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OLGA - GOELAND AREA, ABITIBI-EAST COUNTY

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GEOLOGICAL SURVEYS BRANCH

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GEOLOGICAL REPORT 51

OLGA - GOÉLAND AREA

ABITIBI - EAST COUNTY

by

P. E. Imbault



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OLGA-GOÉLAND AREA

ABITIBI-EAST COUNTY

by P.E. Imbault

INTRODUCTION

Location and Means of Access

The Olga-Goéland area, which was examined and mapped during the summers of 1947 and 1948, comprises approximately 450 square miles and is bounded by longitudes 76°40' and 77°15' West, and by latitudes 49°45' and 50°00' North. It lies in the northern part of Abitibi-East county and is about 100 miles north of Senneterre, a town on the Quebec-Cochrane line of the Canadian National Railways. Most of Dussieux, Duchesne, Meulande, and Johnstone townships, and more than half of Morris and Livaudière, are included in the map-area.

The most direct canoe route is by way of Bell river from Senneterre to Mattagami lake, the eastern end of which is included in the map-area (Plate VII-A). There are two other routes, each of which uses part of Bell river. One starts from the village of Rochebaucourt, about 23 miles northwest of Senneterre, and descends Laflamme river to Kanikwanika island where this stream joins Bell river, and thence follows the Bell to Mattagami lake. The other route follows Bell river from Senneterre to the mouth of Wedding river, 56 miles to the north; ascends Wedding river to its source, Wedding lake; crosses over to Duplessis stream through a three-mile portage; and follows this creek to O'Sullivan river and the latter river to Waswanipi lake. This lake drains into Goéland lake through a branch of Waswanipi river. There are numerous portages along all these routes.

Facilities for land transportation into the region are now being provided. A number of years ago, a wagon road was constructed from Senneterre to Rose Lake mine on Madeleine lake, 25 miles south of the southeast corner of the map-area. This road is now being repaired and extended by the Quebec Department of Mines and, when completed, will provide an all-weather highway to Bachelor lake, 30 miles southeast of Goéland lake. It will cross O'Sullivan river and thus afford a fast and cheap means of reaching the area. There is already a winter road from Madeleine (Rose) lake to Bachelor lake with a short branch northward to the southeast corner of Waswanipi lake.

The Canadian National Railways has completed a branch line from Barraute, 18 miles westward from Senneterre, to Kiask falls, on Bell river, 47 miles north of Senneterre. The line, at that point, meets the Senneterre-Bachelor Lake road.

Hydroplanes are presently used extensively to enter the vast unsettled region lying north of the main railway line. Any of the large lakes in the map-area can be reached from bases at Senneterre within slightly more than one hour's flying time.

Within the area, most places can be reached fairly easily from the shores of the lakes and the banks of the main rivers. The two segments of Waswanipi river are navigable by canoe, although interrupted by a few rapids, all of which can be run in a large canoe, although not ascended. Red chute, a fall and rapids with a combined drop of eighteen feet at the outlet of Olga lake, is avoided by a well-beaten trail, about 1,200 feet long.

The north-central part of the area is the most difficult of access. Its western section can be reached through Canet river which, in the spring, may be ascended with fully-loaded canoes up to its main fork, three miles south of the northern boundary of the area. To cover the eastern section of the area, the party ascended Frederic creek, which empties into Maicasagi lake two miles north of latitude 50°00'. The creek is rather shallow but early in the season is navigable, with only two portages, to its fork, eight miles west of the eastern boundary, and one mile south of the northern limit, of the area. From that point, a four-mile base-line was cut in a southwest and west direction.

Travel overland is quite difficult in the swampy areas because of extensive growths of alders and a dense second-growth of coniferous trees. Elsewhere, the region is easily traversed, except for a few local patches of wind-falls.

Field-work

Pace-and-compass traverses were run throughout the area at approximately half-mile intervals. As far as possible, these traverses were made across the general structure of the rocks.

Vertical aerial photographs, on a scale of about one-quarter of a mile to the inch, were used continuously in the field, and permitted the location of many low exposures.

Previous Work

The region was first visited by Robert Bell, of the Geological Survey of Canada, in 1895 and 1896. During these two summers, Bell (1896, 1897, 1902)^x investigated a large tract of land bounded by Rupert river on the north, the upper part of the Ottawa river on the south, Mistassini lake on the east, and the Quebec-Ontario boundary on the west. The main rock groups are shown on his map, published in 1902, and are briefly described in the Summary Reports of the Geological Survey of Canada for 1895 and 1896.

In 1912, Bancroft (1913) examined and described a region including Olga and Goéland lakes. Later, Cooke (1927) compiled and plotted all the known information on a map published by the Geological Survey of Canada. Other workers who have contributed to the knowledge of the general region include Lang (1933), Norman (1937, 1938), Sproule (1937), Freeman (1938, 1940), and Auger (1942) who, in 1938, studied that part of the area lying west of Olga lake and Waswanipi river.

Acknowledgments

During the 1947 season, Dr. J. Claveau, geologist of the Quebec Department of Mines, spent about six weeks with the writer in the field, in the capacity of technical supervisor. His tactful guidance and encouragement, not only in the field but also throughout the preparation of this report, have proved invaluable. The photographs shown on Plates II-A, III-A, and V-B were taken by him.

Much information used in this report was collected by Malcolm Ritchie and Jean Canet, senior assistants in 1947, and by Walter Coombes and Bruce Lyall, senior assistants in 1948. Their unfailing help is gladly acknowledged.

In 1947, additional members of the party were G. Bessett and L. D'Aigle, junior assistants. E. Chouinard, canoe man; and J. Roberge, cook. In 1948, they were Claude Drouin, junior assistant; Maurice Landry and Maurice Vaillancourt, canoe men; and J. Roberge, cook. All performed their duties in a satisfactory manner.

The base-map used during the field-work of 1947 was an enlargement to a scale of half a mile to the inch of sheet 32F (Waswanipi: 4 miles to the inch) of the National Topographic Series of the Federal Department of Mines.

^xReferences are listed at the end of this report.

During the fall of 1947, the Quebec Department of Lands and Forests prepared a new base-map on a scale of half a mile to the inch from plans and surveys in its possession and from vertical aerial photographs taken in 1946 by Canadian Pacific Air Lines for the Federal government. This map was used as a base during the field-work of 1948 and also for the preparation of the final manuscript map of the whole area.

Deep appreciation is expressed for the valuable guidance and the facilities for research afforded by the faculty of the Department of Geological Sciences, McGill University. The contents of this report form a large part of a doctorate thesis accepted by that institution.

DESCRIPTION OF THE AREA

Topography

The whole area lies less than 1,000 feet above the level of James bay. Topographic features that could be used as landmarks are conspicuously lacking. Seen from the air, the region presents the aspect of a monotonous plain dotted irregularly with low hills that seldom exceed 50 feet in height.

A particularly extensive low tract, characterized by swamps and muskegs, covers much of the northwestern part of the map-area. It marks the southern limit of a swampy terrain that extends for great distances to the north and west, and which locally is called the 'Mattagami swamp'. The basic pattern of this low ground consists of alternating patches of open muskegs, swamps densely covered with alders, and small isolated stands of black spruce. This pattern is interrupted by a few shallow lakes and low morainic hills. The general southern limit of this tract is shown on the accompanying map. Within the map-area, the borders of the individual swamps and muskegs are very intricate in detail. Small lakes are present within most of them and the indications are that, at one time, the area was covered by much larger lakes — possibly only one extensive lake — in which knobs of sand and gravel, and low rocky hills, stood out as islands.

The highest hills are found near the southern border of the area. They range in height from about 75 feet to 150 feet. From west to east along these hills, one successively meets most of the rock types found in the region, namely: oligoclase granite south of Olga lake; volcanic and sedimentary rocks west and south of Laurent bay; hornblende granite east of that bay; and volcanic rocks and biotite granite east of Goéland lake. The kind of underlying bed-rock thus seems to have little bearing upon the local relief.

Drainage

The local drainage is collected by three main basins - Mattagami, Olga, and Goéland (with Maicasagi) lakes, which lie, respectively, at 765, 785, and 810 feet above the level of James bay. The northwest quadrant drains into Mattagami lake, mostly through Canet river which flows south and then west from its source in the granitic terrain north of the map-area. The southwest quadrant drains into Olga lake, and the eastern half of the area into Goéland and Maicasagi lakes.

Except for a few sections along the two segments of Waswanipi river (Plate VIII), all the streams flow in valleys that have been excavated in glacial deposits. No stream has yet attained 'grade' and the irregular courses are due, not to meandering, but to original irregularities in the sloping surfaces on which the streams developed. The courses of most streams are interrupted here and there by rapids that generally result from accumulations of large glacial boulders which the streams have not yet had time to clear away. Red chute, at the outlet of Olga lake, is a notable exception. On leaving the lake, the waters cascade turbulently over a ten-foot rock ledge, to drop another eight feet in the next few hundred yards (Plate I-A).

Because of the narrowness of the valleys, the streams have a wide seasonal range in level. In the spring, just after break-up, they are commonly some ten feet higher than in midsummer (Plate VII-B). (The mouth of Canet river was sixteen feet above normal in the middle of June, 1947). Heavy summer rains often raise the level of the streams, near their headwaters, by many feet. When such is the case, the swollen condition generally persists for a few days and may facilitate access by canoe to a district that, otherwise, can be reached only on foot.

The drainage pattern is a modified dendritic one. East of Olga lake, the westerly-flowing streams debouching into the east-trending bays of that lake may follow lines of weakness parallel to the strike of the volcanic rocks. There is, in fact, abundant evidence of strike shears in these rocks. Since, however, most of the streams flow in narrow valleys, cut so far only in glacial deposits, it is difficult to arrive at definite conclusions as to the part played by local bed-rock controls without spending more time in the study of these features than is possible in the course of geological mapping on a regional scale.

Timber, Game, and Fish

Except for the northwest quadrant, the area is heavily wooded. Black spruce forms the bulk of the several good timber stands of the region, but there are also local stands of jack-pine, birch, poplar, and tamarack. A few cedar trees were observed on the shores of Olga and Goéland lakes.

Moose and bear are scarce in the area. Many of the streams are blocked by beaver dams, a great majority of which are now abandoned.

Pike and pickerel are abundant in the rivers and lakes. Apparently there are no trout, even in the small streams of the higher parts of the area.

GENERAL GEOLOGY

General Statement

Broadly stated, the main geological features of the area are a central, east-trending belt of volcanic and sedimentary rocks, and, bounding this on the north and on the south, and indenting it in places, a number of bodies of intrusive rock among which granitic types predominate.

Most of the rock exposures are low-lying and generally covered with thick moss. They are commonly no more than a few hundred square feet in extent, except around the shores of the larger lakes and along the banks of Waswanipi river, where removal of the 'clay' cover has exposed large sections of the bed-rock.

All the consolidated rocks are of Precambrian age. About two-fifths of the area is underlain by Keewatin-like lavas and sedimentary rocks. The remainder is occupied by basic and acidic intrusive rocks. The basic intrusives crop out mostly in the northwest quarter of the area. They are older than the acidic intrusives and the most common type is diorite. The acidic intrusives consist mainly of the following three bodies: a narrow strip of rather massive oligoclase granite, south of Olga lake; grey, gneissic, partly contaminated oligoclase granite extending across most of the northern half of the area; and a small batholith of pink, massive, hornblende-biotite granite, underlying the basin of Goéland lake.

All the rock types of the area are shown, in proper sequence, in the accompanying table of formations.

Table of Formations

Quaternary	Clay, clayey-sand, varved-clay, till, sand		
Great Unconformity			
Diabase (Keweenaw?)			
Post-Keewatin intrusives	Pink, microcline granite and pegmatite		
	Lamprophyre, diorite, and gabbro dykes		
	Coarse-grained, pink, massive, hornblende-biotite granite (Goéland granite)		
	Grey, generally massive, oligoclase granite (Olga quartz-diorite), probably related to the 'northern granite'		
	Grey, gneissic, oligoclase granite, often referred to as the 'northern granite'		
	Diorite-syenite group (basic series)		
Folding; Intrusive contact			
Keewatin(?)	Concordant bodies of fine-grained gabbro and of granite porphyry		
	Intrusive contact		
	Volc.-Sed. Series	Meta-trachytes, generally porphyritic, in places fragmental; a few beds of tuff	
		Fine-grained greywackes recrystallized to biotite and/or hornblende schists; a few beds of chert	
		Meta-andesites (and possibly minor basalt flows), commonly ellipsoidal; a few beds of tuff	

Keewatin Rocks

(Volcanic-Sedimentary Series)

Except for the area occupied by Goéland lake and a narrow strip south of Olga lake, which are underlain by granite, Keewatin-like rocks occupy roughly the southern half of the map-area. They consist largely of a volcanic-sedimentary series which is part of a long belt of these rocks that extends for more than 200 miles from the Quebec-Ontario boundary, through Mattagami lake, to and beyond Chibougamau lake. In the region studied, the belt varies in width from four miles, west of Olga lake, to about ten miles, just east of Goéland lake. The best exposures are on the west and south shores of Laurent bay (a small recess in the western part of Goéland lake), around Olga lake, and on the numerous islands in this lake.

West of Goéland lake, this belt of Keewatin-like rocks may be pictured as consisting of a core of predominantly trachytic flows surrounded by strips of andesitic and of sedimentary rocks. Northward from the area of trachytes, there outcrops first a band of sedimentary rocks, then a belt of andesitic lavas. On the south side, the succession is reversed; the andesites occur next to the trachytes and separate them from the remnants of a sedimentary band cropping out on the south shore of Olga lake. The general trend of both the bedding and the schistosity in the whole of this district is east-west.

On approaching the Goéland batholith, the trachytes give place to a north-south, crescent-shaped band, about a mile wide, that consists mainly of andesites containing long and narrow sedimentary lenses. These lavas form a belt curving around the west side of the granite mass that underlies Goéland lake. East of Goéland lake, the lavas form an easterly-trending belt about nine miles wide.

Many inclusions of volcanic and sedimentary rocks are found in the younger intrusives — both basic and granitic — exposed in the northern half of the map-area. They are usually small, either angular or ellipsoidal in outline and their greatest dimension seldom exceeds a few feet. Occasional larger units do occur, however, and they are indicated on the accompanying map. The two largest of these are in the north-central part of the area. They have been joined on the map by dotted lines to indicate the contact as deduced by geologists of the Dominion Gulf Exploration Company from geophysical surveys^x.

^xPersonal communication.

Numerous small masses of granite porphyry and of gabbro are found here and there among all three rock types of the volcanic-sedimentary series. They appear, in all cases, to have intruded the series concordantly before folding took place. The larger of these bodies are shown on the accompanying map.

Andesitic Rocks

Distribution

These rocks are meta-volcanics, mostly meta-andesites with a few meta-basalts. Their structural characters are generally so well preserved that their volcanic origin can be recognized readily both in the field and under the microscope. This group is exposed as three main belts:

a) North of Olga Lake. The andesites form a zone or belt trending east to northeast and bounded on the north by granitic intrusives and on the south by a sedimentary band. This belt, which is up to three and a half miles wide, is exposed for a length of only three miles. At its western end, north of Red chute, it is truncated by intrusive basic and acidic rocks. Its eastward extension could not be ascertained because of heavy drift cover.

b) Near the Southern Margin of the Area. From the western limit of the map-area this belt trends eastward, with a width of about a mile, through the largest island in Olga lake and thence follows the north shore of the southernmost east-trending bay of that lake. From the end of the bay it swings gradually southeastward, widening to about two miles, and leaves the area south of Laurent bay.

c) Around and West of Goéland Lake. If it were not for the Goéland batholith, this belt would presumably underlie the greater part of the southeastern quadrant of the map-area. At the eastern boundary it is about nine miles wide. Its western limit is an arcuate line roughly following the western shore of Goéland lake at a distance varying from one-eighth of a mile, south of Laurent bay, to about one mile, northwest of that bay. At the north end of Goéland lake, between Max narrows and Maicasagi lake, the zone is in contact with the northern granites. West of Goéland lake a belt of trachytes is found between the andesites and the northern intrusives.

In addition to these three main belts, there are a few small bodies of andesitic rocks within the area of trachytes. The more important are seen along the east shore of Olga lake, both north and south of Waswanipi river. Other occurrences are on the north and south sides of the Waswanipi almost at the centre of the map-area.

The presence of inclusions in the intrusive rocks in the northern part of the area has already been mentioned. The exact nature of these inclusions could seldom be determined with certainty because recrystallization has obliterated all primary structures and has given the rock a granular appearance. On the basis of their composition, they are classified as andesites, differing from the corresponding lavas of the main belts only by their more metamorphosed condition.

Description

These intermediate lavas are fine-grained, in places almost aphanitic, and dark grey, often with a greenish tinge. They commonly have a porphyritic appearance, although the largest crystals are of porphyroblastic development. Amygdaloidal flows, in which the amygdules are much flattened, were noted in a few places. In structure, these lavas show all gradations from almost massive to highly schistose.

Many pillows were seen, especially on the clean rock surfaces along the shores of Olga lake. All the pillows are very much deformed; the length:width ratio is commonly of the order of 20:1, so that the pillows appear as thin lenses from which little information can be obtained as to the tops of the flows. Only at one place could such a determination be made. This locality is on the south shore of the middle bay, east side of Olga lake, about half a mile east of the mouth of the bay. On this exposure, the sequence from north to south is as follows:

Andesite, not pillowed	12 ft.
Pillowed andesite	18 ft.
Slaty tuffs (mostly acidic)	30 ft.
Pillowed andesite	100 ft.

The pillows here still have a faint bun shape and their arrangement indicates that the tops of the flows face south. As a corroboration, a systematic series of specimens was taken across the eighteen-foot flow. From a study of these it is seen that near both borders the grain is aphanitic, and that the coarsest part of the bed is twelve feet from the top as indicated by the pillows. The curve shown in Figure 1 differs from that given by Cooke (1925, p. 8) for the position of maximum grain size, but in general form it is similar.

Petrography

The andesites consist of amphibole and feldspar with, generally, some quartz, epidote, chlorite, calcite, and magnetite. The

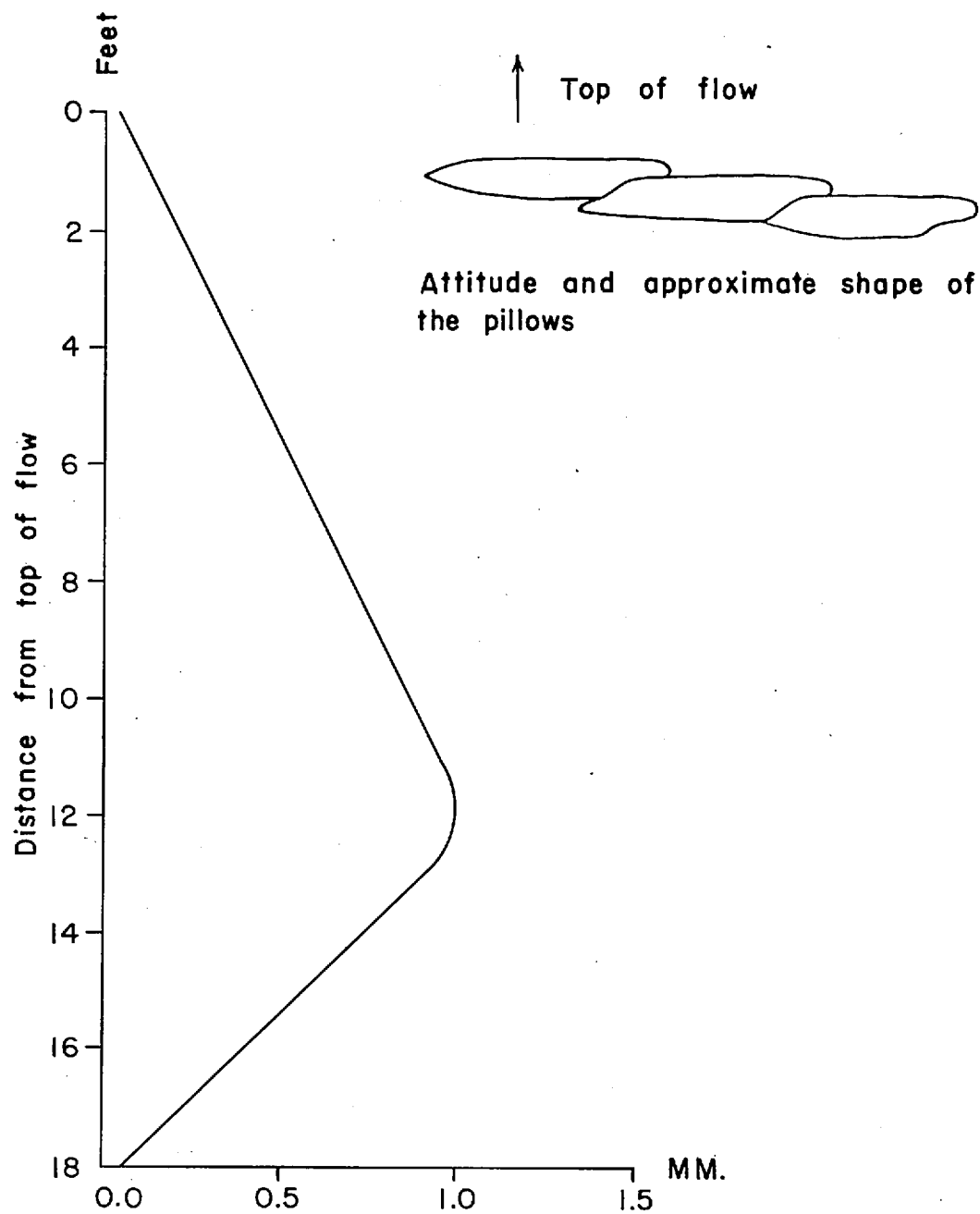


Fig. 1

GRAPH SHOWING VARIATIONS IN GRAIN SIZE IN AN ANDESITIC PILLOWED FLOW

percentage mineral composition of the rock is highly variable, as indicated below:

Amphibole	40-80%
Feldspar	10-50%
Quartz	5-15%
Epidote	5-20%
Chlorite	Acc.-10%
Calcite	0-15%
Magnetite	0- 2%

The common amphibole is ordinary hornblende with the following optical properties:

Pleochroic formula: Z = blue-green to deep blue
Y = olive-green
X = greenish-yellow to straw-yellow

$Z \wedge c = 16^{\circ}-24^{\circ}$; $(-)2V = 75^{\circ}-80^{\circ}$; absorption: $Z > Y > X$.

One of the sections examined contains a much paler, less pleochroic amphibole, identified as actinolite:

Pleochroic formula: Z = light green
Y = olive-green (pale)
X = straw-yellow

$Z \wedge c = 18^{\circ}$; $(-)2V = 85^{\circ}$.

The feldspar grains are usually clouded by kaolinite and white mica, and carry ragged masses of epidote, possibly with cores of clinozoisite. As a consequence, it is rarely possible to determine their original optical character. However, some of the fresher sections examined contain broken phenocrysts of a plagioclase near andesine (An_{28-30}) in composition. Faint indications of albite twinning can be seen occasionally. No prominent zoning was observed.

Albite is present in most of these andesitic rocks. It occurs, in places, as small, clear, anhedral grains along the borders of the altered feldspar. More commonly, it is found as thick lenses measuring, as a rule, up to 5 mm. in length (exceptionally up to 3 centimeters). In these, the albite is still clouded with kaolinite and especially epidote. The lenses are aligned parallel to the schistosity of the rock. They have grown by pushing aside the smaller-grained minerals and are truly porphyroblastic.

Some quartz is found in all these rocks. It occurs either as small lenses parallel to the schistosity or as veinlets cutting across it. Often, also, it is interstitial to the altered feldspar and to the hornblende, and contains minute inclusions of those two minerals. In the amygdaloidal flows, the amygdules consist mostly of quartz which, in many cases, is shattered and carries shreds of chlorite. Probably little of the quartz is original.

The most abundant variety of chlorite is penninite. It is light green in colour, has low birefringence, and is optically positive. Clinocllore was found in one slide. The chlorite is all secondary after hornblende, and its greatest development is in and near the numerous well-defined shear zones that traverse the andesites of the area.

Calcite, when present, is distributed through the rock as small specks or occurs as veinlets, up to an inch thick, that follow the schistosity. It is often associated with quartz and pyrite. The small, disseminated grains may be the result of alteration of plagioclase and other calcium-bearing minerals of the rock, but there is no doubt that there has been considerable migration of material to form the veinlets.

Magnetite occurs commonly as small grains marginal to and within the hornblende crystals, rarely as blebs or large clots. One slide contains well-developed octahedra of magnetite around which the schistosity is seen to curve. In some thin sections, magnetite accompanies secondary chlorite, which would indicate that it is a released product from the transformation of hornblende to chlorite. In a few slides, however, magnetite is associated with hornblende in a rock devoid of chlorite, in such a way as to suggest that both minerals have formed through the decomposition of a pyroxene.

Texture

The texture is essentially crystalloblastic. It is dominated by two minerals, hornblende and albite, which are the products of recrystallization. The lenticular habit of the albite porphyroblasts and their relation to other minerals has already been mentioned.

Throughout the main belts of these andesitic rocks, hornblende occurs as tabular grains, commonly less than 1 mm. long, or as shreds, depending upon the grade of metamorphism of the rock. Prismatic faces are generally much better developed than terminal faces. In those rocks where recrystallization is more advanced, the grains are up to 2 mm. long. Their orientation is erratic; some follow the

borders of the albite porphyroblasts, others abut against them. Even in the more massive types, however, there is always at least a general sub-parallel orientation of the grains, imparting to the rock a faint schistosity. This schistosity is more apparent where the hornblende has recrystallized only in the form of long, thin shreds.

Due to the paucity of exposures and the impossibility of separating the two types in the field, it was not found possible to define consistent bands in which the hornblende appears dominantly either as well-developed prisms or as shreds. It is probable that slight local differences either in original composition of the rock or in intensity of metamorphism were important factors determining which of the types would be developed. It is generally admitted that rocks of different composition react differently under the impulse of identical conditions. It is also possible that, in a homogeneous series undergoing metamorphism, small changes in otherwise constant conditions of temperature and pressure (especially stress) may cause local differences in the appearance of the end product.

The grains of original feldspar are, as a rule, less than 1 mm. long and lie in random orientation within the rock. The crystal boundaries of some of them are well preserved, despite rather extensive fracturing. Generally, however, and especially in those specimens in which the albite porphyroblasts are better developed, the original feldspar grains lack sharp definition. They appear either as indistinct masses, clouded with epidote, or as sinuous streaks between trains of hornblende shreds. Many of the larger grains are surrounded and partly replaced by secondary hornblende.

Type and Grade of Metamorphism

The critical mineral association in these andesitic belts is hornblende-albite-epidote. These rocks thus fall quite naturally into the albite-epidote-amphibolite facies of Turner (1948). As far as can be ascertained from microscopic studies, most of the original rocks consisted of hornblende and plagioclase, so that the mineralogical changes were likely effected quite easily. A few beds, however, probably had a basaltic composition, but these two now have the hornblende-albite-epidote association.

That such extensive and widely separated belts of rock should present similar characteristics must be due to regional metamorphism. The rocks have many of the characteristics described by Harker (1932) for the lower grade of such metamorphism. Albite porphyroblasts are numerous; hornblende is well developed; and there is some epidote that is not yet assimilated. The changes were not of high enough grade to

obliterate all primary structures, although such features as amygdules and pillows are highly deformed.

All the lavas of intermediate composition have undergone extensive shearing along restricted zones, especially in the main belts. The amount of chlorite developed as a result of this shearing is rather small as observed in the thin sections examined. This is explained by the fact that, for purposes of microscope studies, only the fresher specimens were considered. In the field, on approaching a shear zone, the amount of chlorite increases gradually until the rock becomes a highly chloritic schist, glistening with waxy flakes of chlorite. This schist crumbles so easily that it is usually impossible to detach a specimen of suitable size. The width of such transition zones ranges from a few inches to many feet.

Hydrothermal development of chlorite is exceptional in the more massive rocks. Generally, the formation of chlorite has been favoured only along definite shear zones at a time following the first period of metamorphism. Other hydrothermal effects, consisting chiefly of the introduction of quartz, calcite, and pyrite, are, as a rule, intense along such zones.

Slight bending of the hornblende prisms and occasional fracturing of albite porphyroblasts was observed in some of the rocks away from the main shear zones. These features may probably be regarded as mild or remote effects of the stresses whose greatest intensity was localized along those zones which are now heavily sheared and chloritized.

Trachytes

Distribution

Trachytes underlie a roughly-triangular area, the western apex of which is an imaginary point lying in Olga lake somewhere north of the largest island. They are bounded on the south and on the east by andesitic belts. Although most of their northern boundary is hidden by overburden, it would appear to follow the general trend of Waswanipi river, at a distance of one-half to one mile north of it, for eight miles eastward from Olga lake. Along this stretch the trachytes are probably bounded on the north by the eastward extension of the sedimentary band cropping out on the north shore of Olga lake. Farther east, however, they are in contact with gneissic granite, probably as far as Max narrows. They apparently end near these narrows, their place being taken by the belt of andesitic rocks which surround the northern part of Goéland lake.

As exposed on the east shore of Olga lake, the belt of trachytes is four miles wide. It broadens gradually eastward to some eight miles at a point about two miles west of Goéland lake. From there, the belt divides into south and north segments which curve around the crescent-shaped band of andesitic rocks. The southern branch narrows rapidly and, south of Laurent bay, where it has a width of one-eighth of a mile, it terminates against the granitic rocks of the Goéland batholith. The northern branch narrows gradually and disappears, in the vicinity of Max narrows, between andesitic rocks and the northern granitic intrusives.

Description

The trachytes are light green to greenish-brown, commonly slightly schistose, rocks. Examination in thin section reveals that they are all porphyritic to some extent. In many specimens, the phenocrysts cannot be observed with a hand lens, and such rocks have a uniform glassy appearance.

Faint remnants of pillows were seen in the rock on the point south of where Waswanipi river enters Olga lake. On a horizontal surface, these now appear as elongated ellipsoids, about one foot long and three inches wide. They all parallel the schistosity and are distributed over a width of eight feet. The presence of amygdules, although useless for determining the tops of the flows, was most helpful in establishing the true volcanic origin of certain doubtful exposures.

Some of the trachyte flows are fragmental. Because of their interesting character, these flows will be described separately.

Petrography

Microscopically, the trachytes consist of a fine groundmass, composed predominantly of feldspar, through which feldspar phenocrysts, in varying abundance, are distributed. Numerous other minerals are found in the groundmass. Their proportions are variable, as indicated in the following table:

Feldspar, as phenocrysts	10-40%
Feldspar, as groundmass	20-70%
Quartz	1-10%
Epidote	1-20%
Calcite	Acc.- 5%
Chlorite	Acc.-15%
Biotite	0- 4%
Sericite	Acc.-20%

Magnetite	Acc.
Hematite	Acc.
Leucoxene	Acc.

The phenocrysts are generally 1 mm. (sometimes up to 3 mm.) in length. They commonly show Carlsbad and albite twinning. Saussurization is widespread, but phenocrysts fresh enough for identification were found in all thin sections examined. Their composition is remarkably uniform, being albite, near An₇. The feldspar of the groundmass is in grains so small that accurate determination is impossible. Potassic feldspar may be present, although a comparison of refractive indices seems to indicate that the feldspar of the groundmass has a composition essentially similar to that of the phenocrysts.

Some of the quartz in these rocks may be original, but most of it appears to be later than the consolidation of the lavas. The introduced quartz is found as small veinlets cutting the rock, and as amygdular filling in vesicles. The amygdules are oval and in some of them remnants of clouded plagioclase are associated with their filling of shattered quartz. In many specimens, quartz is found also as large rounded clots, each composed of a multitude of minute grains. These clots are distributed erratically and are believed to represent crushed quartz 'eyes'. Finally, some quartz is found in the groundmass as individual grains which generally are a little larger than the feldspar.

Of all the thin sections examined, only two contain biotite. It is pleochroic from dark green (almost black) to light green. The flakes are ragged and small, and are in part altered to chlorite. There is thus a suggestion that biotite may originally have been present in all these rocks, and that the chlorite, which is present in all the sections (it is commonly the only dark mineral), may be an alteration product of biotite. The usual chlorite is greenish, has low birefringence, and belongs to the penninite group.

Texture

The trachytes are characterized by a well-preserved, porphyritic texture. Most of the plagioclase phenocrysts are still intact, and even in the case of rare broken ones, the fragments are still close enough to one another to allow recognition of the original crystal shape. The cracks are commonly filled with calcite, but sometimes with epidote, and/or quartz. In a few cases, the smaller fragments have been rotated and now lie transverse to the bulk of the phenocryst.

As seen in thin sections, the rock exhibits a pronounced fluidal (trachytic) texture. This results partly from a suborientation

of the phenocrysts themselves, and partly from the alignment of the original minerals (mostly biotite and feldspar) of the groundmass. In the schistose varieties, the texture is further accentuated by an alignment of the shreds of chlorite and the flakes of sericite in a direction parallel to the lines of flowage.

The behaviour of these platy minerals, when they meet a phenocryst, is in typical contrast with the arrangement observed in the porphyroblastic andesites. In the latter, the porphyroblasts have more or less pointed ends, on either side of which the platy minerals diverge. They show evidence of having grown by pushing aside the smaller minerals. In the trachytes, on the other hand, the platy minerals follow and wrap around the long edges of the phenocrysts, and abut directly against the central portions of these ends.

Fragmental Trachytes

Several of the acidic flows are characterized by the presence in them of a large number of fragments. Two kinds of inclusions are found, each producing a distinctive type of breccia.

Flow Breccia (first type)

On the north shore of the point opposite the east end of the large island in Olga lake, a fragmental zone of particular interest was seen about 3,000 feet east of the tip of the point. The rock consists mainly of fine-grained, slightly porphyritic trachyte. It contains fragments of a rock having about the same composition as the matrix, but in which the feldspar phenocrysts are more numerous and larger (up to one-quarter of an inch).

The fragments are of all sizes from a fraction of an inch to almost three feet in length. Their width is variable so that some are ellipsoidal, whereas others have a ribbon-like appearance. Rarely, it is seen that a fragment has been broken, and that the pieces have drifted away from one another (Figure 2). In other instances, quartz replaces selectively the porphyritic fragments (Figure 3).

This type of fragmental lava is closely similar to that observed by Wilson (1941) in the Noranda district and described by him as a flow breccia. The fragments may represent loose material lying in the path of an advancing flow that was caught up and engulfed in the consolidating lava. On the other hand, the breccia may have resulted from the consolidation of the surface of the lava flow, and subsequent breaking of the crust while movement was going on. The presence of large phenocrysts only in the fragments favours the first-mentioned method of formation.

Flow Breccia (second type)

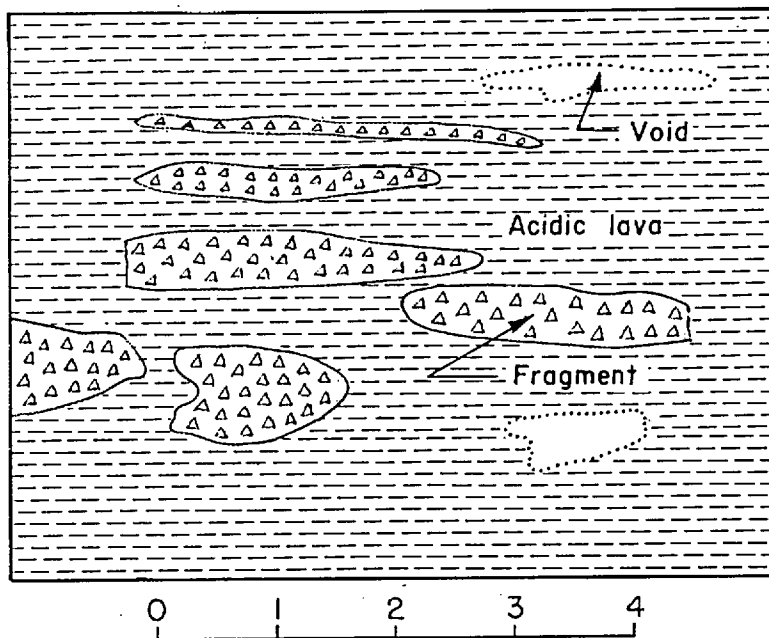
The most typical fragmental flows of this type are on the east shore of Olga lake, immediately south of Waswanipi river, and on the south shore of the northern bay. At the first locality, the flow is 25 feet thick and is exposed for more than 100 feet. At the second, fragmental flows are exposed for a length of about a quarter of a mile around the west end of the rounded point in the middle of the south shore. Since the shore-line here bevels the east-west bedding, the flows appear to have a true thickness of at least 500 feet. Similar fragmental lavas were found, also, north of Goéland lake, two miles northeast from the bend where the course of Waswanipi river changes from northerly to westerly. In all these occurrences, the fragments are distributed rather uniformly across the whole width of the flows.

In size and shape, the inclusions in these flows are of two types: (a) small, angular to subangular fragments, whose greatest dimension seldom exceeds a few inches; (b) flat ellipsoids up to fifteen inches long and four inches wide. Although fragments of both types are to be seen in most exposures, the smaller pieces predominate in the Olga lake outcrops and the ellipsoidal fragments in the exposures north of Goéland lake.

The fragments of both types are identical in composition. They all weather to a cream-buff colour and their fresh surface is a lighter green than the enclosing lavas. Their very fine grain, finer than the enclosing rock, gives them a glassy, or in places cherty, appearance. As a rule, they do not contain any megascopic phenocrysts. The orientation of the elongated fragments is very regular; they all lie with their long axis horizontal and parallel to the schistosity of the enclosing lava.

One of the flat, ellipsoidal fragments, believed to be representative of this type, was studied in thin section and its composition was found to be very similar to that of the surrounding rock. Completely saussuritized feldspar phenocrysts form about ten per cent of the fragments; they are set in a groundmass of epidote, clouded feldspar, calcite, chlorite, sericite, and some quartz. The composition of the feldspar could not be determined. It has, however, the same appearance as the albite of the matrix and is presumed to be a sodic plagioclase. The fragment also contains shattered amygdules of quartz.

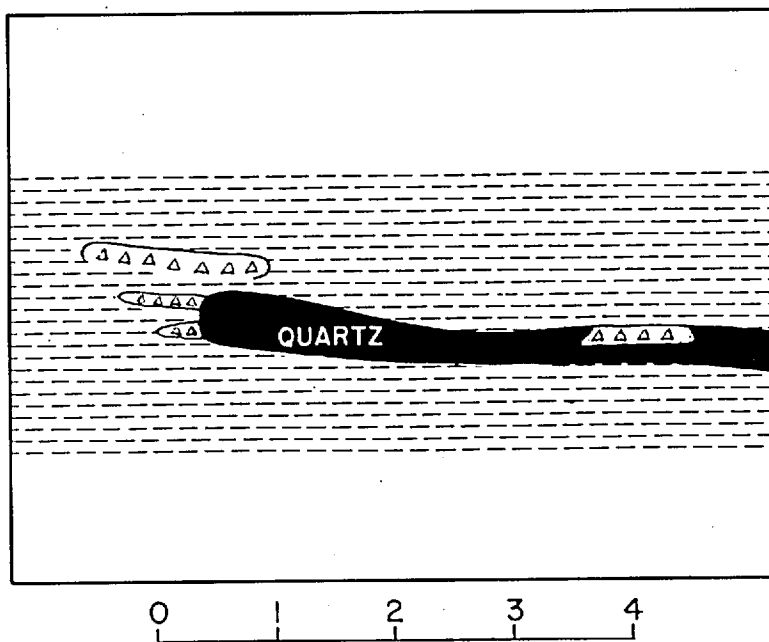
A striking feature of this fragment is its well-preserved physical condition. The phenocrysts have well-defined outlines. They are smaller than those in the main body of rock but none of them has



Feet
Fig. 2

PORPHYRITIC FRAGMENTS IN ACIDIC LAVAS

D. M. Q. 1951 No. 912



Feet
Fig. 3

QUARTZ REPLACING PORPHYRITIC FRAGMENTS IN ACIDIC LAVAS

D. M. Q. 1951 No. 913

suffered any granulation. Due to their orientation along parallel lines the rock has a fluidal texture that is better developed than in the lava, and, as in the latter, this texture is rendered even more conspicuous by the parallelism of shreds of chlorite and sericite. The impression given by this fragment is that it has kept its original form, even though its oval shape resembles very much that of the squeezed pebbles found in certain conglomerate belts, e.g., the one cropping out on the north shore of Mattagami lake west of the present area.

If it be true that this fragment is a representative one, it may then be concluded that the flat lenses found in these fragmental lavas are not the product of mechanical deformation. This fact and their composition are the main elements to be considered in trying to explain the origin of the fragments.

The fragmental lavas of this second type must have originated as the result of one of, or a combination of, the following processes:

Mechanical process
Hydrothermal action
Igneous process

M.E. Wilson (1941) describes flow breccias of two kinds; one contains angular fragments, the other, thin ribbons. The distribution of the angular fragments is commonly irregular, and without consistent relationships to either the strike or the dip of the lava flow of which they are a part. "The flow breccias were presumably formed by the engulfing of fragments of lava crust either within the volcanic vent or while the lava was being extruded" (Wilson, 1941, p.20).

It is unlikely that the undeformed fragments under study could have originated through the breaking up of a crust or vent walls. The phenocrysts of the fragments are smaller and better oriented than those in the enclosing lava. Furthermore, while it is admitted that angular slabs may be rounded by re-resolution of their corners, none of the fragments examined show any evidence that this process was operative.

Descriptions of flow breccias occurring near the top of a lava flow (the most common type of fragmental lava) are very numerous in the literature. They are found, in fact, in almost every paper or report discussing volcanic rocks. The present lavas, however, differ from them not only in the shapes of the fragments, but also in their distribution from top to bottom of the flow.

Gunning and Ambrose (1940, p. 9) describe nodular flows of dacitic and rhyolitic composition. The nodules are cigar-shaped and

are oriented with their long axis vertical. Their constituent minerals (mostly quartz, albite, epidote, and chlorite) are regarded by the authors as of hydrothermal origin. These nodules have a few characteristics in common with the fragments under consideration such as: shape, and the presence of introduced quartz and of secondary chlorite and epidote. Differing from the nodules, however, the fragments lie in a horizontal position. The albite phenocrysts, the well-preserved fluidal texture, and the presence of quartz-filled vesicles, are evidence of igneous rather than hydrothermal origin. Because of their shape, distribution, and composition, the fragments cannot satisfactorily be explained as being due to either mechanical engulfment in a lava flow or to hydrothermal action. In consequence, only an igneous origin remains to be considered.

It is believed that the peculiar nature of these fragments is satisfactorily explained if they are considered as volcanic bombs. This hypothesis accounts very well for the similarity in composition between the fragments and the lava: they are, indeed, products of the same magmatic fluid. The lighter colour of the fragments may be due to the more altered state of the feldspars. Their oblong shape is not as streamlined as might be expected, however, and no indications of spiral twisting were observed in any of the inclusions. Some of the smaller lenses have one fairly sharp end, whereas the other is rather blunt. The larger ellipsoidal fragments always have blunt terminations. It may be that their ends broke on striking the ground.

The orientation of these 'bombs' in rocks that have been isoclinally folded requires a complex adjustment of circumstances. As already noted, they lie in horizontal position, with their long axis parallel to the schistosity and the bedding of the enclosing rock. If bombs were blown up to fall on a static terrane, their orientation would inevitably be erratic. A parallel orientation could scarcely be the result of dynamic metamorphism. Movements adequate to rotate the bombs would, at the same time, cause severe deformation, both in the matrix and in the bombs. The well-preserved condition of the phenocrysts in both renders this hypothesis unlikely.

Consequently, if undeformed bombs are found in parallel orientation, the help of directional forces in the lava that receives them must be invoked. One is thus brought to visualize a shower of bombs falling into a lava flow that is moving with sufficient freedom to impose upon the bombs a common orientation. In a broad way, their parallelism could be compared with that of logs being transported by a river.

Conditions in the volcano would be somewhat as follows: fluid lava would be flowing from cracks in the side or along the base of the cone while from the top, due to gas explosions, bombs would be expelled. The frequency of such explosions would be such as to produce a more or less uniform distribution of the bombs in the moving lava.

Until now, the discussion has been concerned only with the oblong fragments found in the trachytes. The small, angular ones, interspersed with them, need much less consideration. From their distribution throughout the width of the flows, it appears that they are not contact effects. They possibly represent pieces torn away from the inner wall of the volcanic chamber; more probably, however, they originated from the breaking up of the larger fragments.

Metamorphism of the Trachytes

The trachytes are surprisingly different in appearance from the andesites. Their albite phenocrysts do not display any evidence of granulation or recrystallization. They are still present in their original form, and the trachytic texture that developed during the consolidation of the lava remains unaffected and has been rendered even more conspicuous by the development of chlorite and sericite in shreds and flakes parallel to the schistosity.

The difference, in these and other features, between the trachytes and the andesites must, in the writer's opinion, be related only to the difference in composition between the two types of lava, and to the general absence of igneous intrusions in the neighbourhood of the trachyte. The structure of these rocks is discussed in a separate chapter, but it may be said here that the trachytes are believed to lie in a synclinal area, and that their extrusion occurred between two periods of andesitic volcanic activity. Since the andesites that underlie the trachytes, and those that overlie the trachytes have similar metamorphic characters, it is concluded that differences in such factors as temperature, pressure, and stress are not responsible for the difference in appearance between the two types of volcanic rocks.

It has been seen, however, that the andesitic belts have undergone regional metamorphism under conditions that favoured the development of hornblende and of albite porphyroblasts in the andesites. These minerals constituted the stable association under the newly-created environment. The trachytes, consisting as they did predominantly of albite, were already adjusted to the new conditions and therefore could not undergo much mineralogical change.

During their long history, however, the trachytes have not been immune to a certain amount of transformation. Some of these changes are believed to be due to metasomatism (probably hydrothermal), whereas others may be classed as retrograde metamorphism. Metasomatic changes are evidenced by the presence of important quantities of quartz, calcite, and epidote. Retrograde metamorphism has occurred along the numerous shear zones that follow the schistosity. In these zones, the trachytes have been converted to sericite-chlorite schists.

Tuffs

Bands of tuffaceous sedimentary rocks were observed at only ten places in the area. They occur within both types of lava, although there are more of them in the trachytes than in the andesites. One narrow band, six inches wide, was found interlayered with the sedimentary rocks on the north shore of Olga lake.

The thickness of these pyroclastic layers is usually in the order of inches, with the exception of the 30-foot bed already mentioned (p.10) in the description of the andesitic rocks. They are all schistose, and most of the beds, because of their grain size, could be designated more accurately as slates. In one locality, it was possible to break off thin resistant slabs, one-sixteenth of an inch thick and measuring up to six inches square.

In all the occurrences, the tuffs are acidic, very fine-grained rocks that show a delicate banding. This feature results from interlayering of two types of rock in beds that may be as thin as one-eighth of an inch.

One type has a glassy appearance and a generally cream colour. The composition of this type cannot be resolved under the microscope. The rock appears to be thoroughly silicified. Some of these beds show variations in colour — and thus in basicity — from light grey to almost white, in a direction perpendicular to their bedding planes. At the place where the top of a flow was determined by means of pillows and grain gradation, these small bands were found to vary in colour from dark greenish-grey, at the bottom, to almost pure white at the top. Shrock has described similar variations in beds of recently fallen ash surrounding El Parícutin volcano (Shrock, 1948, p.330, foot-note 1).

The sequence of variations in colour in the tuffs is the opposite of that found in varved clays and Precambrian varved sedimentary rocks, although admittedly the deposits did not originate under similar conditions. With sufficient observations, this variation in

colour may become a useful means of determining the tops of the flows in which the tuffs occur, and thus become an important help in solving the regional structure.

The layers interbedded with the glassy beds are dark grey and coarser-grained (about 1 mm.). They do not display any variation in either grain size or colour. In thin section they are seen to consist of angular fragments of clouded albite and clear quartz embedded in a fine mass of quartz and feldspar. The schistosity is marked by long thin flakes of sericite which curve around the larger fragments. Some of the rocks contain iron oxides, in amounts varying from accessory to 30 per cent. The predominant oxide is a deep orange-brown hematite. Magnetite is rare, and its occurrence as small specks surrounded by hematite suggests that probably all the latter mineral is an alteration product of the magnetite. Most of the tuffs show evidence of the introduction of quartz, in veinlets along the planes of schistosity.

Sedimentary Rocks

Sedimentary rocks form three main bands in the area. The largest, later referred to as the Red Chute band, occurs on the north side of the core of trachytic lavas and lies south of an andesitic belt. This band is from one to two miles wide and crosses the northern part of Olga lake. Like the northern andesites, it is truncated at its western end, just west of Olga lake, by younger intrusive rocks. East of the north end of the lake, the band undoubtedly persists for some distance, as suggested by the exposures along the northeast shore. The extent of its eastward continuation is, however, a matter of conjecture because of the uninterrupted mantle of drift. It is possible that this band extends far enough east to be truncated by the gneissic granite, whose western margin appears to run in a southeasterly direction through a low-lying, drift-covered area.

The second belt of sedimentary rocks is exposed near the southwest corner of the map-area, along the south shore of Olga lake and on nearby islands. As shown on the accompanying map, it varies in width from three-quarters of a mile to one mile. It trends more or less northeast and is exposed for a little over three miles, although it probably continues eastward for a greater distance. The granitic exposures along the south shore of the long, east-trending bay about two miles from the southern boundary of the map-area are largely mixed rocks, or migmatite, in which most of the inclusions are of sedimentary rocks.

The third principal occurrence of sedimentary rocks forms a crescent-shaped band that extends from the south shore of Laurent bay to Waswanipi river, a distance of about six miles. Its convex side is

toward the west. This band is up to a quarter of a mile wide and its eastern border follows approximately the western shore of Goéland lake. The north end of this band gradually tails out into andesitic rocks, as indicated by interstratification of both types of rock on the south shore of Waswanipi river, a quarter of a mile west of Goéland lake. The belt appears to be much wider on the south shore of Laurent bay, near where it is truncated by the Goéland batholith. This apparent increase in thickness is believed to be due to drag-folding, of which there is some evidence in the form of small drag folds plunging steeply northward in these rocks.

In addition, numerous narrow strips of sedimentary rocks are found intercalated with the andesites, both north and east of Goéland lake. The most extensive of these are shown on the accompanying map, but there are many more, especially on the southeast shore of Goéland lake, that are too small to be shown separately from the lavas. In this locality, indeed, Claveau (1948) found the southern extension of the volcanic rocks to consist predominantly of typical sedimentary rocks. That such an extensive horizon is not found northward cannot be explained only by lack of continuous exposures. It appears probable that Claveau's sedimentary rocks form a lenticular body (similar to the one on the west shore of Goéland lake) which is interlayered with the lavas and whose northern tip fingers out near the southern border of the present area.

Red Chute Sedimentary Rocks

These rocks are everywhere schistose and fine-grained. Porphyroblasts of feldspar are often the only grains that can be identified in the hand specimen. The beds are generally thin, seldom more than an inch in width, although on some exposures no bedding was observed across widths of many feet. Such large thicknesses appear to be due to the fact that the individual beds are closely similar in composition and colour. Even on the cleanest surfaces, bedding lines appear very faint and a slight film of dirt is sufficient to mask them.

As one approaches the bodies of intrusive rock, veins and igneous seams and lenses of various composition begin to make their appearance in the sedimentary rocks. At Red chute, about 500 feet east of the northeasterly-trending contact with the syenite, the injections consist of quartz, which forms bead-like veins or follows the sinuous courses of drag folds. Continuing westward, small stringers of aplite, pegmatite, and syenite are found in increasing number. The syenite is older than both the aplite and the pegmatite, but the age relations between the aplite and pegmatite could not be determined. About 200 feet east of the contact, there is a ten-foot concordant

body of syenite which contains inclusions of coarse-grained, garnet-hornblende rock and, from there onward, the sedimentary rocks are highly contorted and contain a multitude of igneous stringers.

Similar features were observed on the west side of the small plug of oligoclase granite on the west shore of Olga lake. In this case, however, dislocation effects are very minor and the igneous material consists almost exclusively of oligoclase granite, similar in composition to the main body of this rock.

The sedimentary rocks are light to dark grey in colour, rarely purple or black. They are highly metamorphosed and for the most part devoid of any clastic texture, but in spite of the universal development of schistosity, the original bedding planes have been remarkably well preserved. This feature was of great help in recognizing their true sedimentary nature.

According to their mineral compositions, the rocks may be classified into three groups: (1) biotite schists, (2) biotite-hornblende schists, and (3) hornblende schists. Groups 1 and 2 are exposed chiefly on the north shore of Olga lake, whereas group 3 predominates on the west shore. In addition, chert layers are numerous throughout the belt, and a two-inch magnetite bed was seen on the south end of the point immediately south of Red chute.

The mineral composition of the schists, as determined with the microscope, is as follows:

Biotite schist:

Quartz	40-45%
Plagioclase	20-25%
Biotite	20-30%
Sericite	0-10%
Accessory: magnetite, potassic feldspar, epidote, calcite	

Biotite-hornblende schist:

Quartz	40-45%
Plagioclase	20-25%
Biotite	10-20%
Hornblende	10-15%
Accessory: magnetite, potassic feldspar, epidote, calcite	

Hornblende schist:

Quartz and
feldspar 45-65%
Hornblende 25-50%
Accessory: chlorite, magnetite,
calcite, epidote,
biotite

In all the schists, the feldspar is probably plagioclase. It is always clouded to some extent and cannot be identified with certainty, especially where it occurs as grains from 0.02 to 0.03 mm. in diameter. Many of these rocks, however, contain plagioclase porphyroblasts showing a degree of cloudiness and relief similar to the smaller grains. The porphyroblasts range in composition from An_{28} to An_{33} and it is assumed that the small grains have a similar composition.

The biotite is strongly pleochroic, with absorption dark brown to greenish-yellow. In the biotite schists, on sections cut perpendicular to the schistosity, it appears as delicate needles, about 0.5 mm. long, almost perfectly aligned in one direction, which is also that of the bedding (Plate VI-B). The needles are uniformly distributed throughout a mass of quartz and feldspar whose grain size is from 0.02 to 0.03 mm. In one section cut parallel to the planes of schistosity, the biotite has the form of more or less rounded flakes, partly altered to sericite. The latter mineral occurs as clots of minute flakes, very irregular in outline, some of which contain remnants of biotite, iron oxide dust, and less frequently epidote.

The hornblende in the schists of groups 2 and 3 is much lighter in colour than that found in the recrystallized lavas. Its grain size, and also that of the associated biotite, is larger than that of the biotite in the biotite schists; the grains measure up to 2 mm. in length. The optical properties of this hornblende are:

Pleochroic formula: Z = light bluish-green

Y = light olive-green

X = straw-yellow

$Z \wedge c = 17^{\circ}-19^{\circ}$; $(-)2V = 75^{\circ}$; absorption: $Z > Y > X$

Poikiloblastic inclusions of quartz and feldspar are common in the prisms of hornblende, testifying to the secondary origin of this mineral. Of still greater significance is the preservation within the large crystals of hornblende of numerous small, rounded grains of hornblende which are believed to be original constituents of the rock (Plate II-B). Such detrital grains were seen within

lozenge-shaped basal sections of the mineral and in more or less rectangular prismatic sections. The secondary hornblende, in all cases observed, grew in optical continuity with the nucleus, although the physical boundary of the latter was in all cases preserved.

The relationship between the schists of one group and those of the others is not known. Close to the intrusive at Red chute and along the north shore of Olga lake, biotite schists are interbedded with biotite-hornblende schists. The alternating beds are in many places very narrow: one thin section contains a central layer, 7 mm. wide, of hornblende flanked on both sides by biotite schist. Southward, along the west shore of the lake, these schists are succeeded by the hornblende-rich rocks which, because of their darkness and uniformity in composition, can easily be mistaken for altered lavas. No gradations between the schists of one group and those of the other were observed either in the field or under the microscope.

On the west shore of the lake (three miles in a straight-line southwest of Red chute), numerous low, isolated exposures of sedimentary rocks are found spaced over a distance of about half a mile westward from the small plug of oligoclase granite. The rocks away from the intrusive appear to correspond to the biotite-hornblende schists that are found at Red chute, although they have a slightly higher content of amphibole than biotite. It is difficult to establish their true composition, however, because of extensive hydrothermal alteration. Chlorite, epidote, and leucoxene are the conspicuous new minerals and form about 30 per cent of the rock. These minerals have no preferred alignment but form clots typical of development under conditions of uniform pressure.

Closer to, and also in inclusions within, the granite plug, the sedimentary rock is a very brittle hornfels which rings quite clearly under the blow of a hammer, and breaks readily into sharp, angular fragments. This rock is dark grey, with sometimes a green or purple tinge. In spite of the evidently more intense metamorphism to which it has been subjected, the bedding is well preserved in numerous places. The rock is so altered and so fine-grained that, under the microscope, sericite, which occurs as small non-oriented flakes, is the only mineral that can be identified with certainty. The remainder of the rock is a maze of minute grains which appear to be quartz, epidote, and magnetite.

Throughout this Red Chute belt of sedimentary rocks, there are numerous narrow layers of chert. Recrystallization through metamorphism has changed them into fine-grained rocks with the appearance of impure quartzite, and weathering gives them a light grey colour, which makes them stand out clearly among the darker schists.

On the west shore of Olga lake, the schistosity is locally transgressive to the bedding. If, in such cases, cherty layers are present, a distinctive feature has been produced. During folding, the sedimentary rocks were locally highly crumpled and, where the schistosity happened to cross the bedding, the cherty layers, more brittle than the encasing schists, broke in numerous places. These small fragments, probably in the process of flowage and slippage, assumed a lenticular form and migrated a short distance along the planes of schistosity of the schists (Plate III-A). Layers thus completely fragmented have the appearance of conglomerate. Transitional stages, preserved in many places, permit the proper explanation of their origin.

The highest grade of metamorphism in this Red Chute belt was attained in a few inclusions of doubtful origin found within a concordant body of syenite, injected into the sedimentary rocks at Red chute about 200 feet east of the main body of syenite. These inclusions are seen over a distance of 100 feet. They are well rounded and the largest of them has a diameter of three feet. They are medium- to coarse-grained, dark-coloured rocks containing numerous red garnets. Their composition is:

Hornblende	55%
Red garnet	20%
Quartz	15%
Plagioclase	5%
Accessory: chlorite, biotite, hematite, clinozoisite	

Much of the hornblende is in well-formed, slightly-bent prisms which contain poikiloblastic inclusions of quartz. It is more similar to the hornblende of the intermediate lavas than to that of the nearby sedimentary rocks. Its optical properties are:

Pleochroic formula: Z = deep blue-green
Y = olive green
X = pale green

$Z \wedge c = 20^\circ$; $(-)2V = 75^\circ$; absorption: $Z > Y > X$

The garnet has a glassy lustre and a deep-red colour; in thin section it appears creamy, and is completely isotropic. The grains are sub-idioblastic and enclose small crystals of hornblende and quartz. Because of the ubiquitous presence of such poikiloblastic inclusions, which would have rendered the results inaccurate, the determination of its specific gravity was not attempted. From its colour and its presence in a rock which contains aluminum, calcium,

and iron, the garnet is believed to be either almandite or andradite, or possibly a mixture of the two molecules.

The feldspar is completely saussuritized. It forms irregular masses, none of which even remotely resemble the shape of a crystal. It is interstitial to the hornblende and contains ragged grains of this mineral. Magnetite, in small specks and lenticular grains, is also a common inclusion. The feldspar is, in many places, partly replaced by garnet, so that its formation dates between the recrystallization of hornblende and the development of garnet.

The quartz has two modes of occurrence. What appears to be original quartz is found as lenticular grains that have no common direction of elongation. This quartz has been shattered into very small pieces. More than half the quartz, however, occurs as larger grains which show strong undulose extinction and though slightly broken have not been subjected to the same crushing stresses as the lenses. Many grains are disposed along parallel lines, forming discontinuous veinlets.

This hornblende-garnet rock is quite unlike any of the sedimentary rocks of the belt in which it occurs. It presents no distinctive features that might give a clue to its origin, but it certainly developed from a rock that was more basic than the nearby biotite schists and biotite-hornblende schists. Even if all the quartz is considered as original, the proportion of this mineral would still be considerably lower than in the typically sedimentary rocks. Another significant point is the absence of garnet in those sedimentary rocks that are immediately in contact with the main syenite dyke. The possibility of extensive transfer of material to and from the syenitic magma is ruled out because the dyke has essentially the same composition as the main syenitic body.

These observations indicate the presence, within the typically sedimentary beds, of a conformable layer of different, more basic, composition. This layer was more easily ruptured than the surrounding rocks so that the intrusive syenite could infiltrate along it, thoroughly brecciate it, and subject it to sufficient temperature and stress to induce the development of garnet. This bed, if not sedimentary, could be either a volcanic flow or a basic intrusive. The dimensions of the fragments, and their shape, grain size, and composition, offer no decisive evidence favouring either one of these hypotheses rather than the other.

Sedimentary Rocks South of Olga Lake

The sedimentary rocks in this belt are similar in colour and composition to those exposed in the band just discussed. They are dark grey rocks in which closely-spaced bedding planes are still occasionally visible. They differ from the rocks of the Red Chute belt in having a slightly coarser grain and in the presence of garnet which, though not universal, is of widespread occurrence. A typical section studied under the microscope shows the following composition:

Quartz	40%
Feldspar	15%
Biotite	5%
Hornblende	15%
Calcite	5%
Garnet	20%
Accessory: epidote, magnetite	

The rock is finely banded as a result of alternations of biotite-rich and hornblende-rich beds. In the latter, biotite is present in small amount and it appears to be the product of recrystallization of hornblende. Garnet, which has its greatest concentration in the lighter-coloured (biotite) beds, forms knots up to 4 mm. in diameter. These, however, are not single crystals of garnet. Under the microscope, garnet, in the form of small, partly isolated grains, is seen to constitute no more than 60 per cent of their volume, the balance being quartz, carbonate, and some feldspar and biotite.

No exposure in this southern belt is free from injected material. The sedimentary rocks are traversed by stringers, dykes, and concordant bodies of granite, pegmatite, and aplite (Plate III-B). The proportion of these intrusions is greatest along both the south and north contacts with the oligoclase granite, where a true zone of migmatite has been formed (Plate IV-A). This feature is even more conspicuous eastward from the belt, along the south shore of the long bay, where there is a zone, about half a mile wide, which constitutes a gradational contact between a quartz-hornblende schist and the southern granitic intrusive. The granite is always predominant, but some remnants of intruded rocks are seen in almost every exposure. As the remnants have assumed a diversity of shapes, the resulting complex is much varied in appearance. In some exposures, the old rocks persist only as ragged, more or less crushed, masses; in others, they occur as sharp-cornered inclusions. More generally, the two rock types form an assemblage consisting of long, thin lenses of schist alternating with concordant bands of intrusive material. For each type of rock, the bands range in width from many feet to mere stringers less than one-eighth of an inch wide, and they commonly attain lengths

of scores of feet. Weathered surfaces of this complex often have the appearance of a well-bedded sedimentary series (Plate IV-A). Features resembling pillows have even been produced as a result of pegmatitic injections along two sets of joints in the inclusion.

The nature of the injected rock in this zone is not positively known. As it is impossible to study in detail all the minor variations of such a complex, one must, to a great extent, rely on megascopic field observations in order to obtain a broad picture of its more important features. Since these exposures were mapped after the Red Chute sedimentary rocks and most of the volcanic rocks in the west half of the area had been studied, it was possible to proceed, in exploring the complex, by a method of comparison, not only of hand specimens but also of the general surface appearance of the rock exposures.

The greatest proportion of the inclusions were thus classified as representing recrystallized sedimentary rocks. They are similar to the schists found on the west shore of Olga lake. Although no actual bedding was seen, there are, nevertheless, some transverse variations in the composition of the injected rocks. The darker schists are generally predominant over the biotitic types such as are found at Red chute.

The belief that these rocks are of sedimentary origin is further supported by the abundance of closely-spaced intrusions parallel to the schistosity and probably also to the original bedding, since the two directions generally coincide. The rocks are schistose, but still dense, and there is a strong suggestion that the bedding planes provided the channels (planes of weakness) along which the granitic material was introduced.

There are, however, some inclusions in this migmatite zone which cannot be so certainly regarded as of sedimentary origin. These are dark hornblende schist having the following composition:

Quartz	20%
Plagioclase (An ₂₃) .	30%
Hornblende	40%
Biotite	10%
Accessory: epidote, apatite, potassic feldspar, magnetite	

Their grain size is much larger than in any of the sedimentary rocks, and all their principal minerals are products of recrystallization. The plagioclase is fresh and occurs as porphyroblasts containing inclusions of quartz, biotite, and hornblende. Hornblende

is sub-idioblastic and many grains of this mineral are full of non-oriented inclusions of quartz, apatite, and magnetite. Biotite, pleochroic from dark brown to light brown, forms flakes or long narrow stringers attached to, and crossing through, the hornblende, in a way which suggests clearly its secondary origin from the amphibole mineral.

The optical properties of the hornblende are:

Pleochroic formula: Z = deep greenish-blue
Y = dark olive-green
X = light yellow-green
Z $\wedge$ g = 25°; (-)2V = 75°; absorption: Z > Y > X

These schists are quite similar to the hornblende-garnet rock found in the syenite dyke at Red chute. The hornblende, in particular, has about the same properties and composition. The main difference between the two rocks is the presence of garnet in that at Red chute, and of biotite in that of this southern zone. Both minerals are, however, derived from hornblende. Without necessarily implying that the two rocks have the same origin, it may be pointed out that the appearance of one or other mineral may simply reflect differences in the intensity of metamorphic conditions.

Sedimentary Rocks in the Eastern Half of the Map-Area

These rocks are more thinly bedded than those around Olga lake. The thickest bed observed measures eight inches and such a width is exceptional. Commonly, the thickness is less than one inch, and many exposures consist of a succession of layers as thin as one-eighth of an inch. For the most part, the colour of the beds ranges from almost white through shades of grey to black, but reddish shades, due to a coating of iron hydroxides, are common also. Due to the thin bedding (Plate IV-B), exposures have a very striking appearance, reminiscent of the varved schists described by Eskola (1932) in Finland.

As in the other zones, the grain size of these rocks is small, the largest grains observed being about 1.5 mm. in diameter. Within many individual beds, however, there is a definite gradation in granularity, and on a number of exposures it was possible, by study of this feature, to distinguish between tops and bottoms of the beds and so determine the attitude of the series.

The composition of these rocks varies within such wide limits that a detailed description of all the types seen is not possible. The following table shows the composition, as determined in thin section, of three common types:

I	II	III
Albite 40%	Plagioclase (An ₂₄)..60%	Plagioclase (An ₁₇)..30%
Quartz 30%	Quartz 20%	Quartz 40%
Chlorite 12%	Biotite 15%	Biotite 25%
Epidote 5%	Hornblende 5%	Magnetite 2%
Muscovite 10%	Accessory: hematite,	Garnet 3%
Leucoxene 3%	albite or	Accessory: sericite,
Accessory: pyrite,	potassic	epidote
hematite	feldspar	

The rocks belonging to these three types are lighter in colour, and are much more abundant, than the intervening dark grey beds, which are similar to the hornblende schists cropping out on the west shore of Olga lake. Their feldspar, quartz, and biotite clearly show evidence of metamorphic development. The hornblende has the same composition as that of the schists just referred to, and occurs as subrounded grains about 1 mm. in diameter. Most of the grains are partly altered to biotite.

Cream-weathering chert was seen in almost every exposure. The beds have a thickness comparable to that of the detrital rocks, but they are not continuous. The chert most commonly occurs as narrow ribbons, only a few feet long, which pinch out at both ends. It is a completely recrystallized, grey, fine-grained rock with the aspect of a quartzite.

An exposure on the southwest shore of Laurent bay, on the west side of Goéland lake, contains a strong concentration of cherty fragments in a matrix of well-layered, biotite-hornblende schist. The fragments have a wide variety of shapes, although lenticular forms predominate. They range in length from less than an inch to fifteen inches.

The fragmentary rock (Plate V-A) has a striking resemblance to a conglomerate, but careful examination of the fragments failed to reveal the presence of any rock types other than chert and probably some micaceous quartzite. Furthermore, the fragments have a much wider range in shape and size than the boulders found in the true conglomerate beds of the region, as may be seen by comparison of Plate V-A with Plate V-B, which shows the conglomerate of the Mattagami series, exposed on the north shore of Mattagami lake, west of the present area.

It would seem that, during folding, the schists behaved more or less like plastic layers, whereas more rigid beds of chert and quartzite could not yield sufficiently to avoid being broken into a

great number of fragments. Belief that this 'pseudo-conglomerate' originated in this manner is strengthened by the presence of curved fragments (not shown in the photograph) which are thought to represent the remains of drag-folded layers. It is thus assumed that this 'conglomerate' and that on the west shore of Olga lake (see p. 32) were formed as a result of the operation of substantially similar processes, and that differences between the two occurrences are attributable to differences in the attitude of the schistosity with respect to the bedding of the original rocks.

Gabbro Intrusives

Small intrusive bodies of older gabbro are very restricted in the present area. These intrusives are believed to have been emplaced before the folding of the volcanic-sedimentary rocks, and are not related to the large intrusive masses which will be described below. As in other regions of complexes of volcanic rocks of intermediate composition, the problem of separating the true lavas from concordant intrusives of similar composition is a difficult one. Often recrystallization of the lavas has produced a rock which, in grain size and texture, is very similar in appearance to the intrusive.

Unmistakable sills, however, were seen here and there throughout the volcanic-sedimentary series. The largest are near the southern border of the map-area, between Olga and Goéland lakes. Similar rock is exposed on the point south of the northern bay on the east shore of Olga lake. Other units, too small to be shown on the accompanying map, are found at numerous places in the area, especially in the western half. One such body intrudes the sedimentary rocks at Red chute.

These rocks are fine-grained to low medium-grained, that is, slightly coarser than the average lava. As a rule they are more massive than the volcanic rocks, although occasional small bodies were seen which had suffered the same degree of shearing as the enclosing lavas. This shearing and concordant habit are taken as an indication that the rocks were injected as sills before the volcanic-sedimentary series was folded.

Dark minerals constitute from 35 to 50 per cent of the gabbroic intrusives. The most prominent is amphibole, in the form of actinolite. In some specimens, the needles of this mineral are quite long (up to 6 mm.), and they lie without any linear orientation. Most commonly, the actinolite forms lenses or irregular masses with horse-tails, typical of metamorphic development. The origin of the amphibole is revealed in a few sections, where ragged remnants of a pyroxene (probably of the diopside-hedenbergite series) are found partly changed into actinolite.

Besides the pyroxene, the only original mineral appears to be a plagioclase feldspar, which is so strongly altered that its original composition cannot be determined. It was probably calcic since the rock contains a large percentage of clinozoisite (up to 35 per cent) which seems to have been derived from alteration of the feldspar. Minor quantities of albite and of late quartz, frequently associated with calcite, are also present in the rock.

These minerals form a groundmass in which the actinolite needles are set. Even the feldspar occurs as exceedingly small grains. Some of the masses of such fine feldspar grains have a sharp, almost square outline, indicating that the original plagioclase has been thoroughly shattered. Unlike the andesites, there was no development of porphyroblasts in the rock previous to the formation of the amphibole.

Granite Porphyry Intrusives

Numerous small masses of light-coloured granite porphyry are found within the area of outcrop of the volcanic-sedimentary rocks. They generally form narrow sills and occur in each of the three main rock groups - andesites, sedimentary rocks, and trachytes - although they are most common in the last-named type.

The largest sill is on the north shore of Waswanipi river, just east of Olga lake. Discontinuous exposures suggest that it is about two and a half miles long. Similar rock found on the southern part of the island a mile west of the mouth of the river may belong to the same mass. If so, the sill would have a possible length of four miles and a width of several hundred feet.

The rock is fine-grained, conspicuously porphyritic, and varies in colour from creamy-white, when fairly fresh, to various shades of brown, or even green, when strongly affected by hydrothermal alteration. In fairly fresh specimens, seen at a few places on the north shore of Waswanipi river, the rock is only moderately deformed. Under the microscope, it is seen to contain numerous phenocrysts of quartz and of partially altered feldspar, set in a strongly sericitized groundmass, in which the schistosity is marked by sericite flakes curving around the phenocrysts. The feldspar phenocrysts that are fresh enough to be identified have the composition of oligoclase (An_{13-24}).

In general, and probably because they were less competent than the enclosing rock, the porphyries are highly deformed. They are strongly crushed and, under the microscope, the phenocrysts of quartz

and feldspar are seen to be intensely broken. The groundmass is fractured and the cracks are filled with secondary quartz and calcite.

The porphyritic texture is conspicuous on the weathered surface of the rock. On fresh fractures, however, it is masked by the crushing of the phenocrysts and the advanced alteration of the rock. For the same reasons, it is generally indistinct in the thin sections.

Post-Keewatin Intrusives

These intrusive rocks form a large percentage of the bed-rock of the map-area. They are of two types, a basic series and an acidic series. The intrusive bodies just described are not included here, as they appear to be genetically affiliated with the volcanic rocks rather than with these later intrusives. Post-Keewatin dyke rocks, including lamprophyre and possibly late diabase, which are younger than the main intrusive bodies, are discussed later.

The basic series (generally referred to as the 'diorite-syenite group') is older than the acidic series. It is definitely the more complex of the two and includes several types of rocks, or facies, which appear to represent differentiates of a common parent magma. The various differentiates, in their present state of alteration, range in composition from amphibolite, through diorite, to syenite.

The acidic series consists chiefly of plagioclase-rich granites. They form three main bodies:

- (1) Southern, generally massive, granite (Olga quartz-diorite)
- (2) Northern, generally gneissic, granite
- (3) Goéland batholith

The first two possibly belong to a single intrusive stage.

In addition, there are a few small bodies of massive pink granite that is distinctly later than the northern granite.

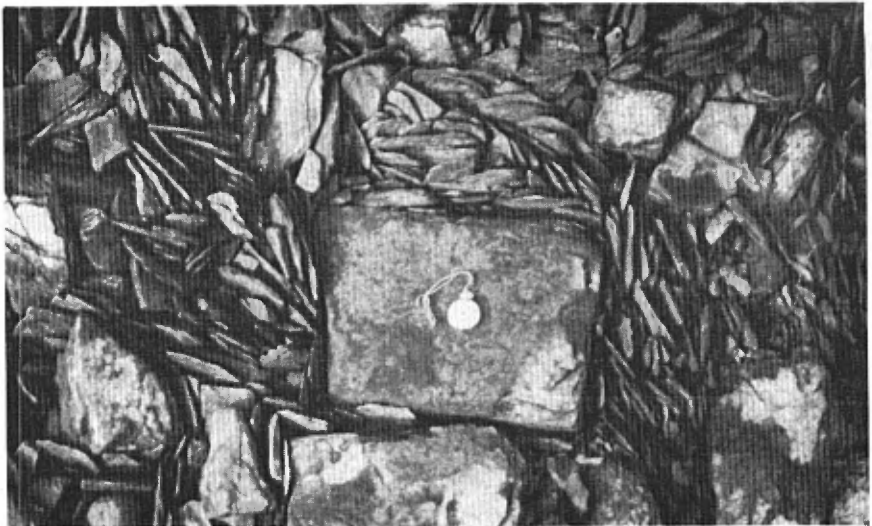
Diorite-syenite Group

The main body of these rocks underlies a triangular-shaped area of at least 35 square miles in the northwestern part of the map-area. The southeastern boundary of this intrusive mass is a wavy line that trends across the map-area in a northeasterly direction from the west shore of Olga lake. The location of the northern limit of the intrusion is necessarily somewhat arbitrary, due to the presence of

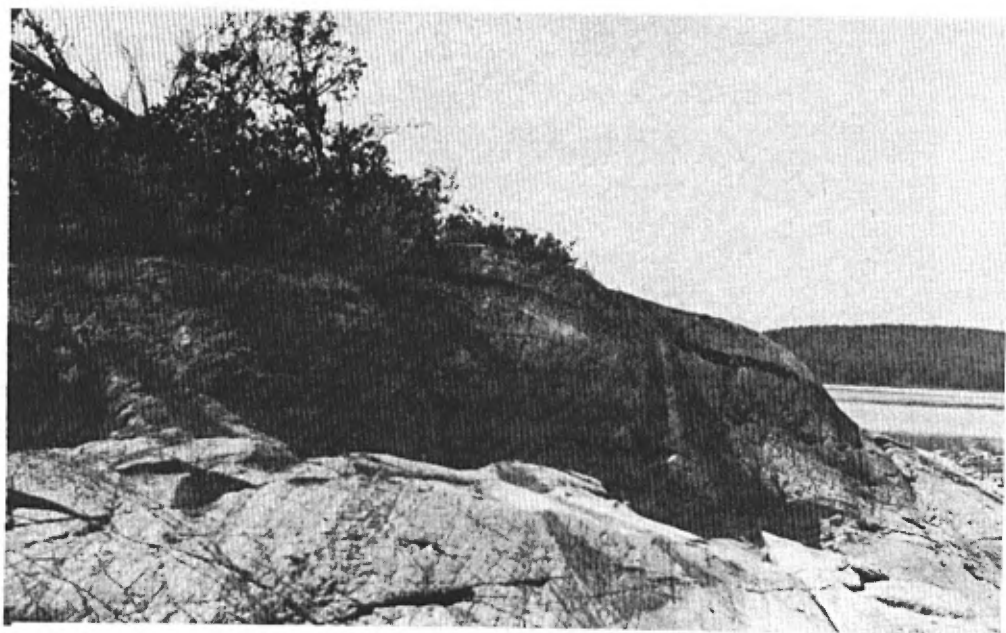
Plate 1



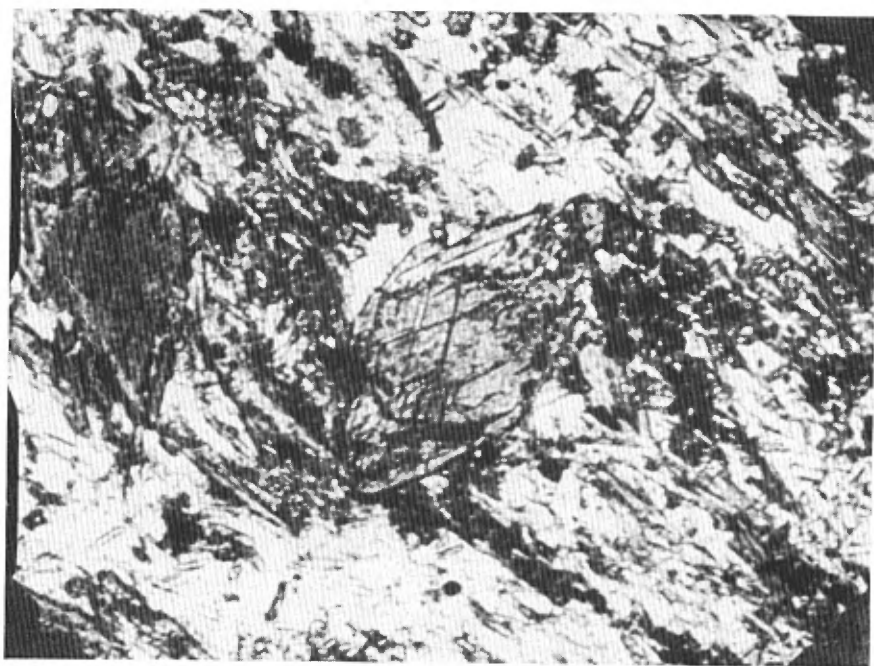
A. - Red chute, outlet of Olga lake.



B. - Unusual arrangement of schist pebbles, east shore of Olga lake.

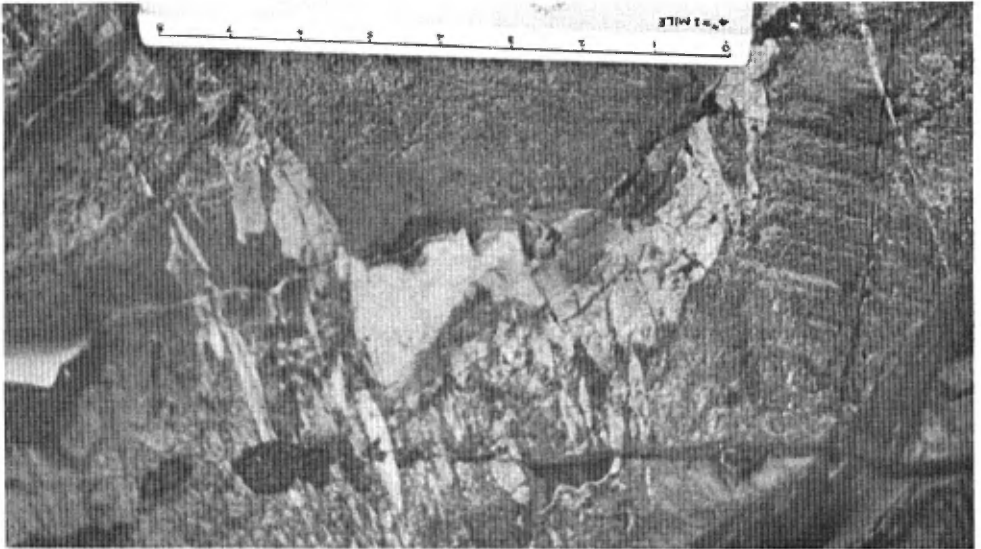


A. - Glacial fluting, east shore of Olga lake.



B. - Photomicrograph of recrystallized hornblende grain of detrital origin, sedimentary rocks, west shore of Olga lake. Natural light. (x60).

Plate 111



A. - Narrow cherty layer in sedimentary rocks, drag-folded and broken into fragments by a cross-schistosity, west shore of Olga lake. (The scale is 6 inches long).



B. - Crumpled sedimentary rocks, closely injected by stringers of granitic material, south shore of Olga lake.

Plate IV

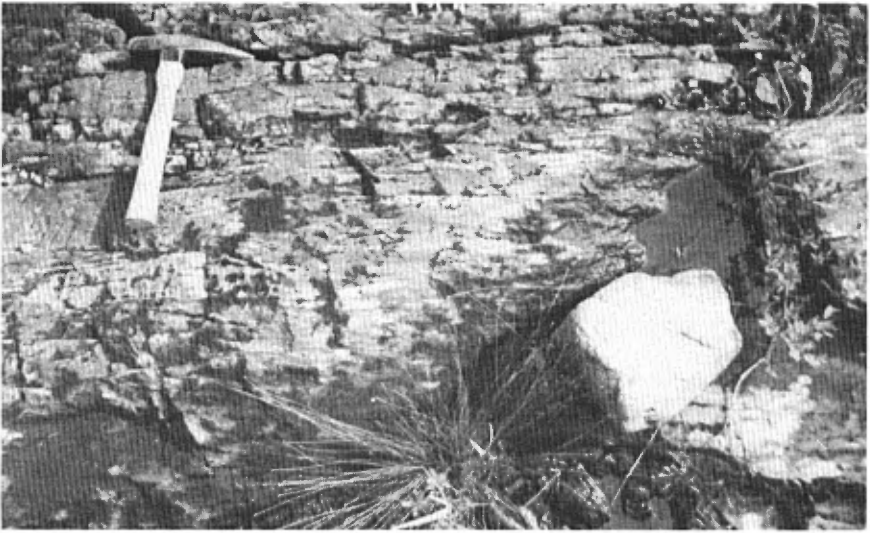


A. - Injection complex (migmatite) having a sedimentary appearance, south shore of Olga lake.

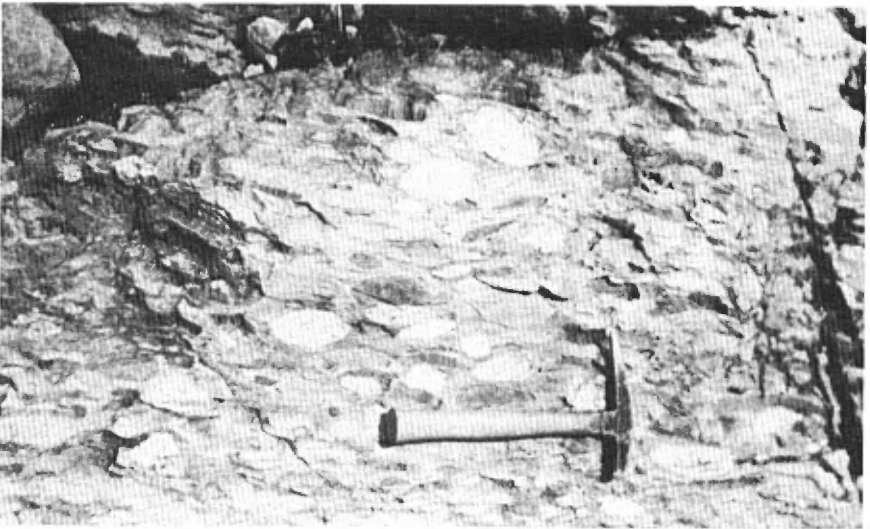


B. - Thinly-bedded sedimentary rocks, southwest shore of Laurent bay, Goéland lake.

Plate V



A. - "Pseudo-conglomerate", broken lenses of chert and micaceous quartzite, sedimentary rocks, southwest shore of Laurent bay.

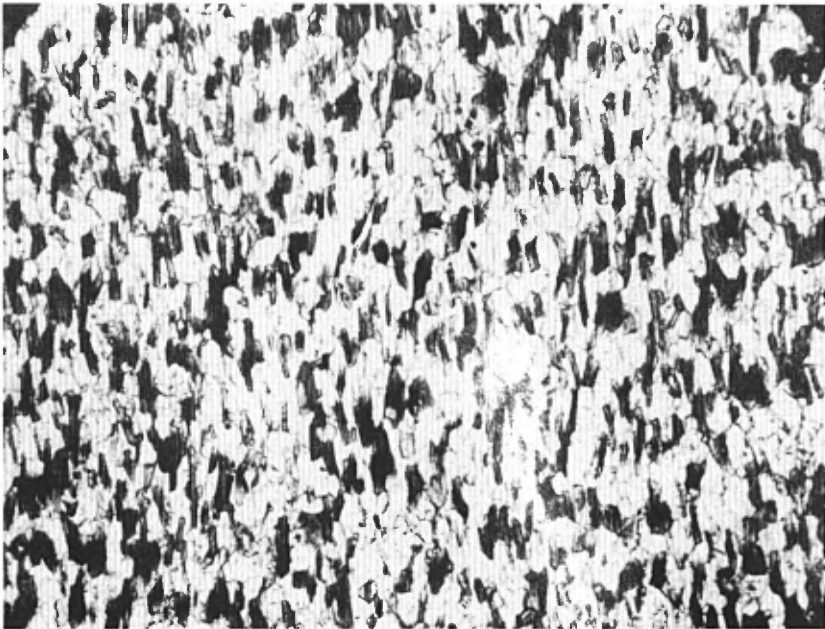


B. - Conglomerate of the Mattagami series, north shore of Mattagami lake, west of the map-area.

Plate VI

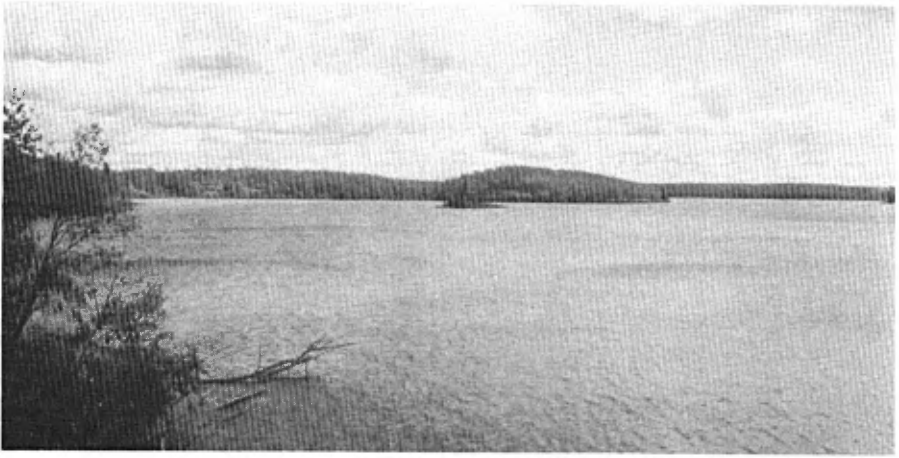


A. - Composite dyke (diorite with fragments of amphibolite), cutting the Goéland batholith, small island immediately west of the largest one in Goéland lake.



B. - Photomicrograph of biotite schist, sedimentary rocks at Red chute. Natural light. (x30).

Plate V11



A. - East end of Mattagami lake, looking east.



B. - Canet river, six feet higher than normal, July, 1947.



Rapids on Waswanipi river at outlet of Goéland lake .

a low-lying, swampy tract, devoid of exposures, along most of the northern margin of the western half of the map-area. It is possible that the contact (as shown on the accompanying map) follows approximately the edge of this swampy area, because generally the rocks of this group of intrusives have, in this district, a greater tendency to form hills than do the other rock types. There is a small body of similar rock at the northern margin of the map-area, about ten miles from its western boundary. It may be that this mass belongs to the main body, but this question must remain open due to the intervening exposureless area. The rocks of the diorite-syenite group are best exposed around Mattagami lake and along the section of Waswanipi river connecting Olga and Mattagami lakes.

There are, in addition, a number of smaller bodies that presumably belong to the same group; the larger of these are shown on the accompanying map. In places, as on the south shore of Maicasagi lake, they intrude the volcanic-sedimentary series in an apparently concordant manner. More commonly, they are found as remnants and inclusions in rocks of the acidic intrusive suite. The largest of these occupies a four-square-mile, triangular-shaped area, with its base extending for about two miles along the north shore of Max narrows where it joins Maicasagi lake. The apex of this mass is less than half a mile south of the northern limit of the map-area. Another body, about one and a half square miles in extent, is found near the northern boundary of the area at the headwaters of Frederic creek. There are, also, two relatively large remnants in the southwestern corner of the map-area, south of Olga lake.

The various facies of this diorite-syenite group are described below.

Amphibolite

Dark, coarse-grained amphibole rocks were noted at numerous places in the area. They commonly occur as angular fragments within the dioritic members of the group, and, as such, their typical locality is on the east end of Mattagami lake. Larger, mappable units are found in two places: (1) on the west shore of Olga lake, where they are exposed for about a quarter of a mile around a small point lying between exposures of sedimentary rocks on the north and of andesitic lavas on the south; (2) on the southeast shore of the southernmost, east-trending bay, of Olga lake, where the exposure measures a few hundred square feet.

The amphibolites consist predominantly of hornblende whose large crystals constitute from 80 to 95 per cent of the rock. Other

minerals include a completely clouded feldspar, and small amounts of quartz, albite, biotite, chlorite, clinozoisite, apatite, and magnetite. With the exception of the saussuritized feldspar, the apatite, and possibly the magnetite, all of these appear to be secondary. Augite was identified in one thin section. In others, some of the hornblende grains contain ill-defined cores that could not be identified with certainty, but which are probably uralitized pyroxene. It is thus possible that part, if not all of the hornblende is an alteration product of pyroxene.

Diorite

The most common facies of the basic post-Keewatin intrusives have the composition of diorite. They form most of the large bodies of the group and are also predominant among the smaller masses. Although dioritic as a whole, they nevertheless vary appreciably from place to place, both in the tenor of their dark minerals and in the nature of their plagioclase. Furthermore, they embrace a number of sub-facies, some of which show, locally, cutting relationships to the others. This is especially evident around the east end of Mattagami lake, where the complexities of these basic rocks are best displayed.

The diorites are from fine- to coarse-grained, and, in places, are even coarse enough to be called pegmatites. The feldspar crystals are almost always euhedral and, as a result, the rock often has a porphyritic appearance. Schistosity is generally absent, and, when present, is rather faint. The finer-grained types are generally dark grey whereas those of coarser grain, because of their larger feldspars, have the appearance of a mosaic of pink or white grains in a dark green mass.

The average composition of the dioritic rocks is:

Plagioclase	40-60%
Microcline	0-30%
Quartz	0-25%
Hornblende	10-50%
Biotite	10-20%
Accessory and secondary minerals: epidote, chlorite, magnetite, zoisite, clinozoisite, and titanite	

Following is a description of the various facies of the diorite, which becomes progressively less basic southward in the main mass around Mattagami lake.

Around the north shore of the east end of the lake, and in the few inland exposures in the northern part of the body, the diorite carries a fairly calcic plagioclase, with an average anorthite content of 30 per cent. Microcline is rare and wherever present is in accessory quantity. Quartz, occasionally found in small amount, often appears to be of late origin. In one thin section, a veinlet of potassic feldspar is associated with quartz. The hornblende is the common green-pleochroic variety, sometimes with a bluish tinge for light vibrating parallel to the Z axis.

Around the south shore of Mattagami lake and on the group of three islands nearby, the dioritic intrusive commonly consists of a complex assemblage of many sub-facies. The transition from one to the other is generally so indefinite that it is doubtful whether the areas underlain by each type could be satisfactorily delimited even through detailed mapping. Exceptionally, however, along the south shore of the lake, especially close to and outside the western boundary of the map-area, it was possible, through cutting relationships, to distinguish three different sub-facies of the dioritic group.

The composition of the sub-facies, as revealed through microscopic study of thin sections, does not vary sufficiently from one to the other to warrant special discussion. The rock underlying the central of the three islands can be taken as representing the average diorite in this vicinity. It contains a fairly sodic plagioclase (An_{7-18}) and hornblende is still the predominant mineral, although it is more altered than in the more basic rock to the north. Biotite occurs only sporadically and never exceeds 15 per cent. As in the more basic facies around the north shore of the lake, quartz is present in minor amount, but it is much more regularly distributed; each of the thin sections examined contains about 5 per cent of this mineral.

Farther south, a fairly consistent dioritic facies is exposed along Waswanipi river, from Mattagami lake to a point about one mile northwest of Red chute. The same facies underlies the group of low hills south of the river.

The striking mineralogical change in the diorite between the localities just mentioned is the appearance of microcline in percentages that range from 10 to 30. Biotite, also, becomes a ubiquitous and uniformly-distributed mineral. It constitutes 15 to 20 per cent of the rock. Secondary alteration, evidenced by some epidotization and slight sericitization, is common in this facies.

The preceding discussion is summarized in the following composition tables:

- I -

<u>Amphibolites</u>	
Hornblende	80-95%
Feldspar	5-10%
Late quartz	0-10%
Accessory: biotite, chlorite, apatite, magnetite, clinozoisite	

- II -

<u>Diorite, north of Mattagami lake</u>	
Plagioclase (An_{28-34}) ...	40-65%
Hornblende	25-60%
Quartz	0- 5%
Biotite	0-15%
Accessory: microcline, epidote, apatite, magnetite, zoisite, clinozoisite	

- III -

<u>Diorite, south of Mattagami lake</u>	
Plagioclase (An_{7-16})	40-80%
Hornblende	10-50%
Biotite	0-15%
Quartz	4- 5%
Accessory: microcline, epidote, apatite, clinozoisite	

- IV -

<u>Diorite, Waswanipi river</u>	
Plagioclase (An_{16-19}) ...	40-70%
Microcline	10-30%
Hornblende	15-40%
Biotite	15-20%
Accessory: apatite, epidote, zoisite, sericite	

The inclusions in the granite south of Olga lake are for the most part dioritic. They occur as two apparently disconnected bodies included as remnants within the younger oligoclase granite. Both are oriented parallel to the structure of the nearby sedimentary rocks.

The rocks have the same appearance as those of the main mass of diorite to the north of Mattagami lake. They are grey, and fine-to coarse-grained. The feldspars are either white or pink and generally idiomorphic; porphyritic texture is very common. The main constituents of the rock are highly variable in amount as indicated in the following table:

Plagioclase (An_{14-28}) ...	35-80%
Hornblende	25-60%
Biotite	Acc.-15%
Quartz	0- 5%
Accessory: epidote, sericite, chlorite, magnetite (sometimes with a leucoxene border)	

The wide range in composition confirms the field observation that here, also, several facies of the diorite are represented. The many types examined might be arranged into a sequence corresponding to, and as complex as, that of the northern rocks. Such a sequence, however, could not be established, because of the lack of cutting relationships.

The rocks of the small dioritic masses exposed in the north-eastern part of the map-area have not been studied in thin section. In appearance and composition they are generally so similar to those rocks described above that no doubt can be entertained as to their genetic relationship. Like the rocks exposed south of Olga lake they exhibit numerous mineralogical changes, but, there is no clue as to the relationships of the different facies.

Syenite

The syenitic facies of the series, although seen in places around the east end of Mattagami lake, is best developed near and to the north and south of Red chute. It thus forms a band which appears to vary in width from half a mile to one mile along the southeastern border of the main dioritic mass. Syenitic rocks also occur, but to a restricted degree, in association with the diorite along Waswanipi river.

The transition from the dioritic to the syenitic facies is well exposed on a small rounded point, on the south shore of Waswanipi river, about one mile northwest of Red chute. Travelling from west to east on that point, over an area of diorite, one first encounters what appears to be a gradational contact, about ten feet wide, between the two facies. After a few feet of overburden, however, diorite reappears; it is cut by a six-inch dyke which, in colour and in composition, is related to the syenitic facies. Ten feet farther, the two facies are separated by a distinct contact line trending north-south. Thence, syenite continues eastward, with local variations, until it gives place to sedimentary rocks at Red chute.

In hand specimen, the syenite is not much different from the more basic facies, except for a lighter colour due to the reduced tenor of ferromagnesian minerals. It has the same texture and is commonly massive. Close to the contact with the sedimentary belt, it possesses a distinct lineation resulting from the alignment of the hornblende prisms. The mineral composition of the syenite is:

Plagioclase (An ₁₂) ...	35%
Microcline	30%
Quartz	5%
Biotite	20%
Hornblende	10%
Accessory: sericite, epidote, apatite, and magnetite	

Texture of the Diorite-Syenite Rocks

Euhedral development of the plagioclase is a pronounced feature of the rocks of the basic series. Whether the rock has a porphyritic or an equigranular appearance, the plagioclase grains are almost without exception bounded by crystal faces. It is rare to see plagioclase that has interlocking boundaries with either hornblende or biotite.

These last two minerals form either large flakes with irregular terminal faces, or clots of small grains that seem to fill the spaces between the plagioclase crystals. Microcline and quartz are interstitial to all the above minerals. To a limited extent, there has been partial replacement of the plagioclase by a myrmekitic intergrowth of quartz and microcline at the contact between adjoining grains.

Deformation effects are not very conspicuous in the massive rocks of the main body of the series. The feldspar crystals show no granulation along their edges, and their cleavage and twin planes are not distorted. Slight bending of the biotite flakes was observed only in a few sections. Quartz grains show undulose extinction and some of the larger crystals have been broken into several pieces, none of which, however, appears to have been rotated from its original position.

The rocks of the smaller bodies generally show effects of greater strain. In most of them, the feldspar is slightly granulated and the quartz crystals are highly shattered.

Whether or not they be conspicuously developed, these strain effects are the result of deformation that the rocks have undergone after the consolidation of all the minerals.

Correlation and Origin of the Basic Series

The basic series is intrusive into the Keewatin-like volcanic and sedimentary rocks, and is, in turn, intruded by the masses of oligoclase granite. The series is similar in composition to the northern and western facies of the massive Dunlop intrusive described by Longley (1943) in the Kitchigama Lake area. This intrusive is considered by Longley to be near in age to the Bell River anorthosite complex which is exposed in the Opaoka River area (Freeman and Black, 1944).

If the basic series was of the same age as the Bell River complex, it would, in all probability, be presently tilted on edge, as is the complex. In this connection it is interesting to recall the

observed variations in the composition of the main mass of the series. From Mattagami lake to Olga lake, that is, from north to south, the rocks gradually become less basic. The diorite of Mattagami lake gives way southward to a syenite rich in biotite and microcline, through stages which, although imperfect, may well be called transitional.

One can thus visualize a huge, concordant intrusive consolidating slowly beneath a thick cover of overlying rocks. In this intrusive mass, several horizontal layers would be formed as a result of the magma differentiating into successively more acidic portions. This process is consistent with modern theories of differentiation. After the consolidation was effected, the rocks would become involved in the regional folding, as a result of which they would now show a more or less vertical cross-section through the original mass.

This hypothesis can even be carried one step further. Since the more acidic differentiates would be lighter than the more basic ones, they would, before folding, occupy the top of the series. In their present position, the more acidic facies occurs along the southeastern border of the main mass. The stratigraphical sequence of the diorite-syenite series, with its top toward the south, is thus in accord with the synclinal structure which is postulated for the rocks of the volcanic-sedimentary series in this area.

Important objections to the acceptance of this hypothesis are the massive condition of the rocks and their apparent lack of metamorphic recrystallization. If they had been intruded in sill-like fashion into the lavas and clastic rocks before folding, their minerals should show, at least to a certain degree, effects similar to those noted in the finer-grained rocks: these effects are recrystallization, schistosity, shearing, and crushing. It is true that, in a few specimens, traces of a cataclastic texture were seen, but this texture is generally so inconspicuous that it may be more correctly attributed to slight post-consolidation stresses than to the enormous forces that must have been active during the folding of the Keewatin-like rocks. These observations favour the hypothesis that the basic series was intruded in late- or post-folding time.

Classification of the Basic Series

It is rather difficult to assign a proper specific name to this intrusive group. In the diorite, the dark minerals are, in places, present in sufficient quantity to give the rock the appearance of a gabbro. The plagioclase, however, in all the types, is too sodic even for a normal diorite. For many facies, Idding's term 'laugenite' (oligoclase diorite) would seem appropriate. Since this term is not

in general use and, further, since it does not convey the idea of the great complexity found in this series, the expressions 'diorite-syenite group' or 'basic series' are preferred by the writer.

Massive Oligoclase Granite (Olga Quartz Diorite)

The granitic intrusive rocks exposed south of Olga lake are the northern border of a large batholith which Freeman (1938) named 'Olga quartz diorite'. The contact of these rocks with the sedimentary rocks along the south shore of the lake has already been described. Although the contact zone is intricate and is generally less than half a mile across, almost every exposure of the granitic rock in the hills that border the southern limit of the map-area contains a few inclusions of dark biotite-hornblende schist.

In order to find the uncontaminated facies of this rock, it is necessary to go outside the confines of the present area. As described by Freeman (1938), the Olga quartz diorite is a variable grey to reddish rock of medium grain which normally consists essentially of oligoclase (An_{20}), quartz, and biotite, with small amounts of microcline, albite, hornblende, epidote, apatite, and titanite. Its average mode is:

Oligoclase	65%
Quartz	25%
Biotite, hornblende, epidote	10%
Accessory: apatite, magnetite, titanite	

Normally, microcline is in small amount, but near the contacts with older rocks it may form as much as 30 per cent of the rock.

Within the Olga-Goéland Lake area, this granite has its characteristic grey colour, and, as seen in hand specimens, an interlocking (granitic) texture. Even those tongues that intrude the sedimentary rocks in a lit-par-lit fashion have a massive structure that only rarely gives place to a faint gneissic structure. The mineral composition, however, differs from the mode given above, notably in the fact that the less altered representatives of the mass generally contain more microcline:

Plagioclase (An_{14-24})..	50%
Microcline	20-25%
Quartz	10-20%
Biotite	5-10%

The more contaminated facies, usually found close to inclusions of older rock, are also characterized by microcline and, in addition, by the appearance of amphibole with a corresponding decrease in biotite. The following table shows the approximate composition of such true border facies along the south shore of Olga lake:

Plagioclase	50-70%
Microcline	10-30%
Quartz	10-20%
Biotite	0- 2%
Hornblende	5-10%
Epidote	Acc.- 3%
Accessory: sericite, hematite, magnetite, apatite, pyrite	

Except in one of the thin sections examined, the plagioclase is from An_{20} to An_{33} , and the grains are so granulated that their original crystal outline is entirely lacking. In the section referred to, however, the plagioclase is An_{14} and the grains are porphyroblastic.

The amphibole is ordinary hornblende and occurs as ragged individuals or clusters of grains. Ferrohastingsite (Billings, 1928) was seen in one thin section. Its optical properties are:

Pleochroic formula: Z = deep bluish-green
Y = deep olive-green
X = pale greenish-yellow

$Z \wedge c = 23^\circ$; Uniaxial (-)

The origin of the amphibole is probably dual: some ordinary hornblende may be magmatic, but some of it and all the hastingsite were probably formed as a result of assimilation of older rocks by the granitic magma.

The manner in which the secondary amphibole has originated is well shown on the west shore of Olga lake where a small plug that has a composition similar to the rocks of the main mass of Olga quartz diorite is exposed. The exposures of the eastern part of the plug, along the shore of the lake, contain numerous inclusions of fine-grained hornblende schist. The inclusions are generally elliptical in outline, with their long axis aligned in a general northerly direction, that is, parallel to the assumed borders of the intrusive. A few inches away from the inclusions, the granite has a green-tinted pink colour and the feldspars are euhedral. Its composition is:

Plagioclase (An ₂₀)	50%
Microcline	25%
Quartz	15%
Hornblende	15%

Hornblende occurs as individual grains, slightly altered to chlorite, with a release of magnetite.

Immediately at the contact with the inclusion, the granite is grey, due to a higher content of ferromagnesian minerals:

Plagioclase (An ₁₅)	35%
Microcline	20%
Quartz	10%
Hornblende	35%
Accessory: sericite, epidote, magnetite	

Here, the hornblende occurs predominantly in lenticular clots. These consist almost exclusively of small, non-oriented hornblende crystals separated from one another by a network of completely-clouded feldspar. Some of the hornblende, however, is found as porphyroblasts peppered with poikiloblastic inclusions of quartz, feldspar, and magnetite.

These dark, hornblende-rich clots clearly represent small pieces of older rock, probably volcanic, detached from their parent body by the magma. In some cases, there is evidence that the slightly-zoned, euhedral crystals of plagioclase flowed around these masses, since they lie with their long axis parallel to that of the lenses.

The increase in the proportion of hornblende is thus due, in this granitic plug, to contributions from the invaded rocks. This contamination is similar to the process described by Collins (1917) in the pre-Huronian batholithic rocks of the Onaping map-area.

The oligoclase granite (Olga quartz diorite) rocks exposed in the present map-area generally show some effects of such contamination. The main difference in composition between them and the rocks of the main body is their higher percentage of microcline and the predominance of hornblende over biotite.

The origin of the microcline is puzzling. Enough of the batholith is actually known to rule out the possibility that the presence of this mineral is due to heterogeneity in the magma. The constant appearance of the potassic feldspar in those portions of the

granite that are close to remnants of older rocks cannot be purely coincidental. It seems safe to assert that microcline appears as a result of contact metamorphic processes.

The invaded rocks, however, cannot be considered as a likely source of potash. They do not contain any notable amount of potassic feldspar. As already indicated in the discussion of the sedimentary rocks, many of the inclusions in the migmatitic zone contain some potash in the form of the stable mineral biotite. These contaminated oligoclase granites display no evidence that the microcline was derived from the transformation of biotite. On the contrary, they contain magmatic biotite, so that, according to the present theories of differentiation, the biotite of the inclusions should appear, unchanged, in the granite. The potash is thus probably magmatic. It may well have been supplied by a late facies of the batholith. Potassic feldspar is essentially a mineral of late crystallization and, furthermore, within a differentiated series of rock, the feldspar-rich portions tend to crystallize last.

In the Iserhoff River area, Claveau (1951) has shown that the Olga quartz diorite batholith consists of three facies, the youngest of which is a pink, leucocratic granite, rich in microcline. Late fractions of a consolidating mass may be expected along or near contact zones where, because of physical discontinuities in the complex, the solutions have more opportunity for movement.

Gneissic Oligoclase Granite (Northern Granite)

Distribution

The northern granite underlies a greater part of the map-area than does any other single rock type. It occupies a large part of the northern half of the area and is the southern margin of a great expanse of intrusive rocks that extend for long distances east, west, and north of the map-area. Due to the relative scarcity of outcrops the local boundaries of this mass are known only rather indefinitely. The topography is of no help in their determination, since the granitic rocks here form hills that are generally no more conspicuous than the low mounds underlain by volcanic rocks.

The southern boundary appears to follow a more or less east-west-trending sinuous line from the southwest shore of Maicasagi lake westward to a point about half a mile north of mile-post 7 on the east-west surveyed township line. This point represents the southern tip of a narrow granitic tongue that is bounded by andesitic lavas on the southeast and by rocks of the basic intrusive series on the northwest.

It was not found possible to establish the relationship between the main mass of northern granite and the smaller bodies of similar rock cropping out on the edge of the swampy area in the north-west quadrant of the map-area. From their physical characters and composition, however, these rocks appear to belong to the same body, and they are here interpreted as such.

Due to the absence of exposures in the intervening areas, however, there is much uncertainty concerning the actual position of the contact line, and it seems preferable to leave the question open for the present.

Inclusions

An important characteristic of the northern granite is the almost universal presence of inclusions. Distinct bodies of older rock, forming roof-pendants in the granite mass, have already been described. In addition, practically every exposure of granite in this northern section contains small inclusions. Most of these are fine-grained hornblende and/or biotite schist that, both in hand specimen and in thin section, is seen to resemble rocks of the volcanic-sedimentary series. Also found, but in more restricted quantity, are rocks which undoubtedly belong to the basic intrusive series.

Only in two localities were inclusions of schist and of basic intrusive rock seen in the same exposure. One of these is on the northwest-facing escarpment that bounds the low granitic hill at the southern tip of the tongue mentioned above, that is, about three and a half miles from the western border of the area and a mile south of Canet river. The other locality is on the west shore of Maicasagi lake, slightly less than a mile south of the northern boundary of the map-area. At both places the two types of inclusions are found in relative abundance and they are quite uniformly distributed.

The small inclusions generally measure a few square feet or less, and are commonly angular in shape. In places, they form ribbons, a few inches wide and scores of feet long, lying parallel to the fluidal structure of the granite. In some occurrences, these ribbons, because they are not clearly cut by offshoots of the intrusive, cannot be distinguished from basic dykes, except through comparison with undoubted inclusions.

The contact between the inclusions and the intrusive granite is everywhere sharp. Zones of transition from granite to older rocks were observed in a few localities. These zones, which are described below, show an intimate interlayering of the two types of rock, tending toward the production of a gneiss. However, except where the

alternating bands approach in thinness the size of individual mineral grains, the physical boundary between the two rock types is still well preserved in these transition zones.

Petrography

Because of the wide distribution of inclusions, the granitic rocks of this northern body show numerous variations in their field appearance. These variations are conspicuous, not only from one locality to another, but also, commonly, in a single exposure. Consequently, it is almost impossible to describe a rock that could be considered as the entirely non-contaminated representative of the mass.

Generally, the northern granite is a light-coloured rock, either grey or pink. It is fine- to medium-grained, and possesses a well-developed interlocking texture. In some exposures the rock is massive, but a gneissic structure is sufficiently common throughout the body to justify the use of the term 'gneiss'.

As much as possible, the specimens selected for microscopic study were taken from granite free from inclusions. Examination of the thin sections showed that all the gneissic types have a closely similar mineralogical composition, with range as follows:

Plagioclase	40-70%	Average ..	52%
Microcline	5-30%	"	10-15%
Quartz	5-45%	"	24%
Biotite	Acc.-30%	"	15%
Amphibole	0- 5%		
Accessory: epidote, chlorite, zoisite, magnetite, apatite			

In all sections, the plagioclase is quite fresh. The grains are subhedral with some rounding of their corners. Both albite and Carlsbad twinning are common. The composition of the plagioclase, in 18 of the 21 thin-sections studied, is from An_{14} to An_{21} , and the grains are slightly zoned. The remaining thin sections, although generally similar to the others, contain a more calcic, strongly-zoned plagioclase - An_{24} in the core, and An_{17} along the outer border. Since these three specimens were collected near the northern boundary of the eastern half of the map-area, they may indicate a progressive change in the composition of the granite from north to south.

The oligoclase was clearly the first of the light-coloured minerals to crystallize. Although the microcline grains are commonly polygonal, their shape has been determined by that of earlier formed,

contiguous crystals. Quartz, as is usual in granitic rocks, is entirely interstitial; the grains pinch, swell, and curve as they fill the voids between the earlier minerals, with the result that, in hand specimens, the subhedral form of the plagioclase is masked and the rock has an interlocking texture. The microcline and quartz are probably contemporaneous, since, in places, they form a myrmekitic intergrowth which, rarely, has replaced part of a plagioclase grain at the contact between the two feldspars.

Of the ferromagnesian minerals, biotite is much more abundant than amphibole. It is pleochroic from dark brown to brownish-yellow. It occurs as more or less parallel flakes, a few millimeters long (exceptionally 1 cm.). Many of the oligoclase grains contain small flakes of biotite. This is interpreted as evidence that biotite had at least begun to form before crystallization of the oligoclase.

Noteworthy amounts of amphibole were found in two thin sections only. This amphibole is, in both cases, a soda-rich type, probably belonging to the hastingsite group. Its physical properties are:

Pleochroic formula: Z = dark blue
Y = almost violet
X = greenish-yellow

$Z \wedge c = 30^\circ$; very small (-)2V

It occurs as irregular prisms or as trains of small grains. The prisms have many inclusions of quartz and clouded feldspar, and many of them terminate by an interfingering of amphibole and biotite. The trains form discontinuous streaks which often intersect one another as they curve around the larger grains of light-coloured minerals.

Of the accessory minerals, apatite and possibly magnetite appear to be original. Epidote, chlorite, and zoisite are alteration products resulting from hydrothermal processes.

Origin

The origin of granites - especially of those bodies that have a gneissic character - is presently a much-debated and highly controversial subject (Read, et al., 1948). On the one hand, the view is widely held that most granites were formed through the consolidation of a magma. Opposed to this is a school of geologists who hold the opinion that many granites were formed by transformation of pre-existing rocks through some agency not connected with magma.

While a thorough discussion of the present divergent views is beyond the scope of this report, the writer feels that enough data are available to classify the northern granite as magmatic. This gneissic body is believed to be partly protoclastic and partly lit-par-lit injection gneiss. This opinion is based on the following facts:

- (1) As noted above, the northern gneissic granite, away from inclusions, is very uniform in composition. It contains the same minerals, in approximately the same proportions, as the southern granite (Olga quartz diorite), which appears without doubt to be an intrusive body. The variations in the gneiss are no greater than in the southern granite, and certainly do not exceed the limits of heterogeneity that may be expected within such a large mass.
- (2) Well-preserved inclusions of rocks of both the volcanic-sedimentary series and the basic intrusive series are found in some exposures. Their presence together is not easily explained by any granitization hypothesis.
- (3) The gneiss is cut by dykes and apophyses that are similar both in composition and texture to the gneiss itself.
- (4) The common presence of zoned plagioclase crystals is difficult to explain unless they were formed through the solidification of a liquid mass.
- (5) The angular inclusions, with sharp contacts, are not consistent with any hypothesis postulating either hydrothermal or solid transformational processes.
- (6) No evidence of anything that even remotely resembles a basic front was seen in the map-area.
- (7) Gradational contacts between granite and schists were observed in several places, but these are not to be confused with a basic front as described by Reynolds (1947).

The best example seen of this transitional contact is exposed on the south shore of Canet river where this stream enters Mattagami lake. At this locality, a roughly triangular-shaped mass of biotite schist, tapering southward, is bounded on both sides by granite. It is exposed for a length of about 50 feet and has a width at the base of 35 feet (Figure 4). Specimens were taken systematically every few feet across the exposure following two east-west lines, 25 feet apart, transverse to the schistosity of the inclusion.

The granite bounding the schist on both sides and on the south has a mineral assemblage similar to that of the northern granite. Its composition is as follows:

Plagioclase (An ₁₇)		40%
Microcline		10%
Quartz		40%
Biotite		10%
Accessory: epidote, penninite		

Progressing from the granite to the schist in the central part of the inclusion, all transitional stages are seen. The granite first becomes slightly gneissic, as a result of a rough alignment of small clots of biotite flakes. This granite has the following composition:

Plagioclase (An ₁₉)		10-25%
Microcline		20-40%
Quartz		30-40%
Biotite		15%
Hornblende		0- 5%
Accessory: epidote, chlorite, apatite, hematite		

Farther in, narrow bands of schist, one-eighth to one-thirty-secondth of an inch thick, give the granite a coarser gneissic appearance. As the distance from the granite increases, the intruding material becomes scarcer, and the veinlets become more widely spaced until, about ten feet inside the schist, the rock is a dark, fine-grained schist that shows no evidence of granite. Throughout this transitional zone, the layers of schist are sharply defined against the coarser intrusive material.

The alternating light- and dark-coloured bands have compositions as follows:

<u>Light-coloured bands</u>	<u>Dark-coloured bands</u>
Plagioclase (albite) ..	10-15%
Microcline	30%
Quartz	45-50%
Accessory: biotite, epidote	
Quartz	40%
Biotite	20%
Epidote	30%
Feldspar	10%

The composition of the schist in the central part of inclusion is:

Hornblende	40%
Biotite	20%
Microcline	15%
Plagioclase (An ₃₅)	10%
Quartz	15%
Accessory: epidote; apatite	

This schist is characterized by alternating layers of hornblende- and biotite-rich material.

A significant feature of this contact zone is the increase of microcline in the granite as the included schist is approached. A similar increase has already been noted in the description of the contact zone of the Olga quartz diorite.

There is, south of Canet river, definite evidence that the gneiss has been intruded by dykes of a younger granite rich in microcline. It may be that all additions of potash to which reference has been made are related to this intrusive.

Testimony to hydrothermal changes that affected both the granite and schist is abundant. Epidote is found in all the thin sections studied. In one of them, it clouds all the minerals. Quartz veins are numerous. Some of them traverse, without a break, the contact between the two rock types.

It is quite clear that the exposure south of Canet river contains two types of rock, namely, an older schist and some younger granitic material. The granitic fluid, on consolidation, gave a rock which: (1) contains zoned crystals of plagioclase; (2) maintains its identity even in narrow stringers within the schist; (3) becomes strongly gneissic only in those places where the intruded schist was more thoroughly split up, that is, along its margins.

From these facts, it is concluded that the fluid that injected the schist at this locality was not of hydrothermal, but of magmatic, nature. This conclusion is evidently applicable to the whole of the northern granite. The physical properties of the intruded rocks are believed to have been the main factor in determining the character of the resulting composite gneiss. Massive, jointed rocks were partly preserved as more or less angular inclusions; more fissile rocks were intruded along closely-spaced fracture planes, with consequent production of a fine- to medium-grained gneiss.

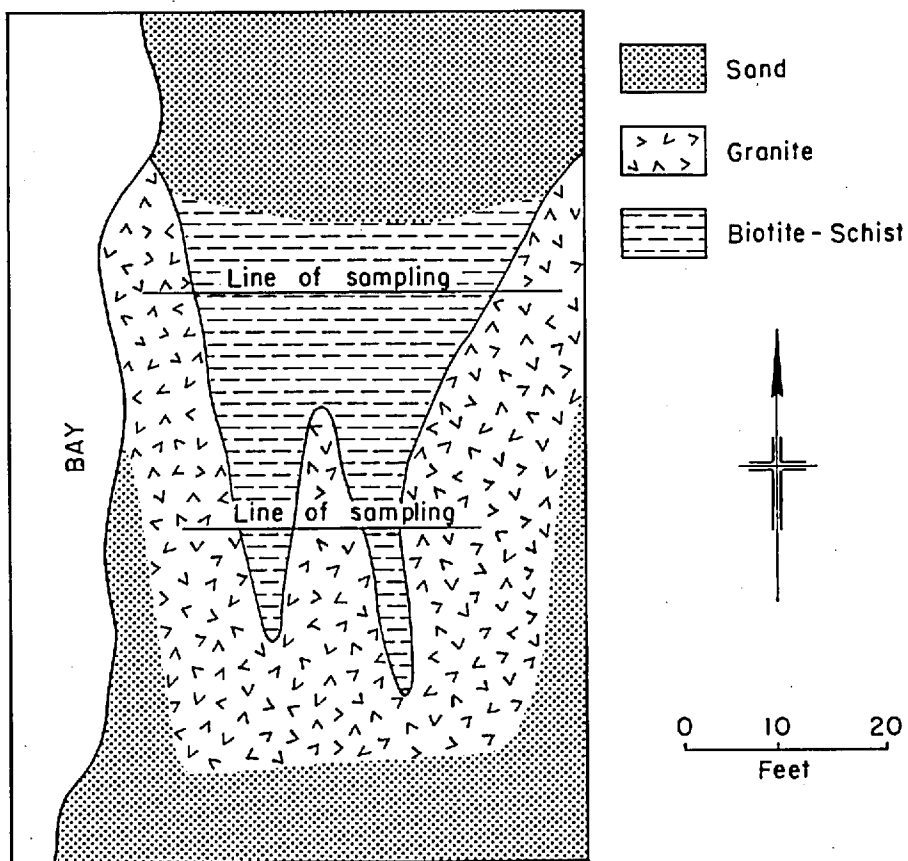


Fig. 4

INCLUSION OF BIOTITE SCHIST IN GRANITE

South shore of Canet river, at its mouth

D.M.Q. 1951 No. 914

Relations Between the Southern and the Northern Granites

The above discussion shows not only that the northern granitic gneiss is a true granite, but also that it is very similar in composition and texture to the southern (Olga) granitic body. The main differences between the two masses are the commonly gneissic character and the more contaminated state of the northern granite.

These differences lose much of their significance if the two bodies are compared with other batholiths in the Waswanipi-Chibougamau belt that have been described elsewhere. Indeed, all the granites from Madeleine lake to Chibougamau lake are characterized by the absence of potash, or at least the predominance of soda (Shaw 1939, Mackenzie 1936, Mawdsley and Norman 1935, Norman 1937a, Tolman 1931).

The universal presence of acidic plagioclase in the granitic rocks may be diagnostic of magmatic relationships. It is to be wondered whether these isolated masses do not represent cupolas of a single extensive batholith in which the present volcanic belts form huge roof-pendants.

If this hypothesis be true, then the difference between the northern granite and the southern granite of the area under study would simply reflect a difference in the original elevations of the 'cupolas'. Difference of erosion cannot be considered as a possible factor since both masses have been planed down to about the same level.

The features as observed in the northern 'cupola' are those that would be found near the top of the intrusive, where the magma would be still in contact with, and contaminated by, the invaded rocks. The general absence of inclusions within the southern granite means that this 'cupola' reached a higher level than the northern one. Its present eroded surface thus represents a deeper level of the magma chamber where, except along the sides, remnants of the invaded rocks would be absent.

Goéland Granite

Description

Numerous exposures of pink granite are found along the shores of Goéland lake and on some of the islands in the lake. This granite thus appears to form a batholith, about ten miles in diameter, underlying most of the lake. In addition, two small bodies of similar rock crop out east of the lake, within the wide area of andesitic lavas. The small area of granitic rocks exposed in the extreme southeast corner of the map-area may belong to or be related to the same intrusive.

The Goéland granite is quite different from the two types described above. Besides its pink colour, it is characterized by an equigranular texture, a massive appearance, and uniform composition: pink feldspar, quartz, hornblende, and minor biotite. Its grain size is medium to coarse. In many places, weathered surfaces have a porphyritic appearance, as a result of large quartz grains standing out in relief against the leached feldspars.

Petrography

The mineral composition of this granite, as determined in thin sections, is:

Plagioclase	65-80%
Microcline	5-10%
Quartz	10-15%
Hornblende	5- 8%
Biotite	Acc.0- 2%
Accessory: calcite, titanite, apatite, epidote, chlorite, hematite, magnetite, sericite	

Apatite is probably the earliest mineral in the granite. It occurs as small, euhedral grains which are found as inclusions in both the plagioclase and the hornblende.

Generally, the plagioclase grains are almost perfectly euhedral, and invariably they are zoned. This zoning is manifested in the fresh rock by shells that have different extinction angles, and in the more altered rock by the presence of concentric lines of alteration to saussurite. The composition of the core is about An_{24-28} , whereas that of the rim is An_{19-20} .

Hornblende, also, appears to be an early mineral of the rock. It occurs as long, narrow prisms that lie without common orientation. These have lost much of their original sharp definition as the result of partial alteration to epidote and biotite. The small amount of magnetite present in the rock may be a product of this alteration.

Myrmekitic intergrowths of quartz and microcline were observed in a few thin sections; they are taken as evidence that these minerals belong to the same stage of crystallization. Microcline occurs interstitially as grains less than one millimeter long. Some quartz shows similar characteristics, but in many places the rock contains clots of clear quartz up to one centimeter in diameter, whose grains are only slightly broken, if at all.

Titanite (sphen) is present in every thin section examined. The grains are generally too small to be identified in hand specimens, even with a hand lens, although occasionally perfectly euhedral (prismatic) crystals measuring up to 3 mm. in length were observed.

Cavities are common in this granite. They are from less than a quarter of one inch to more than a foot in diameter. Their walls are rough and most of them are partly filled with such minerals as quartz, calcite, epidote, and hematite. The largest observed (about 13 inches) is almost entirely lined by a coating of hematite, about one millimeter thick, overlain by a later, five-millimeter-thick layer of glassy quartz crystals that terminate outward from the wall in lustrous pyramidal faces. Clots of massive, brownish calcite, the size of one's fist, are attached to this surface in a few places. More than half of the original cavity remains empty.

Besides occurring in the cavities, epidote and hematite often form veins several inches thick. The walls of the epidote veins are commonly sharp. The hematite veins, also, have sharp walls, but in many places this mineral has penetrated for a short distance into the granite, giving it a deep-red colour.

The feature that most distinguishes the Goéland granite from the other intrusive rocks of the area is its texture. The euhedral crystals of plagioclase and large rounded clots of quartz can be seen on all the exposures of the rock. Except in the outcrops in the southeast corner of the map-area, gneissic structure resulting from alignment of dark minerals is entirely absent. On a few shore exposures, however, the rock exhibits a faint planar structure, due to the disposition of the quartz grains. Granulation is rare and, where present, restricted to the borders of occasional quartz grains.

Age

Offshoots of this batholith are found in the volcanic and sedimentary rocks on the west shore of Goéland lake, and two small plugs of similar rock pierce the lavas east of the lake. These satellite bodies prove conclusively that the granite is younger than the lavas and the clastic rocks.

This is the only definite age relationship known concerning the Goéland granite. Petrographically, however, the rock is quite similar to the hornblende granite mapped by Claveau (1948) in the Waswanipi Lake area (west half). This hornblende granite, according to Claveau, grades westward into a quartz syenite that he studied during the summer of 1946 in the Iserhoff River area (Claveau, 1951) and which he assumed to be younger than the 'Olga quartz diorite'.

If the above assumptions are correct, they would indicate that the Goéland batholith was injected after the consolidation of the other large granitic bodies of the region under study.

Dykes

Numerous dykes of various compositions and ages are found throughout the map-area. Most of them, because of their areal distribution, mineral composition, and texture, may readily be correlated with one or other of the main intrusive masses described above, namely: the diorite-syenite group, the southern granite, or the northern granite. Most of the remainder of these satellitic bodies, believed to be younger in age, are of the following types:

Lamprophyre,
Pink granite,
Diabase,
Amphibolite and diorite.

Lamprophyre Dykes

The term lamprophyre is here used to designate a group of fine-grained, dark rocks that are found as dykes in many localities. These rocks consist essentially of hornblende and plagioclase, although the proportions of these minerals are somewhat variable: the hornblende content ranges from 50 to 80 per cent and that of plagioclase from 5 to 25 per cent of the rock. Minor constituents are fresh albite, quartz, biotite, chlorite, magnetite, apatite, leucoxene, and hematite.

The hornblende is the ordinary green-pleochroic variety. It forms ragged, felted masses, up to two millimeters wide, full of randomly-oriented small crystals that have retained their original boundaries. In some of the thin sections, it appears to have been partly recrystallized. The development of the hornblende 'envelopes' may have occurred in the magmatic stage, since none of them contain any inclusions of feldspar.

The plagioclase is all anhedral. It occurs as brownish masses partly surrounded by a rim of fresh albite. In one thin section, the composition of the plagioclase, believed to be original, was determined as An_{20} . Albite is undoubtedly a late mineral since, in addition to surrounding the plagioclase grains, it forms veinlets associated with quartz.

The lamprophyres cut both the dioritic and granitic intrusive masses. Around Mattagami lake, they intrude a grey granite dyke related to the northern granite, but are, in turn, cut by stringers of pink granite.

Pink Granite Dykes

Occurrences of pink, massive granite and associated pegmatites are concentrated mostly around the east end of Mattagami lake. Generally, they form well-defined dykes and stringers that cut the northern granite and also, as mentioned above, dykes of the lamprophyre group. Where, as was sometimes the case, their borders could not be observed, dependence was placed on similarity in composition in assigning them to this group.

Besides their pink colour, these rocks are characterized by a low percentage of dark minerals, and by a high proportion of potassic feldspar. Their composition is:

Microcline	30-50%
Plagioclase (An ₁₈₋₁₅)	13-30%
Quartz	30-40%
Biotite	0- 5%
Accessory: epidote, magnetite, sericite, chlorite	

The plagioclase crystals, as in the main granitic masses, are generally subhedral, and the same is true of the microcline. In some of the thin sections examined, both feldspars are severely crushed, in contrast with the quartz, whose large grains show only a slight undulose extinction.

These dykes are comparable in composition to the large body of pink granite exposed in the east-central part of the Iserhoff River area (Claveau, 1951). Although correlation of the two is not possible in the present state of knowledge, it is considered likely that they belong to the same intrusive cycle, and that they represent the end stage in the consolidation of the huge batholith postulated in the section of this report discussing the relationship between the southern and the northern granites.

Diabase Dyke (Keweenaw?)

A small exposure of grey, brown-weathering diabase was seen on the top of the dioritic hill one mile north of Mattagami lake and 3,000 feet east of the western border of the map-area. The exposure measures only a few square feet and is completely isolated from the diorite. It was thus impossible to ascertain the dimensions and shape of the mass of which it forms a part, or its relation to the surrounding diorite.

The rock is medium-grained with a well-developed ophitic

texture. It consists essentially of diopside (65%) and plagioclase, An_{40} (30%). The diopside is partly altered to tremolite, and some of the plagioclase is replaced by late quartz.

Because the field relationships are too scanty, this small exposure has not been shown on the accompanying map. However, from the composition and texture of the rock, the occurrence may well be interpreted as a Keweenaw dyke.

Amphibolite and Diorite Dykes

In many places the Goéland batholith is cut by basic dykes, most of which strike in the northeast quadrant. They are black, medium-grained rocks of equigranular texture. As a typical representative, a thin section from a 15-foot dyke exposed on the small island immediately west of the largest island in Goéland lake was studied.

This rock consists of remnants of green hornblende crystals within a mass of greenish-white tremolite. The latter mineral occurs as long, thin prisms and as irregular fibrous clots that correspond in shape to the altered portions of the hornblende grains. Accessory minerals are magnetite and calcite. The magnetite is present either as dust or as trains of small grains distributed in the tremolite. The calcite forms ragged masses between the amphibole crystals and also appears within the tremolite, where it forms intergrowths along the cleavage planes and radiating structures.

Hornblende, because of its well-shaped grains, is believed to have been the first mineral to crystallize. The basic composition of the rock suggests that it originally contained pyroxene, but no evidence of the former presence of this mineral was observed in the thin section. The tremolite has presumably resulted from alteration of hornblende. Such a transformation is suggested, not only by the clots mentioned above, which appear to be pseudomorphs of tremolite after hornblende, but also by the distribution of the magnetite. All the magnetite in the section occurs within tremolite and may well represent the iron released during the postulated alteration of hornblende to tremolite.

A similar dyke on the same island has been brecciated after its consolidation and has been injected subsequently by less basic material (Plate VI-A). This composite dyke has a width of 30 feet and its walls are sharp against the granite. The material last injected has a dioritic composition; it consists essentially of plagioclase and hornblende in equal amounts, with minor calcite, magnetite, chlorite, biotite, and apatite. The plagioclase (An_{15}) is slightly clouded. The grains are generally subhedral and in the section

examined some are partly replaced by calcite. Hornblende, of the green-pleochroic variety, is also subhedral. It is very fresh, except for minor alteration to biotite and chlorite.

Quaternary

- Field evidence indicates that all soil and subsoil was stripped from the area by advance of the Pleistocene ice-sheets. Erosion of fresh rock, however, appears to have been slight. Glacial striae and polished surfaces are the only visible results of the rock denudation accomplished by the glaciers. On exposures of every rock type in the area, smooth surfaces may be seen in which, narrow, shallow striae are indented. Many granitic exposures have a highly polished, mirror-like surface which post-glacial weathering has left practically intact. Glacial fluting and roches moutonnées are rare (Plate II-A).

The most conspicuous witnesses to glaciation of the area are extensive deposits of glacial till and outwash material. These deposits, by filling the depressions, have not only disturbed the drainage but have given the area its plain-like appearance. They fall into two main categories: glacially-transported sand and boulders, and lacustrine muds and silts. Of these, the muds are by far the most important.

The muds are generally massive and sandy, although well varved 'clay' is seen occasionally. In the varved sediments, the summer layers are generally about half an inch thick, the winter ones, one quarter of an inch. The 'clay' seldom exceeds 30 feet in thickness and its top stands approximately 800 feet above sea-level as determined with an aneroid barometer using the levels of Olga and Mattagami lakes as reference points.

These lacustrine deposits are part of the 'Clay Belt', an area of some 68,000 square miles in northern Ontario and Quebec. The 'clay' accumulated, during the retreat of the glaciers, in a large lake (Barlow-Ojibway) impounded between the height-of-land, on the south, and the front of the waning ice-sheet, on the north. The eastern boundary of the lake passed, in a northeasterly direction, about 80 miles east of Goéland lake (Dresser and Denis, 1944, p.26, fig.2).

The till overlying the lake sediments was formed during a re-advance of the ice. This re-advance is probably contemporaneous with that inferred by Antevs (1925) from the study of varves and till near Cochrane, Ontario.

As no stratification was observed in the sand and boulder deposits, they are believed to consist exclusively of glacially-

transported debris. Field observations, supplemented by careful studies of aerial photographs, failed to disclose the presence of any of the features attributable to fluvioglacial deposition, such as eskers, crevasse fillings, and outwash plains. Characteristically, the deposits have the form of small hills of no particular shape, erratically distributed, mostly through the northern half of the map-area. Northeast of Goéland lake, many such hills are grouped in a manner that suggests they possibly represent a recessional moraine. Many of the moraine-like hills in the area are believed to have a core of solid rock, a view based on the fact that all the rocky hills are partly covered by morainic deposits.

Trains of more or less rounded boulders were noted on the flanks of many hills. They consist generally of only one type of rock and, from the writer's observations, they may be taken, in this area, as an indication that bed-rock of this type is exposed not very far northward. In fact, the presence of a sedimentary belt on the northeast shore of Olga lake was revealed by numerous boulders, the largest of which was three feet in diameter. These boulders are less than 1,000 feet south of the southernmost exposure of the sedimentary rocks.

Numerous fossiliferous boulders were seen on the beach at the head of the middle bay on the east side of Olga lake. The fossils are mostly of Silurian age. In addition, on the same beach, there is a large slab of a buff-coloured dolomite, which measures five by three feet, and is only a few inches thick. This slab and the concentrated distribution of the fossiliferous boulders here point to the possible existence in the vicinity of Palaeozoic rocks in place. There is, unfortunately, a complete lack of exposure in the adjacent area to the north.

STRUCTURAL GEOLOGY

Structural Criteria

As mentioned in a previous chapter, sufficient evidence for only one 'top' determination was found in all the exposures of volcanic rocks. That was on the south shore of the middle bay, east side of Olga lake, about half a mile east of the mouth of the bay. This flow strikes N.80°W., dips 85°S. and faces south. It thus lies south of an east-west trending anticlinal axis.

There is no doubt that, notwithstanding recrystallization, many of the lava flows still exhibit variations in grain size, but contacts between individual flows were very rarely observed. The similarity in composition between successive lava flows or layers,

the paucity of tuffaceous material, the general dirty state of the exposures, and metamorphism (both progressive and retrograde), all play their part in effectively masking the contacts. Furthermore, if the complex interfingering of different forms of flows noted in recent volcanoes (Shrock, 1948, pp.342-345, Figs. 301-304) were the rule in Precambrian time, it is no wonder that, after all the changes undergone by these rocks, their assemblage cannot be easily deciphered.

Top determinations in the sedimentary series were made at a number of places, but, with one exception, they were all obtained in the sedimentary rocks west and north of Goéland lake. The criterion generally used in these thinly-bedded series was grain gradation.

Cross-bedding was seen on one exposure in this belt, and again in the sedimentary rocks on the west shore of Olga lake, at a point about a mile southwest of Red chute. On this latter exposure, the bedding strikes southeast and dips 85°S., whereas the schistosity strikes northeast. Fairly well-preserved cross-bedding indicates that the bed faces north and is thus overturned. The value of this information, however, is greatly diminished by the fact that, in the vicinity of this particular exposure, there is evidence of cross-folding, the nature of which could not be determined.

The four top determinations made in the sedimentary rocks on the west and north sides of Goéland lake indicate that the top of the series faces toward the Goéland batholith. Since the sedimentary rocks are interbedded with andesitic lavas, the attitude of the eastern andesitic belt may be inferred, at this locality, from the structural observations made in the clastic rocks. The west and north sides of the belt, therefore, face toward the batholith and, since both the dip and the tops of the beds face in the same direction, a synclinal structure is indicated.

In addition to these top determinations, the following general observations were made in the field:

- (1) As far as could be ascertained, the schistosity is everywhere parallel to the bedding of both the sedimentary and the volcanic rocks, except for a stretch of about one mile on the west shore of Olga lake, where the two structures intersect one another, in places at a high angle.
- (2) For a distance of twelve miles eastward from the western border of the area, the schistosity, which is everywhere developed, trends in a general east-west direction. On approaching the Goéland batholith, the strike of both the bedding and the schistosity changes abruptly to follow the contour of this intrusive body.

- (3) The dip of the schistosity and bedding is generally quite steep or vertical.

Structure

The above data are too meagre to allow a positive interpretation of the structure, from which might be reconstructed the history of these isoclinally-folded rocks. The sequence of the rock groups in the western part of the area is particularly puzzling. As already mentioned, the trachytes are succeeded on their north side by a sedimentary belt, followed by an andesitic belt, whereas on their south side the succession is reversed. Another problem awaiting solution concerns the disappearance of the trachytes against the belt of andesitic lavas just west of Goéland lake.

To explain the peculiar succession of the rock groups, it is suggested that the regional structure is that of an eastward-plunging syncline, followed to the south by an anticline. Both folds are isoclinal. In addition, the north limb of the anticline has been dislocated by faulting.

Synclinal Structure

The andesitic belt surrounding Goéland lake is folded into an east-west-trending syncline plunging eastward. The axis of this syncline appears to cross the lake two miles or so south of its outlet into Waswanipi river. If this axis were prolonged westward, it would bisect the triangular body of trachyte into more or less symmetrical halves, and would meet the western border of the map-area close to the apex of the sedimentary belt exposed on the northern shore of Olga lake (Red Chute belt).

The westward convexity of the eastern andesitic band is thus repeated both in the trachytes and in the Red Chute sedimentary rocks. This part of the belt would thus be folded into an eastward-plunging syncline and the stratigraphic succession would be, from oldest to youngest:

Northern andesites,
Red Chute sedimentary rocks,
Trachytes,
Eastern andesites.

This interpretation may be questioned on the basis of the observed dips in the trachytic flows exposed on the east shore of Olga lake, in the vicinity of the postulated synclinal axis (Figure 5).

Indeed, the dips that are not vertical, in that locality, would seem to favour an anticlinal structure. However, such dips may be due to overturning, and it is believed that more significance must be attached to the outcrop pattern of the belts than to the dips. The westward convexity of the eastern andesites where they supersede the trachytes, the blunt termination of the trachytic band at its western end, and the arcuate shape of the sedimentary rocks (Red Chute belt) which seem to curve around the nose of the trachytes, are to be noted. This entire pattern strongly suggests that the several rock groups belong to one and the same fold system.

Anticlinal Structure

The reversal of succession south of the trachytes is easily explained if the andesites and the sedimentary rocks in this locality are considered to be younger than the trachytes. According to this hypothesis, the complete stratigraphic column of the Keewatin-like rocks in this area would be, from oldest to youngest:

Northern andesites,
Red Chute sedimentary belt,
Trachytes,
Andesites (eastern and southern belts),
Sedimentary rocks south of Olga lake.

The andesites and sedimentary rocks south of Olga lake would represent the southern flank of an anticline brought into contact with the trachytes through movement along a steeply-dipping fault striking more or less parallel to the axial plane of the fold. The postulated attitude of the strata before faulting and the location of the fault are shown diagrammatically in Figure 6. As will be discussed later, evidence of faulting is abundant near the andesite-trachyte contact.

This explanation necessitates the assumption that the southern and eastern andesitic belts belong to the same stratigraphic horizon. Their correlation cannot be affirmed positively, but, at least, it does not appear to be impossible. The two belts consist of similar volcanic rocks. Furthermore, the sedimentary rocks interbedded with the volcanics of the eastern belt may be, more or less, in the same stratigraphic position as the narrow sedimentary band on the south shore of the large island in Olga lake.

Shearing and Faulting

The rocks of the Olga-Goéland Lake area are traversed by two sets of steeply-dipping faults: the more common set parallels the

schistosity of the volcanic-sedimentary series; the other consists of faults that trend in a general southeasterly direction.

The strike faults are shear zones. They are so numerous that no attempt is made to describe their locations in detail. The most important - those exceeding a width of four feet - are shown on the accompanying map.

All these zones have the same appearance: they consist of a central area in which the rocks are intensely crushed, and which, as a consequence, is often marked by a slight depression in the surface of an exposure. On either side of this central area, there is a transitional zone of varying width (up to 100 feet, total width) in which the intensity of shearing decreases away from the centre. It was not found possible to ascertain the amount or direction of movement in any of the shear zones.

Hydrothermal activity has been widespread in these shear zones. The rocks are intensely chloritized, especially in those bands that experienced most of the shearing. Quartz and a carbonate (probably ankerite) are common in the form of veins, lenses, clots, and stringers.

The fault postulated above (Figures 5 and 6.) may coincide with one or other of the two shear zones exposed, respectively, on the north and on the south side of the point opposite the east end of the large island in Olga lake. The more northerly one is the larger; its total width is about 100 feet, although the movement was mostly concentrated across a width of one foot, where the lavas are very thoroughly crushed.

The abundance of east-west shearing in the west half of the map-area, the three east-trending bays in the east shore of Olga lake, and the general westerly course of the Waswanipi river, may indicate the presence of a regional 'break'. Most of the movement along this break would have been localized along zones that could be reflected, in the present topography, by the east-trending depressions.

Three main oblique faults and a few smaller ones were observed in the map-area. They all strike between N.75°W. and N.20°W., except one minor fault on the west shore of the large island in Olga lake which strikes N.80°E.

Offsetting of formations was observed in two places only. At Red chute, a northeasterly-trending shear zone and the contact between the sedimentary rocks and the syenitic intrusive are offset

along a fault striking slightly west of north. The strike separation is about 100 feet right (east side south). Along a small northwesterly-trending fault on the north shore of Waswanipi river, two miles east of Olga lake, the relative displacement of the blocks is only two feet with the east block here again displaced southward.

The other two outstanding faults are, respectively, on the west side of the large island in Olga lake, and on the south shore of Maicasagi lake, two and a half miles northeast of the south end of the lake. The displacement at these faults could not be determined, but strong movement is indicated by the presence of fault breccias eight feet and two feet wide, respectively, containing angular fragments that measure up to several inches.

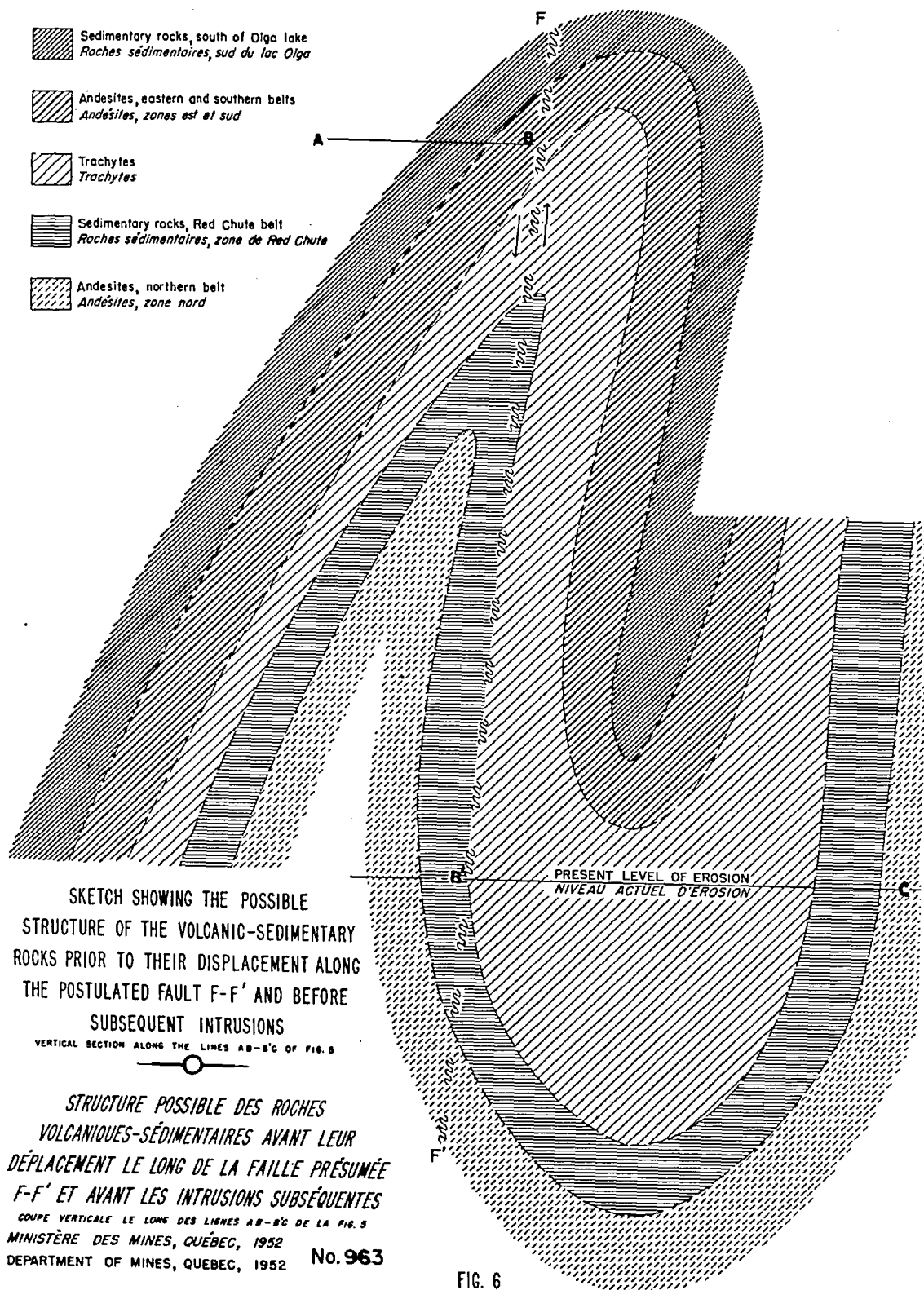
As far as could be observed, all the oblique faults are later than the strike shears. Their relation to the main intrusive bodies are known in two places only: the Red Chute fault is definitely younger than the syenitic member of the basic intrusive series; the Maicasagi fault breccia contains fragments of a granitic dyke presumably related to the northern gneiss. It seems probable that the strike faults (shear zones) are pre-intrusive in age, whereas the oblique faults are post-intrusive.

ECONOMIC GEOLOGY

Because of extensive overburden, most of the northern half of the map-area offers little attraction for ordinary methods of prospecting. Furthermore, the observed underlying rocks consist for the most part of intrusive masses in which no trace of mineralization was found.

The large tract underlain by the rocks of the volcanic-sedimentary series has been prospected spasmodically during the past few years, so far without success. Nevertheless, all the shear zones are somewhat mineralized, and the following localities deserve at least brief mention.

- (1) The sedimentary rocks at Red chute.
- (2) The andesitic rocks on the north and south sides of the point opposite the east end of the largest island in Olga lake.
- (3) The trachytic flows on the small island in Waswanipi river, just south of the bend where the river changes from a northerly to a westerly course.



- (4) A complex of sedimentary and volcanic rocks, with numerous sills of porphyry, exposed west of Goéland lake, two miles south of Waswanipi river and 1,500 feet inland. A strong magnetic 'anomaly' was noted at this locality.
- (5) A sheared porphyry sill within sedimentary rocks on the shore of Goéland lake, two and a half miles northeast of its outlet into Waswanipi river.

At all these localities, the rocks are intensely crumpled along wide shear zones. In addition to hydrothermal veins of quartz and calcite, pyrite is abundant in these zones and chalcopyrite was noted at a few places. A total of ten grab-samples taken from these localities was analysed in the laboratories of the Quebec Department of Mines. No gold was reported, but most of the specimens contain a little silver (up to 0.04 oz. per ton) and 'traces' of copper.

In summary, it may be said that within the area are to be found many of the geological features that characterize other areas of Western Quebec where valuable mineral deposits have been found. These favourable features are:

- (1) Extensive shearing of the volcanic-sedimentary belt;
- (2) Granitic intrusives on either side of the belt;
- (3) Evidence of hydrothermal activity within each of the shear zones;
- (4) Abundance of pyrite mineralization;
- (5) Presence of silver and copper.

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