at no great depth when deformation occurred, because, at any considerable depth, such a soft, weak rock would have yielded by flowage rather than by fracture.

The structure of the Vimy Ridge deposit is shown in Figure 2. The serpentinized peridotites are cut by a large number of faults older than the asbestos veins. Those indicated on the sketch are the larger ones, with movements of a few inches and upward. In addition, there are a

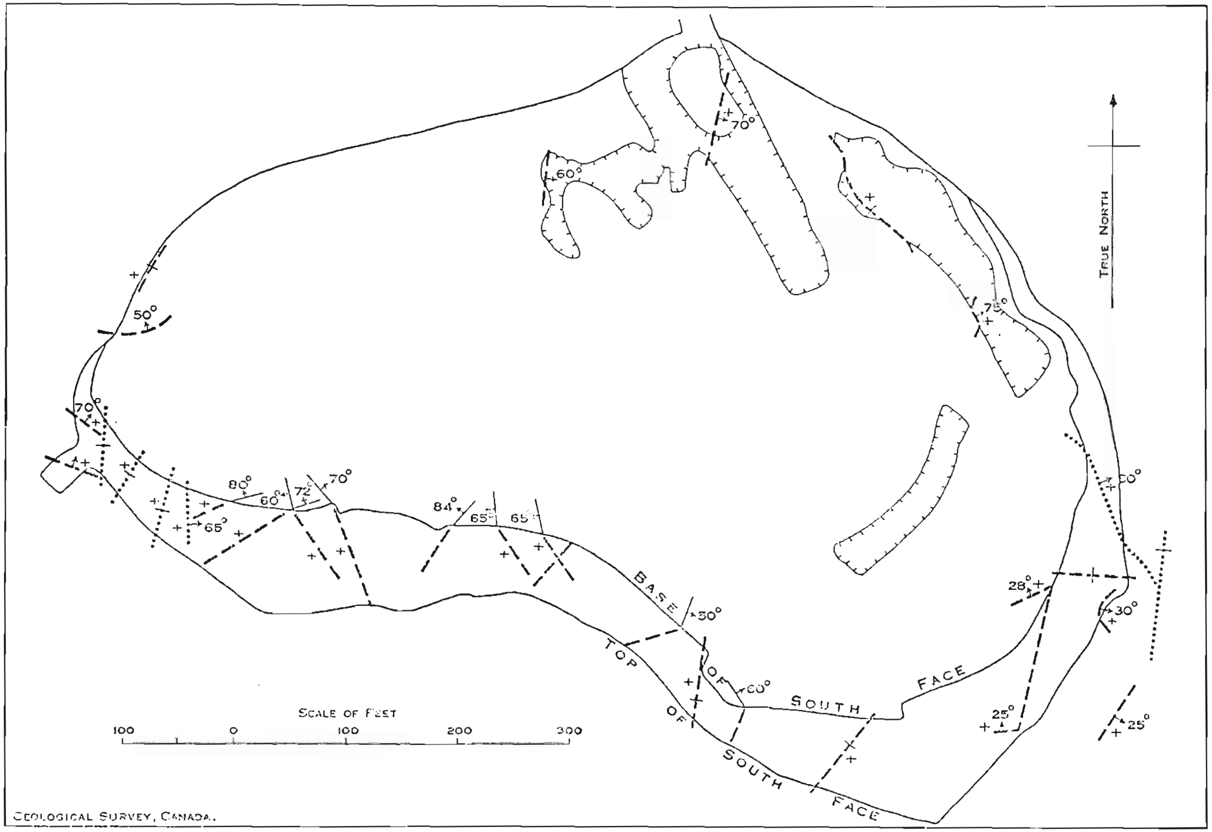

Figure 2. Plan of Vimy Ridge pit, September, 1932. Pre-asbestos faults are indicated by lines of dashes, post-asbestos faults by lines of dots; up-thrown sides are indicated by crosses. The irregular areas outlined within the pit are excavations in the pit floor; the floor is covered with rubble.

great number of fractures with little or no movement along them. When the faults are plotted with their corrected strikes on a circular diagram, there appears to be a concentration of strikes between north 35 degrees east and north 53 degrees east; a smaller concentration between north 26 degrees west and north 40 degrees west; and a number of scattered strikes between north 10 degrees west and north 15 degrees east. In addition, a few faults run east-west. It is doubtful, however, whether this analysis has any great value. Reference to Figure 2 shows that five faults out of the twenty-nine mapped have curving courses, with strikes that swing from northeast to northwest, so that the average strike cannot be known unless the courses exposed are sufficiently long.

The most interesting result of the detailed study was the determination that, in the western half of the pit, the western sides of the faults have been thrust upwards; on the other hand, in the eastern half of the pit, it is the eastern sides that have been upthrust. The block of rock in which the pit lies has thus suffered overthrust from both east and west. In the writer's opinion this fact furnishes the key to most of the peculiarities of the deposit; and he hopes to show that it affords an explanation of many facts hitherto unexplained.

When the relation of the ribbon veins to the faults is examined, it is seen that the veins commence at the faults and run off as in Figure 1. The veins thus have the same relation to the faults that tension cracks maintain to faults in ordinary rocks.

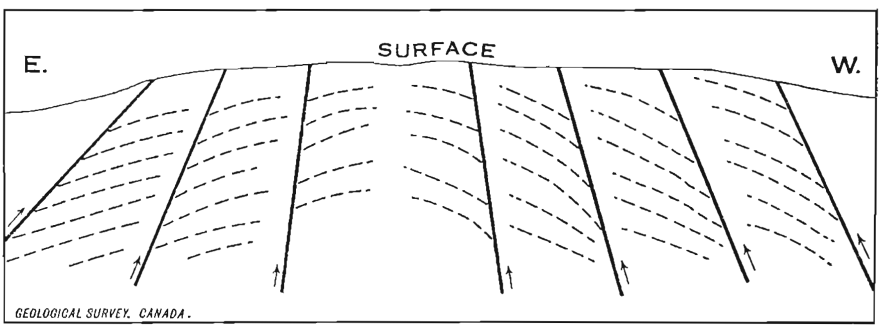

Figure 3. Diagrammatic cross-section of south face of Vimy Ridge pit showing general structure; faults are indicated by solid lines, veins by broken lines.

Figure 3 shows in diagrammatic form the south wall of the pit, with the thrusts from the east and west, and veins running off from the faults as observed. It is clear that the relations of the veins to the faults explain the peculiar anticlinal arrangement of the veins.

NATURE AND ORIGIN OF THE RIBBON STRUCTURE

A "ribbon vein", as the term is used in this paper, is a vein-like body, several inches to a foot or more in width, composed of numerous, parallel veinlets of asbestos separated by thin plates of serpentine. The individual veinlets range in width from a small fraction of an inch to three-quarters inch, rarely more. They have several peculiarities. One is that the asbestos fibres are continuous from edge to edge, whereas in all other veins they run from either edge to a central fissure filled with grains of magnetite and some amorphous or "colloidal" serpentine. Another is, that the asbestos fibres separate readily from the enclosing serpentine on one wall, but stick rather firmly to the other wall, whereas in other asbestos veins the fibres separate from both walls with equal ease. A third peculiarity of these veins is that the individual veinlets are not perfectly parallel to the main vein, but run off from it at an angle which is usually small. In Plate I this characteristic is illustrated, but in the specimen photographed the angle between the individual veinlets and the main vein is much larger than usual.

In ordinary veins the fibres run from both edges to a central fissure filled with magnetite, and the magnetite is moulded against the fibres so as to retain, in many instances, the impression of the fibres on its surface. Thus the magnetite must have crystallized from solution after the asbestos, and it is, therefore, inferred that the growth of the fibres commenced at both walls and continued inwards, until the last residues of solution deposited magnetite, together with any remaining uncrystallized serpentine. In the ribbon veins, however, the fibres of the individual veinlets are continuous from wall to wall, and it is a necessary inference, therefore, that in them crystallization commenced *at one wall only,* and continued until the fibres reached the other wall. It was found also that *the wall from which the fibres readily separate is always the wall nearest the outer side of the whole ribbon vein.* From these facts it is inferred that the crystallization of each veinlet began at the wall nearest the outer side of the main ribbon vein, and continued inward toward the centre.

In the ordinary vein, growth of fibre presumably began at the edges because heat was lost from both edges at about the same rate. Because growth began only at one edge of the individual veinlet of a ribbon vein, it would seem that this edge was the cooling edge, and that the other edge must have been kept hot. Since the cooling edge of each veinlet was the edge nearest the nearest wall of the composite "ribbon vein", it is evident that the ribbon vein as a whole lost heat outwardly from the middle part. This being so, it follows that the whole of a ribbon vein developed at one time. *Thus each ribbon vein, wide as it may be, corresponds only to a single asbestos vein of the ordinary type.* This being the case, the unusual ribbon structure must be due to some peculiarity of fracturing occurring at Vimy Ridge and rarely elsewhere.

Such peculiarity might be due either to the rock at Vimy Ridge being physically different from that elsewhere, so that under stress it fractured differently; or to a difference in the conditions of stress. It seems unlikely that an important physical difference can exist, because all the rocks were originally peridotites of about the same composition, and are now serpentinized to about the same extent. With regard to the second possibility, it has been shown that the Vimy Ridge deposit is a centre of overthrusting from both east and west, whereas in other deposits, so far as known, facts show overthrusting has occurred in one direction only. As this is the only known structural peculiarity of the Vimy Ridge deposit, it seems probable that there is some connexion between it and the ribbon structure.

This conclusion is strengthened when the relative positions of the different parts of the vein systems are studied. It has been mentioned that the individual veinlets are not parallel to the main ribbon, but run off from it at an angle, usually small. This angle always lies in a definite position relative to the ribbon vein and the fault from which the vein

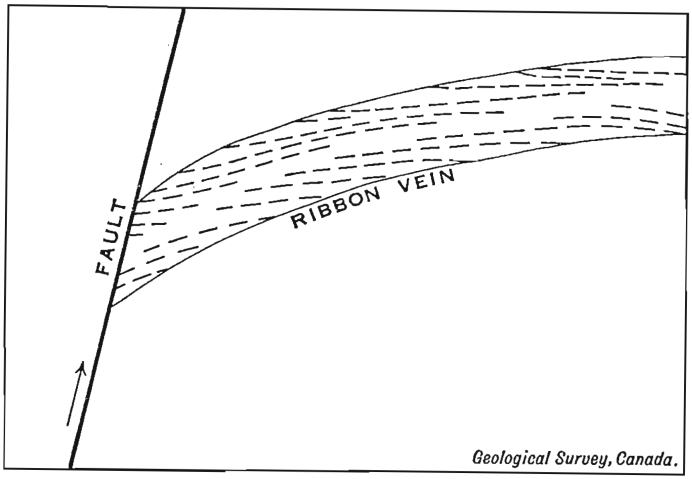

Figure 4. Vertical cross-section illustrating relation of a ribbon vein to the originating fault, and position of individual veinlets (broken lines) in the ribbon vein. Blank areas are serpentine; the band of serpentine along middle of the ribbon vein is a characteristic though not invariable feature.

originates, a position illustrated diagrammatically in Figure 4. This constant relationship indicates that the ribbon structure must be due to underlying structural causes, even though the causes cannot readily be explained.

DISTINCTION BETWEEN PRE-ASBESTOS AND POST-ASBESTOS FAULTS

In the Vimy Ridge pit, in addition to the faults that initiated the veins, there are also faults that cut and displace the veins. The pre-asbestos faults are commonly, though perhaps not invariably, characterized by the presence, in the fault plane, of a sheet of coarse-fibred, long-fibred material. The sheets vary from very thin to one-half inch or even more in thickness. By checking carefully in many places the orientation of the fibres with the normal methods for determining fault movement, it was established that the orientation of the fibres bears the same relation to the direction of movement as does flow cleavage (Figure 5); so that it affords an accurate and convenient new method of determining the direction of fault movement. This relation might also be inferred from theory, since the fibres might be expected to elongate most readily in the direction of least stress. The post-asbestos faults, on the other hand, exhibit no trace of fibrous texture whatever, but the fault faces consist of smooth, slickensided serpentine.

The fibrous material in the pre-asbestos faults varies considerably. In some faults it is true asbestos, or slip fibre. More commonly it is very harsh, but still readily flexible. In other faults it is coarser and harsher,

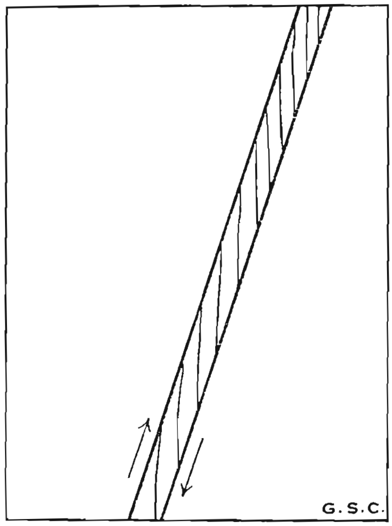

Figure 5. Cross-section of a pre-asbestos fault showing direction assumed by fibrous material.

with so little elasticity that it cracks or breaks when bent. In others again the fibres are even larger and quite stony, forming the fibrous type of serpentine known as picrolite. The reason for this variation is not yet known.

CHROMITE DEPOSITS

It is difficult at the present time to make any detailed examination of the chromite deposits, partly because all the chromite has been mined from a great majority of the pits; and partly because most of the pits are now filled with water. The writer, accordingly, confined his efforts to determining whether there are any peculiarities in the manner of occurrence of the mineral, which might aid prospecting should the price rise sufficiently at any time to render mining profitable.

It is well established that chromite was one of the essential constituents of peridotite and dunite before alteration to serpentine took place. Scattered grains may be found in almost any hand specimen of these rocks. In the deposits examined, the chromite grains are arranged in well-defined bands of varying thickness. Some consist of grains of chromite more or less thickly scattered through a matrix of serpentine; in others the concentration of chromite is such that the material is practically pure chromite. The bands have no well-defined edges, but grade rather quickly into serpentine with little or no chromite. They may possess considerable length, but at their ends they pinch and pass into serpentine exactly as on the sides. The bands are fairly straight, in general, but swing back and forth in broad curves.

Exactly the same arrangements obtain throughout large areas of the peridotite mass, where no chromite occurs. In many places the pyroxene grains are arranged in bands, with strike and dip approximately parallel to the bands of chromite. Similar banding is extremely prominent in the masses of intrusive that contain a large proportion of pyroxenite. In them the bands consist not only of pyroxenite and peridotite, but of a great variety of pyroxenites differing in grain and, to some extent, in composition. Further, although the bands in general run along in broad curves, in a few places they are violently contorted, and the contortions are evidently an original structure, not caused by later folding.

The structures described are characteristic of flow movements in a partly differentiated but still fluid magma. There is no reason for separating the chromite banding from the similar and generally parallel banding of the pyroxenes, hence the writer concludes that the chromite banding is likewise an original flow structure.

A second characteristic of the chromite deposits, so far as these have been studied, is that all occur in dunite, by which is meant a rock made up entirely of olivine with, at most, an occasional scattered grain of pyroxene. The dunite bodies are usually small and rather irregular in shape; and they appear to occur here and there within the peridotite mass, like plums in a pudding. They were presumably basic segregations formed during consolidation of the intrusive mass.

Prospecting for chromite, therefore, can best be carried on, first, by mapping the dunite bodies, a matter only of rather detailed geological study; and, second, by carefully determining the strike and dip of the flow structures either in the dunites or in the general neighbourhood. The mapping will indicate the areas within which chromite bodies are most likely to occur, and the flow structures will indicate the strike and dip of the chromite bands if present, so that prospecting operations may be directed accordingly.

THE OCCURRENCE OF WOLFRAMITE, MOLYBDENITE, AND OTHER MINERALS AT SQUARE LAKE, QUEENS COUNTY, NEW BRUNSWICK

By E. Poitevin

Since early in 1932, residents of the vicinity of Welsford, N.B., have been prospecting an area of granite near Square Lake, Queens County, hoping to find deposits carrying ores of tin and tungsten. Dr. W. J. Wright, Provincial Geologist of New Brunswick, and the writer had recognized the presence of topaz in specimens submitted for examination, and since then most of the minerals usually associated with tin have been identified from specimens derived from this locality. These minerals include topaz, wolframite, fluorite, native bismuth, bismuthinite, molybdenite, arsenopyrite, chalcopyrite, pyrite, pyrrhotite, specular iron, quartz, etc.

Square Lake is located about 2½ miles southwest of Welsford, a station on the main line of the Canadian Pacific Railway. It is situated in the northeast end of an area of Devonian granite some 50 miles in length and about 8 miles in width.[1]

Dr. Wright made a brief examination of the district and the following account is derived from a report, dated May, 1932, submitted by him to the Minister of Lands and Mines, New Brunswick. Granite rocks underlie the whole area. The common granite is rather coarse grained and made up chiefly of orthoclase and quartz, with small amounts of biotite and muscovite. Large areas are underlain by aplite (fine-grained granite) and aplite porphyry. Quartz veins are common, and all of those observed strike about 15 degrees south of east, parallel to a prominent system of jointing. The width varies up to 2 inches and the length up to 10 or more feet, where they usually die out or are succeeded by another vein. In two exposures east of the lake several quartz veins, 8 to 12 inches apart, form parallel systems. The vein filling is chiefly white and smoky quartz with irregular knots of feldspar. One vein, located on the second knoll south of the lake, carries crystals of wolframite up to half an inch or more in length. The wall-rock on both sides of the veins stands up as low ridges on the weathered surface for a width of 2 to 3 inches. This harder rock is usually sparsely mineralized and specimens taken from the prospect pit east of the lake are made up chiefly of interlocking grains of quartz with small amounts of arsenopyrite, fluorite and chalcopyrite, and altered granitic minerals. From what was seen in the field, this description applies to the wall-rock of all the veins inspected during the brief visit.

Topaz greisen is found in granitic boulders, more particularly north of the lake. One of these, located on the camp trail just north of the brook that drains the lake, is greenish grey and made up almost entirely of

[1] *See* Geol. Surv., Canada, Map 259A, New Brunswick and Gaspe Sheet.

quartz and topaz, freely sprinkled with arsenopyrite, chalcopyrite, pyrite, and fluorite. The greisen was no doubt formed by the action of the vein solutions on the granite of the walls. Judging from the size of this boulder, the parent vein is 2 or 3 feet wide.

Molybdenite was found in two or three large granite boulders between the camp trail and the lake outlet to the west. These boulders contain quartz veins with silicified walls and the walls carry minute flecks of molybdenite. One of these boulders shows a small patch of fine-grained pegmatite, with topaz, greenish fluorite, molybdenite, and white and amber mica.

The above notes show that all the veins uncovered so far are small and unless they carry tin or tungsten in appreciable quantities they could hardly be of any commercial value. To ascertain if they did carry these metals, two groups of samples, one designated as "Lot A", consisting largely of a quartz-topaz greisen carrying appreciable quantities of mispickel and pyrite (weight 147 pounds, collected by Mr. A. T. McKinnon during summer of 1932), and "Lot B", consisting largely of a quartzose rock carrying disseminated crystals of wolframite (weight 10·5 pounds, submitted by Dr. W. J. Wright), were tested through the courtesy of the Mines Branch, and the following results obtained:

"The samples were supposed to contain values in tin and tungsten.

Concentration tests were requested to determine whether these values could be concentrated.

Concentration tests were conducted on a small Wilfley table after crushing the samples to pass a 20-mesh screen and sizing on 48-mesh and 100-mesh screens. The concentrates obtained were analysed for tin and tungsten.

Sample designated "Lot A"

The analyses of the concentrates from the tabling of the sized material showed them to contain no tin nor tungsten.

Sample designated "Lot B"

Product		Grammes	Tin oxide (SnO_2)	Tungstic oxide (WO_3)
			Per cent	Per cent
− 20 + 48	Conc.	548·1	none	2·70
"	Midd.	405·1		
"	Tail.	134·7		
− 48 +100	Conc.	265·7	none	3·15
"	Midd.	136·9		
"	Tail.	566·4		
−100	Conc.	249·3	none	3·60
	Midd.	35·6	none	
	Tail.	698·5		
Slime.		103·0		

In calculating these figures back to the head sample the WO_3 content would be 0·68 per cent."

MIDDLE RIVER GOLD FIELD, VICTORIA COUNTY, NOVA SCOTIA

By F. J. Alcock

CONTENTS

Illustrations

INTRODUCTION

The following report on Middle River gold field is based on field work carried out in late September and early October, 1932. Previous work, listed on page 59, had outlined the geology of the area, but certain problems in connexion with the faulting of the Lizard gold-bearing vein on Second Gold Brook remained to be solved. The primary object of the present investigation was, therefore, to determine the structure in the area surrounding the old mine workings. In order to do this a plan of the surface was prepared. The underground workings on what is known as the track level were also surveyed. It was impracticable to examine the intermediate and upper levels owing to the fact that the adits had caved in, and it was impossible to enter the shaft and lower drifts since these are filled with water. The information regarding these parts shown on Figure 8 is, therefore, from plans supplied through the courtesy of Mr. Messervey of the Nova Scotia Department of Mines. In addition to the plan of the area in the immediate vicinity of the old property on Second Gold Brook, the writer spent several days examining the general region drained by First, Second, Third, and Fourth Gold Brooks and in preparing a map of this region. He was ably assisted in the field by E. B. Gillanders and by Mr. Samuel Theriault of Middle River.

The area lies in the southwestern part of Victoria County, Cape Breton Island. The property on Second Gold Brook is readily accessible. The trunk highway from Baddeck to Margaree passes within 6 miles of it. The main road is left at Upper Middle River some 12 miles from Baddeck. The next 4 miles, as far as the last house near the mouth of First Gold Brook, is a good motor road. From here on the last 2 miles of road is narrow and rough, but a motor car can be readily driven to within 400 feet of the old mill where there is ample space to turn.

J. Campbell states in his report of 1863 that he washed gold from the sand of Middle River, and he expressed the opinion that working here would prove remunerative. Heatherington states that John G. McLeod received a free grant in April, 1864, which implies that he was the original discoverer of gold in the district. Fletcher reports, however, that a farmer named Morrison was the first to call the attention of the government to the gold of the district, for which he received an area on one of the brooks free, and he became one of the most successful in washing out gold. The area seemed so promising that the Chief Gold Commissioner recommended in 1863 that it should be proclaimed a gold district. Little work was carried out, however, for several years.

The first serious attempt to wash gold at Middle River was made in 1867 by an American company which built sluices near McLennan's bridge and washed the gravels during the summer, but the receipts did not cover the expenses and work was discontinued. In 1868, several gold-bearing veins were discovered, and a crusher was in the course of erection. In 1870, a Mr. Wright and others tested the brooks above McLennan's bridge by means of cradles, sluices, and pans. The largest nugget found is said to have been worth from $12 to $15, but in general they ran from 50 cents to $2. A shaft was also started on the main river but work on it had to be abandoned owing to an influx of water.

In 1902, the placers were worked by Chinese. Lode mining was also carried out by Mr. W. C. Scranton on the Lizard vein on Second Gold Brook. In 1906, Mr. Scranton's property was bonded to the Great Bras d'Or Gold Mining Company. Active mining operations were carried on by this company up to the close of 1911. Further work was carried out in the years 1914 and 1915. In 1916 some 330 pounds of sample ore was crushed, but no work was done on the property and it has been idle since. In 1929, Messrs. P. H. Fraser and N. M. McRae of Nyanza, Cape Breton, secured the property, and are the present owners.

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TOPOGRAPHY

The region drained by Middle River shows two sharply marked physiographic divisions. The stream for most of its course flows through a region that is flat or gently rolling, and has been developed on Carboniferous rocks. Its upper waters and side tributaries, on the other hand, drain a plateau that consists of a complex of pre-Carboniferous rocks and rises abruptly to an elevation of some 800 feet above the Carboniferous lowland. The auriferous gravels of Middle River are at the border of the plateau where the swift-flowing stream reaches the gentler topography.

The area drained by First, Second, Third, and Fourth Gold Brooks lies within the plateau. The surface of the latter is remarkably flat. The skyline as seen from the Middle River highway has almost a straight edge regularity, and traverses along the summit show broad, flat areas at elevations around 1,000 feet. Middle River in the region of the four Gold Brooks is entrenched to a depth of about 500 feet below the plateau surface. The valley sides of both the main river and its tributaries are steep, averaging over 25 degrees. The side streams have steep gradients with local falls and cascades. The stream that enters Middle River immediately north of the mouth of First Gold Brook has one vertical fall some 80 feet in height, with minor additional drops, so that within a horizontal distance of 700 feet the stream descends 250 feet. Outcrops are abundant in the beds and sides of the streams; on the plateau summit and valley sides outcrops are scarcer and trenching is usually necessary to ascertain the character of the bedrock.

GEOLOGY

With the exception of some small outcrops of Carboniferous conglomerate near the mouth of First Gold Brook the rocks of the area represented by Figure 6 all belong to an older complex, which is separated by a great unconformity from the Carboniferous strata. The oldest rocks are sediments of probable Precambrian age; they are metamorphosed in varying degrees and with them are associated some altered types that may be of igneous origin. This complex is cut by masses of granite and by porphyry dykes and sills whose age may be as young as Devonian.

The chief type of rock in the region drained by the four Gold Brooks is a dark grey to black, quartzitic argillite. Locally, colour banding reveals the bedding planes but in most places the dominant structure is a secondary cleavage. In many places at least the two structures are parallel. In general the strike is east and west and the dips average about 45 degrees to the north, but there are many variations due to local crumpling. Under the microscope the common variety of sediment is seen to consist of quartz, sericite, large flakes of brown biotite, and feldspar in subordinate amounts. Near the Lizard vein is a greenish zone consisting of chlorite schist which may represent an horizon containing volcanic material. On the south bank of Middle River about one-half mile above the mouth of First Gold Brook a zone of well-bedded, white to pink, crystalline limestone occurs in the sedimentary series; similar beds occur on the more westerly of the two streams that join Middle River north of the mouth of First Gold Brook. Between the mouths of Third and Fourth Gold Brooks there outcrops on

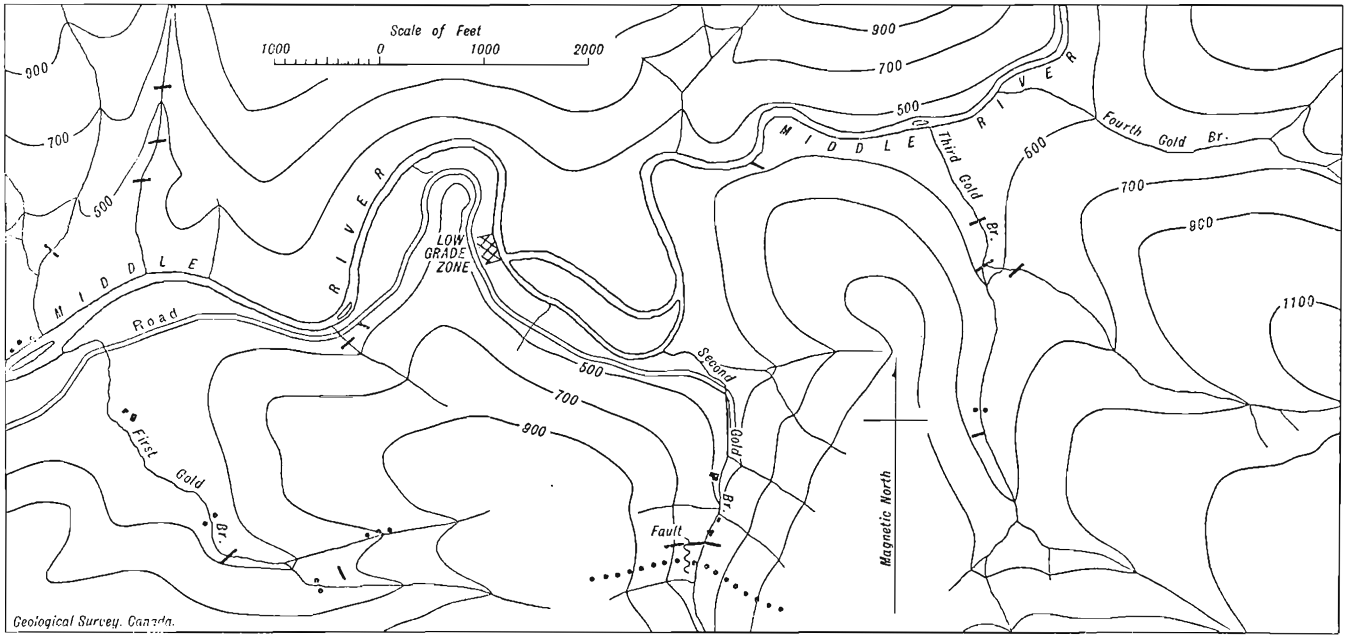

Figure 6. Part of Middle River Gold Field, Victoria County, Nova Scotia; quartz veins are indicated by short, heavy lines; granite-porphyry by dots.

the south side of Middle River a massive amphibolite which appears to have sill relationships with the sediments. Under the microscope it is seen to consist largely of pale green hornblende with minor amounts of epidote, iron ore, quartz, and feldspar. It may represent an altered gabbro or pyroxenite.

The above rocks, as already mentioned, are intruded by granite and granite-porphyry. On Third Gold Brook medium to coarse-grained, reddish granite outcrops less than a mile above its mouth. The rock is fresh and massive. It contains abundant quartz, the feldspars include orthoclase, microcline, and albite; a small amount of hornblende is present.

The granite-porphyry occurs as dykes and sills in the sediments and is almost certainly genetically related to the larger granite masses. The intrusion of chief interest is a sill, some 20 feet thick, that crosses Second Gold Brook 150 feet south of the shaft. It can be traced up both sides of the valley and is also exposed in the underground workings. The rock is dense and massive, of a flesh to pale pink colour, and shows small phenocrysts of quartz and feldspar. It is locally sheared and traversed by small veins and stringers of quartz. Locally it shows a banded structure parallel to the contact. In thin section it is seen to consist of phenocrysts of corroded quartz, orthoclase, and acid plagioclase in a finely crystalline groundmass of quartz and feldspar.

MINERAL DEPOSITS

The mineral deposits consist of quartz, which occurs chiefly as lenses following the structural planes of the sediments. In places they cut across the cleavage, but where they do the angle is usually small. The amount of quartz in the region is apparently large. In all the brooks there is an abundance of quartz float, and locally there are blocks from 4 to 5 feet across. The lenses appear, however, to be irregularly scattered and it has not as yet been demonstrated that there is sufficient tonnage of workable ore concentrated in any one zone to enable it to be profitably worked. The quartz is for the most part milky white, commonly more or less fractured. Most of it contains no visible mineralization, but in places small amounts of sulphides are to be observed. Gold colours can be panned from the brooks.

The deposits are evidently of high temperature origin, formed from solutions given off during the late stages of cooling of the acid intrusives. That they were formed after the intrusion of the porphyry is shown by the fact that quartz veins are found traversing the porphyry sills.

LIZARD VEIN

Mining operations have been confined to a zone known as the Lizard vein. Much of this vein or zone has been stoped out so that for some of the facts regarding it recourse to the older descriptions is necessary. It strikes east and west and dips north, following in general the rock structure. Woodman states that it varied in width up to 3 feet and that the quartz showed a banded structure near and parallel to the margins and

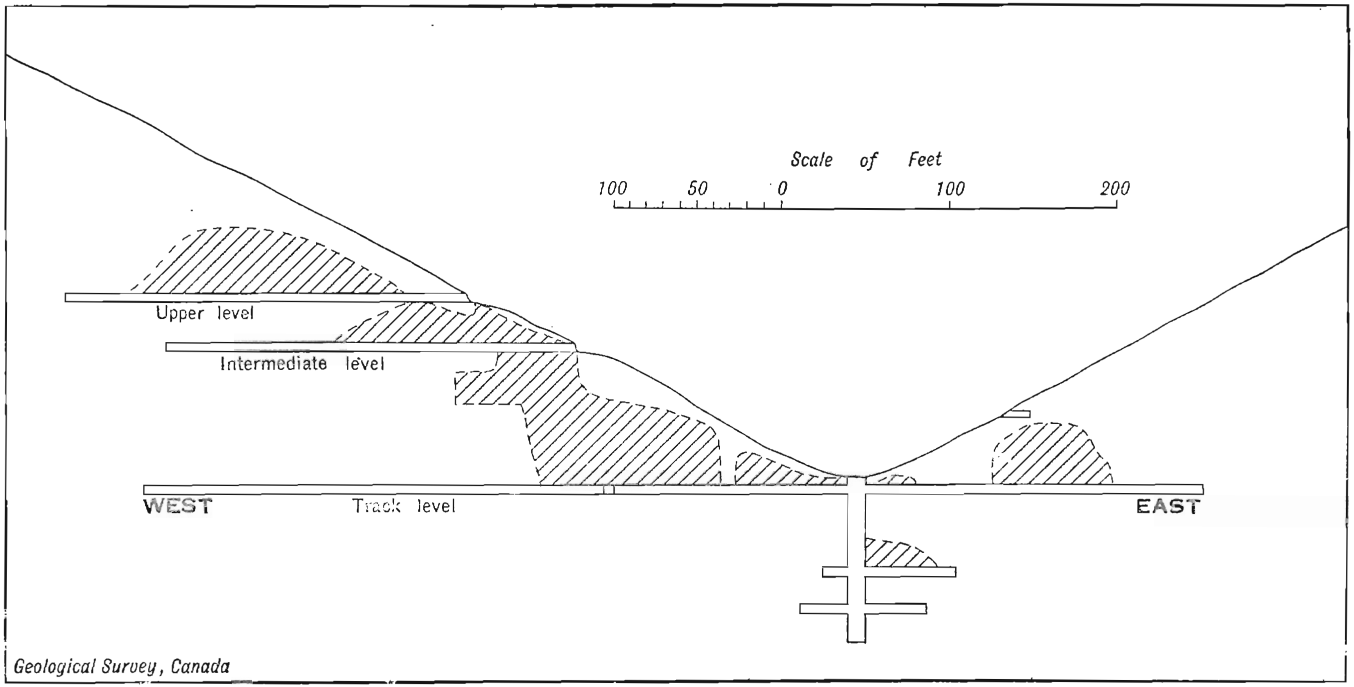

Figure 7. Vertical projection of workings on Lizard vein; stoped areas are indicated by diagonal ruling.

drusy cavities near the centre. The vein swells and pinches and locally breaks up into small veinlets. It appeared to the writer from a study of the track level that the so-called vein is really a series of *en échelon* lenses rather than one distinct vein. With the quartz is associated small amounts of sulphides, including arsenopyrite, chalcopyrite, galena, and dark sphalerite; a little carbonate is present. Close to the fault in the track level a small stringer, consisting mainly of massive pyrrhotite, is exposed. With the pyrrhotite are associated small amounts of chalcopyrite, sphalerite, magnetite, pyrite, and pentlandite.

The workings on the Lizard vein consist of three adit levels and an inclined shaft following the vein for 140 feet, with levels at 50 feet and 80 feet. On the 50-foot level (*See* Figure 7) a drift was carried 16 feet to the west and 54 feet to the east, and on the 80-foot level 30 feet of drifting to the west and 40 feet to the east was done.

On the track level 48 feet west of where the adit joins the drift, the Lizard vein is faulted (*See* Figure 8). The fault plane was followed by a drift for a distance of 90 feet northwards, and various drifts and crosscuts were run west of the fault in an endeavour to locate the faulted continuation of the vein or zone. The fault is well marked by a zone of gouge; horizontal striations on the wall of the drift adjacent to the main plane of movement indicate that the displacement was horizontal. The problem of how much shift took place can best be solved by means of the sill of porphyry that is exposed both on the surface and at two places underground. Figure 8 shows the position of this sill where it outcrops on the surface and where it appears on the track level. It is obvious that the northward dip of the sill is responsible for the V-shaped nature of its surface expression, and for the fact that on the track level it lies to the north of its surface exposure. The horizontal shift of the faulted sill on the track level is about 25 feet. This was estimated in the following manner. Since the actual contacts of the porphyry with the argillites wherever observed were found to follow the structural planes of the sediments, the porphyry contacts were projected on the mine plan in a direction parallel to the strike of the argillites and of the vein. The porphyry does not show in the short crosscut to the west opposite the point where the adit joins the main drift. The shift would, therefore, appear to be at least 25 feet and could be more than that amount. The sill was also carefully traced on the surface up the west side of the valley. Trenching to expose its contacts with the sediments was done at two places. Owing to the heavy overburden, it was difficult to be certain of exact contacts, but an offset was clearly indicated and in amount it appeared to be nearer 15 feet than 25 feet. A slight rotation on the fault plane would explain the difference in shift at the two places.

If the horizontal shift is so small why is the Lizard vein not exposed in the underground workings on the track level to the west of the fault? The answer to this question is that it is exposed there. Towards the western end of the southern of the two drifts west of the fault, at the entrance to the southern crosscut, just above the porphyry sill, a zone of quartz about 4 feet wide has a low dip to the north. It can be followed along the south wall of the drift for a distance of about 20 feet eastward. Beyond this another quartz lens continues eastward along the roof of the

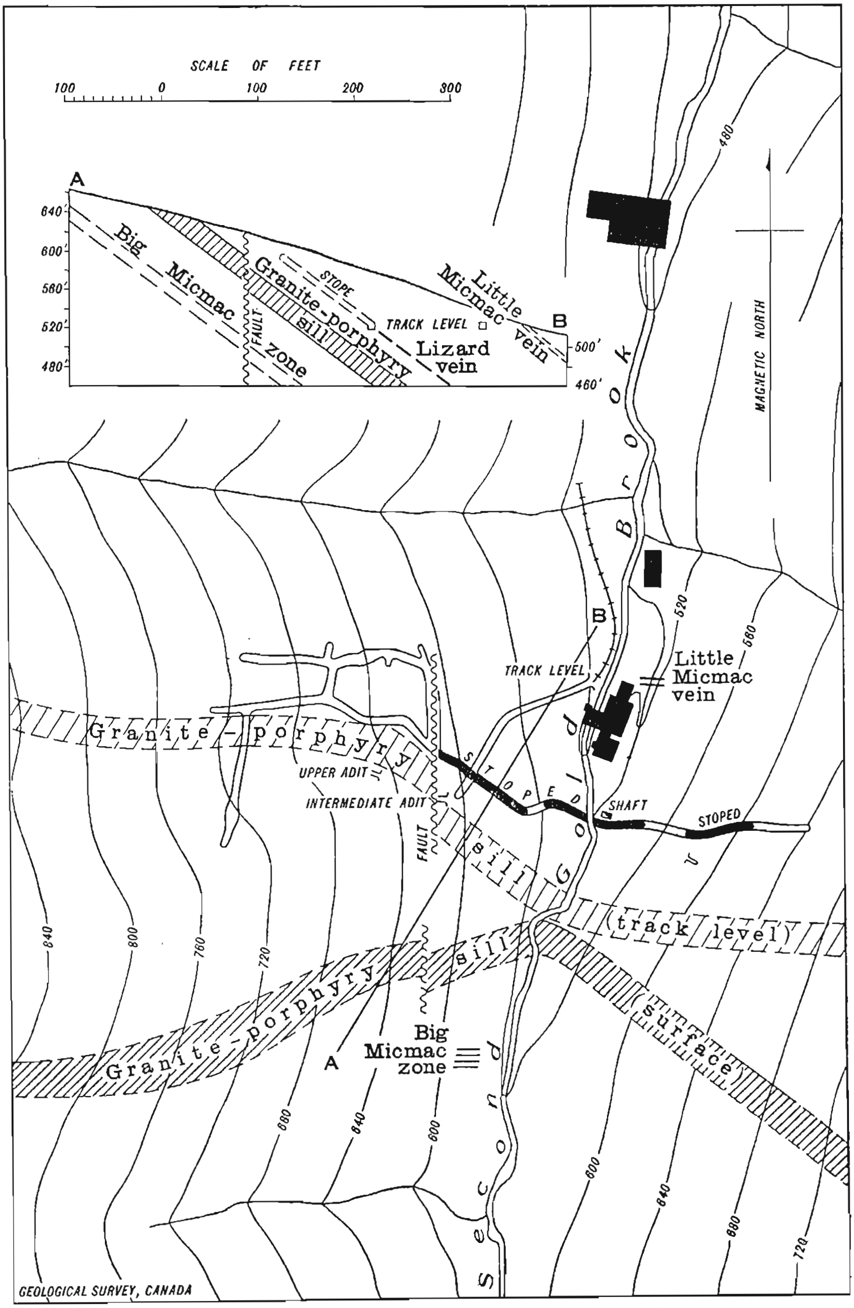

Figure 8. Plan and vertical section, Lizard vein.

drift and disappears in the east wall of the short crosscut, uniting the two drifts. Quartz is also present in the west wall of the crosscut along the fault, at the place where it should be after a shift of 25 feet, that is at a place 25 feet north of the faulted end of the vein as now marked by the west end of the stoped area. On the track level the stope ends at the fault plane, but in the intermediate and upper levels it was the section of the vein west of the fault that was mined.

The Lizard vein was sampled on the track level by Mr. Messervey, and the following values in gold were obtained.

No.	—	$
1	Sample of slash from east end of drift	Trace
2	Composite sample from east end and extending over 100 feet in length	8 00
3	Composite sample from west end of drift	1 00
4	The bottom of the drift 20 feet east of tunnel	38 00
5	The bottom of the drift 150 feet east of tunnel	3 40
6	The bottom of the drift 20 feet west of tunnel	20 00
9	Surface cropping of Lizard vein	3 00

BIG MICMAC ZONE

On the west side of Second Gold Brook, some 280 feet south of the shaft, is a quartz-bearing zone some 20 feet in width across the strike of the beds. The zone contains quartz lenses and bands parallel to the structure. About one-quarter of the zone at the surface consists of quartz. The greatest width of quartz is a lens-shaped mass 22 inches across where it is widest. Other bands vary up to 10 inches in thickness. A somewhat similar zone is to be seen underground on the track level near the end of the long crosscut at the western end of the south drift. The zone here is in the same stratigraphic position relative to the porphyry sill as the exposure on the surface. Several trenches above the surface exposure show quartz and it is probable that the zone is continuous between these two points, which would give it a length along the strike of at least 300 feet. The writer took a sample across the entire face of the surface showing, including both the quartz and the sediments. An assay gave only a trace of gold and a trace of silver. Channel samples were also taken across the zone on the track level underground. The following are the results:

No.	Gold	Silver
1	Trace	Trace
2	"	"
3	"	"
4	"	"

LITTLE MICMAC

Near the north end of the office building, 150 feet north of the shaft, there is exposed in the eastern branch of the brook a quartz vein known as the Little Micmac. It is an irregularly shaped mass dipping at a low angle to the northeast. It has not been traced on either side of the valley.

THE LOWGRADE

On the southwest bank of Middle River between the mouths of First and Second Gold Brooks (Figure 6) is a mineralized zone known as the "lowgrade." It has a width of about 300 feet and consists of quartzitic and thin-bedded argillitic sediments mineralized with many small quartz stringers. The strata are greatly sheared and locally drag-folded and contorted. The zone also contains a porphyry sill about 1 foot wide. Towards the south end of the zone the rocks are less deformed, and here there are a few larger quartz veins of irregular shape, 2 to 8 inches in width, cutting across the strata. One vein has a width of 2 feet. The zone is said to carry low values in gold. On account of its varied character it is difficult to sample, however, and the only satisfactory test would be a mill run. Should the zone prove to have any continuity along the strike the tonnage available would be very large and even low values in gold would be attractive.

OTHER VEINS

On the southwest side of Middle River about half-way between the mouths of Second and Third Gold Brooks is a vein 4 feet wide that dips to the north at an angle of 30 degrees, cutting across the slates at a low angle. The vein has not been followed. On the north side of the south branch of First Gold Brook, about 600 feet west of the forks, is a vein showing a width of 6 feet. It is exposed for a length of about 10 feet. Large blocks of quartz in the stream below evidently were derived from it. The quartz is white and broken and shows little sign of mineralization. A grab sample taken from it gave no values in gold and only a trace of silver. On Third Gold Brook is a quartz vein 3 feet wide, lying nearly flat and cutting across the argillitic sediments. At a distance of 250 feet to the north is a porphyry sill 10 feet thick dipping to the north. It has sometimes been assumed that this porphyry is the continuation of the sill that outcrops on Second Gold Brook. This cannot be the case unless there is a fault between Second and Third Gold Brooks carrying the strata of Third Gold Brook northward. Other quartz exposures are shown on Figure 6 and still other veins outside the area covered by this map are known to occur higher up on the Gold Brooks and on McLean Brook to the south of First Gold Brook.

FUTURE POSSIBILITIES

It would appear from what can be observed at the present time and from what can be gathered about the ore that was taken out, that the best part of the Lizard as yet uncovered is a zone that rakes to the east. It is unfortunate that there is not more information about what was obtained in the shaft and on the lower levels. From the fact that work was discontinued here early it is to be inferred that the amount of ore was not encouraging. This may mean that the best part of the Lizard has been worked out. On the other hand, further work might reveal new lenses of ore along this zone or along another closely parallel zone.

The Big Micmac is a zone whose amount of quartz suggests further testing. The writer's samples, which gave nothing more than a trace of gold or silver, offer little encouragement, however, of this proving a profitable belt. In all probability, too, it would show much less regularity than the Lizard. It is a zone, however, that could be readily explored by diamond drill holes put in from the track level. Holes with inclinations of 45 degrees to the south would require a length of less than 150 feet to intersect the zone. The writer, however, is extremely doubtful whether such expense is warranted.

BORINGS IN EASTERN CANADA

By W. A. Johnston

(Geologist in Charge, Division of Pleistocene Geology, Water Supply, and Borings)

Logs of wells drilled in Ontario in 1931 for oil and gas were received through the courtesy of Col. R. B. Harkness, Gas Commissioner of Ontario. Mr. C. S. Evans of this Survey is making a study of these logs and those of wells drilled in former years for the purpose of aiding companies in the search for new oil and gas fields: in many areas the bedrock is so deeply covered by drift deposits that structural conditions in the bedrock, favourable for the occurrence of oil or gas, can only be determined by geological interpretations of the logs of wells. Records of only a few water wells drilled in the province of Ontario in 1932 were received, as little drilling was done.

Drilling for natural gas in the lowland area south of St. Lawrence River in the Province of Quebec was continued in 1932. Through an arrangement with the Quebec Bureau of Mines well samples were received from the several companies carrying on drilling and reports on the samples were sent to the companies and to the Bureau of Mines. In this connexion acknowledgments are made to Linn M. Farish of the Alberta Oil and Gas Company, R. B. Anderson of the Hope Engineering Company, D. A. Powell of the St. Gerard Drilling and Exploration Company, Limited, and officials of the South Shore Oil Lands, Limited.

Recently there has been a revival of interest in the possibilities of natural gas, both north and south of St. Lawrence River, in the region between Montreal and Quebec, and several deep borings have been made. The geology of the region, and the natural gas resources have been described by Wm. A. Parks.[1] A summary statement regarding the wells drilled in 1932 is given in Table I. No commercial supplies of gas were reported as having been obtained in the wells; the deepest one, the St. Gerard well, was abandoned at 6,160 feet as a dry hole. This well, one of the deepest in eastern Canada, not only reached but passed through the Trenton limestone, which has long been the goal of operators in this region, for it was held by some investigators that a suitable reservoir rock might be found in the upper part of the Trenton. Samples from the well furnish a means of approximately determining the character and thickness of the formations that lie below the middle part of the Lorraine shale, regarding which little was known because of the lack of exposures of these beds. Core samples from a considerable depth in the well show that the

[1] Natural Gas in St. Lawrence Valley, Que. Ann. Rept. of the Quebec Bureau of Mines, part D, 1930, pp. 3-98.

strata are nearly horizontal, so that the thicknesses of formations as indicated by the log of the well may not be much in excess of the true stratigraphical thicknesses.

Log of the St. Gerard No. 1 Well

Name: Drilling and Exploration Company, Inc. (Canadian Seaboard Oil and Gas Company).
Location: St. Gerard, Yamaska county, Que.
Drilling method: Standard to 3,170 feet, Rotary to 4,490 feet, Standard to 6,160 feet.

Depth in feet	Lithology and stratigraphical interpretation
0 - 50	Surface deposits.
50 - 90	Queenston (Ordovician) sandstone; may be lower Silurian and equivalent of Grimsby or Whirlpool sandstone of southwestern Ontario.
90 - 1,190	Queenston red shale (Middle grey shale 750-795).
1,190 - 1,280	Queenston grey shale.
1,280 - 1,530	Lower Richmond grey shale and limestone.
1,530 - 2,260	Lorraine grey shale with thin limestone bands.
2,260 - 2,870	Lorraine, medium grey, sandy shale.
2,870 - 4,400?	Lorraine dark grey shale.
4,400?- 4,840	Utica dark grey and brown shale. (Fossils from core samples from depths of 4,408 to 4,433 and 4,477 to 4,492 feet, determined by E. Ruedemann to be from the Gloucester shale, probably of upper Utica age.)
4,840 - 5,330	Lower Utica dark grey shale with limestone bands. (Fossils from a depth of 5,140 feet determined by A. E. Wilson as an inarticulate brachiopod that occurs in the Utica.)
5,330 - 5,540	Lower Utica or upper Trenton dark grey shale and limestone.
5,540 - 5,980	Trenton and Black River limestones.
5,980 - 6,000	Basal sandstone of Trenton group.
6,000 - 6,030	Chazy? limestone.
6,030 - 6,160	Chazy? shale and sandstone.

The contact of the Utica and Lorraine is not defined as the lower part of the Lorraine is very similar to the upper part of the Utica. There is about 1,500 feet of dark grey shale containing very little sand in the lower part of the Lorraine. These beds do not appear to be known from sections that are exposed.

The beds from 5,330 to 5,540 feet may be lower Utica or Upper Trenton in age. No identifiable fossils were found in the samples from these horizons. They consist of dark shales and limestone bands. This is characteristic of the lower part of the Utica. On the other hand, the Utica in the well section is much thicker and the limestones of the Trenton group somewhat thinner than is shown in well sections at Montreal and at places to the east.

A notable feature is the occurrence of sandstone at the base of the limestones of the Trenton group and lower down in what appears to be the Chazy. Sandstones at these horizons have not been recognized in well sections at Montreal, nor to the east in Quebec. Both sandstones are coarse-grained and should form good reservoir rocks if other conditions are favourable. The source beds for natural gas, however, are above these horizons which may, therefore, be incapable of acting as reservoirs. On the other hand, the dark shale of the lower Lorraine and Utica, many samples from which give off gas when heated, forms source beds of great extent and thickness for the natural gas that is found in shallow wells, particularly in a belt along the north side of St. Lawrence River, in areas where the bedrock is covered with impervious clay which acts as a retainer for the gas and where there is sand or gravel below the clay. In these areas, as pointed out by Parks,[1] the occurrence of gas is independent of structural folds.

TABLE I

Wells Drilled for Oil and Gas in the Province of Quebec, 1932

Lot	Concession	Parish	County	At or near	Depth in feet covered by record	Number of samples received	Remarks
541	....	La-Visitation.......	Yamaska.....	Drummond-ville	4,400	440	South Shore Oil Lands, Ltd., No. 2
543	....	" " ..	"	"	3,200	303	South Shore Oil Lands, Ltd., No. 1
549	Range 3......	St.-Denis...........	St.-Hyacinthe	St.-Denis.....	4,140	335	Richelieu Gas Company No. 1 (Hope Engineering Company)
573	St. Antoine..	St.-Gerard-Magella.	Yamaska.....	St.-Gerard d'Yamaska	6,160	609	Drilling Exploration Co., Ltd., No. 1 (Canadian Seaboard Oil and Gas Company)

[1] Ibid., p. 84.

OTHER FIELD WORK

Geological

E. D. KINDLE AND W. H. COLLINS. E. D. Kindle and W. H. Collins continued the investigation and remapping of Sudbury nickel basin and vicinity, as a basis for future prospecting for nickel-copper deposits and lead-zinc deposits. The lead-zinc deposits appear to be localized along faults within the basin, and there remain to be prospected for nickel-copper deposits considerable drift-covered areas where drilling and geographical methods will be required. Two 1-mile sheets (Espanola and Copper Cliff) are finished and being prepared for publication. Further field work is required to complete two other sheets, Chelmsford and Wanapitei.

C. S. EVANS. Mr. Evans commenced the mapping of an 8-mile map-area, in southwestern Ontario, lying between the Niagara escarpment and the 79th meridian. Data were collected in the field on oil, gas, and water wells within this area and also to the west of the escarpment, that gave much information on thicknesses and extent of the formations and on thicknesses of the drift. A small, gas-yielding structure 2 miles east of Collingwood was examined and indications of another were found below the escarpment at Glen Huron.

ALICE E. WILSON. Miss Wilson continued geological mapping of the Palæozoic strata of the Ottawa 1-mile map-area (latitudes 45° 15′ to 45° 30′, longitudes 75° 30′ to 76°).

M. E. WILSON. Mr. Wilson continued the detailed investigation of a limited area that includes the Noranda, Amulet, and Waite-Ackerman-Montgomery mines in the vicinity of Noranda, Quebec. The area under study is 10 miles long from north to south and 4 to 5 miles wide. During 1932 the geological mapping of the northern part of the area was completed, as was also the more detailed mapping on a scale of 1 inch equals 100 feet, of an area 3,500 feet by 2,400 feet that includes the Waite-Ackerman-Montgomery mine. A copy of the last-mentioned manuscript map has been furnished the mine management and a preliminary report for the same purpose is about ready.

O. L. BACKMAN. Mr. Backman under the supervision of A. H. Lang completed the geological mapping and investigation of the Makamik map-area (latitudes 48° 45′ to 49°, longitudes 78° 30′ to 79°).

J. S. STEVENSON. Mr. Stevenson under the supervision of M. E. Wilson commenced a revision of the Ville Marie map-area (latitudes 47° 15′ to 47° 30′, longitudes 79° to 79° 30′).

A. H. MILLER. Mr. A. H. Miller of the staff of the Dominion Observatory continued the investigation of various geophysical methods being jointly carried out by the Department of Mines and the Department of the Interior. Mr. Miller devoted most of his time to magnetometric investigations in Thetford area, Quebec. The geological results obtained are briefly summarized in the report by H. C. Cooke, in this volume. Mr. Miller spent part of the season in Moncton area, New Brunswick, and in conjunction with G. W. H. Norman was able to demonstrate that certain types of concealed geological structures bearing upon the accumulation of oil and gas could be outlined by magnetometric methods. During a part of the time spent in Thetford area, Mr. Miller was assisted by Dr. L. Gilchrist, of the University of Toronto, who generously volunteered his services.

F. J. Alcock. Mr. Alcock examined a feldspar deposit on the north shore of St. Lawrence Gulf, at Quetachu (Thelma) Bay about half-way between Havre St. Pierre and Natashkwan. A report on the occurrence has been given to those directly interested in the property. Mr. Alcock spent the greater part of the field season completing the 1-mile geological mapping of a region about Saint John, New Brunswick, between latitude 45° 30′, longitudes 65° 30′-66°, and the Bay of Fundy. This area is geologically important as a key-area for much of the southern part of the province. A 1-mile geological sheet will be published.

G. W. H. Norman. Mr. Norman completed the geological mapping of all but a small part of the area of Carboniferous rocks lying in the northern half of the Oxford map-area, Cumberland county, Nova Scotia (latitudes 45° 30′-45° 45′ and longitudes 63° 30′-64°). The earlier part of the Carboniferous strata extend across the map-area and are a continuation of the area to the east that includes the Malagash salt deposits, to which Mr. Norman also devoted some attention. Further field work in Oxford area is required before a geological sheet can be published.

T. L. Tanton. Mr. Tanton commenced a re-examination of the iron ore occurrences of New Brunswick and Nova Scotia and in the course of this work visited many localities. The greater part of the field season was devoted to the study of the Nictaux-Torbrook field, Nova Scotia. The geological mapping of this district had already been brought to an advanced stage by E. R. Faribault; the completing of the work was placed in the hands of E. H. Lovitt under the supervision of Mr. Tanton. With the assistance of J. T. Wilson, a magnetometric survey was made of an area that included a development of the iron ore beds, which were concealed by a widespread cover of drift. By means of the magnetometric work, the iron ore beds were traced and valuable information regarding structure was obtained. Further field work is required. These investigations are part of a systematic survey of the iron ore resources of central and eastern Canada.

Topographical

J. W. Spence. Mr. Spence continued the detailed topographical survey on a field scale of 1 inch to 800 feet, of an area about 10 miles by 4 to 5 miles, within which are located the most important mining properties in the immediate vicinity of Noranda. This survey is for the purpose of providing a base map for the geological work being done by M. E. Wilson. The survey of a northern part of the area has been completed and photographic copies of this part of the map may be obtained at a nominal charge, by applying to the Director, Geological Survey, Ottawa.

H. N. SPENCE. Mr. Spence completed the control surveys necessary for the preparation of maps of Serpentine Lake area, northwestern New Brunswick, latitudes 47° to 47° 30', longitudes 66° 30' to 67°. This district has, from time to time, attracted the attention of prospectors. Vertical ærial photographs of this area were taken during the summer by the Royal Canadian Air Force, and two 1-mile geographical sheets are now being compiled from the control surveys and photographs, in preparation for geological work. Mr. Spence also completed control surveys for the Oxford map-area, Nova Scotia, where geological investigations are now in progress.

PLATE I

A

B

A and B. Ribbon fibre, Vimy Ridge pit. (Page 52.)

INDEX

The annual Summary Report of the Geological Survey is issued in parts, referring to particular subjects or districts. This year there are five parts, AI, AII, B, C, and D. A review of the work of the Geological Survey for the year forms part of the Annual Report of the Department of Mines.