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MATAMEC LAKE MAP-AREA, SAGUENAY COUNTY

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GEOLOGICAL REPORT 22

MATAMEC LAKE MAP-AREA

SAGUENAY COUNTY

by

E. W. Greig.

QUEBEC
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1945

MATAMEC LAKE MAP-AREA

SAGUENAY COUNTY

By E.W. Greig

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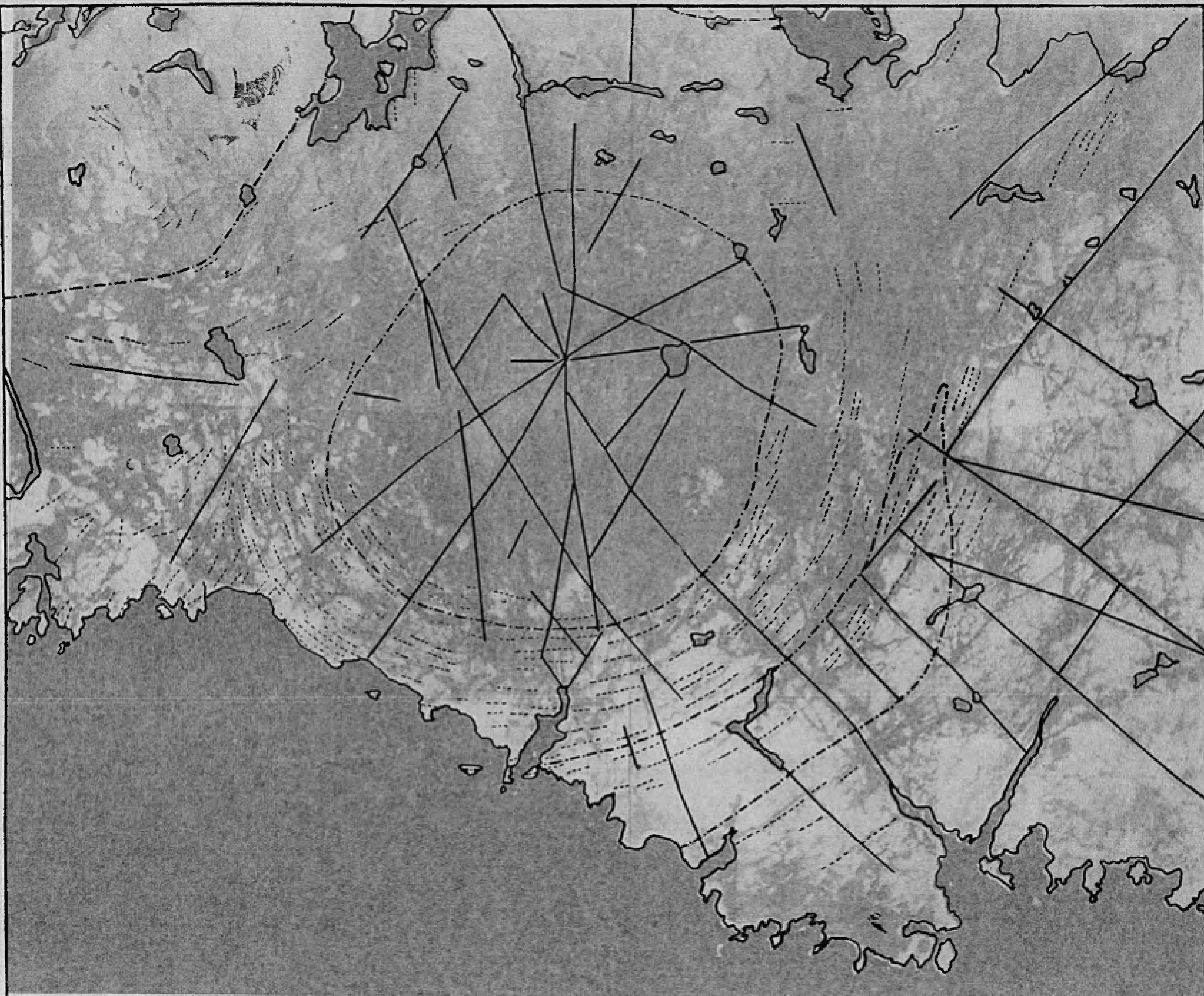
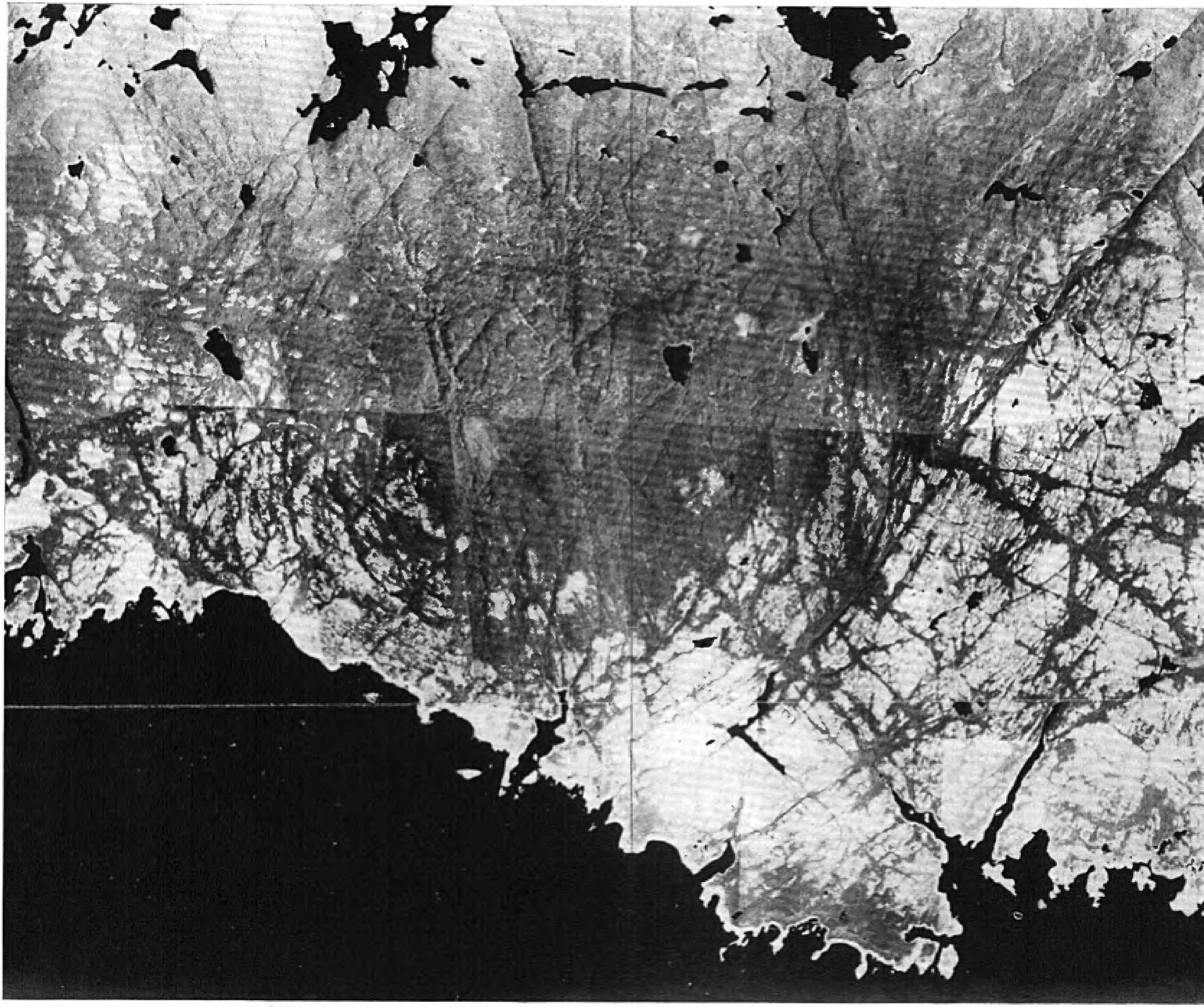


Aerial photograph mosaic of mica diorite plug, with superimposed tracing of jointing and foliation.



Aerial photograph mosaic of mica diorite plug, with superimposed tracing of jointing and foliation.

MATAMEC LAKE MAP-AREA

SAGUENAY COUNTY

By E.W. Greig

INTRODUCTION

General Statement

In 1928, the Quebec Bureau of Mines commenced a programme of reconnaissance geological mapping along and adjacent to the north shore of the gulf of St-Lawrence. This work was started at Ste-Anne-de-Beaupré, about twenty-five miles below Quebec city, and in successive years was continued northeastward as far as Moisie river. During the field season of 1940, the writer extended the mapping eastward from Moisie river for about twenty miles, nearly to Bouleau river.

The purpose of this and of the previous investigations has been to gain a clearer picture of the geology of this portion of the Precambrian shield and of its potentialities for the occurrence of economic mineral deposits such as have been found in other parts of the Laurentian sub-province.

Location and Access

The area investigated embraces the townships of Moisie, Blanche, and Rochemonteix, in Saguenay county, and totals approximately 315 square miles. It extends eastward from one mile west of longitude 66°00' to longitude 65°35', and northward from latitude 50°15' to latitude 50°30', or about sixteen miles inland from the shore of the St-Lawrence.

Matamek Factory, two and a half miles from the western boundary, is the most convenient point of entry to the map-area. During the summer months, passenger boats from Quebec city, and also from Rimouski and Matane, call once or twice a week at Seven Islands, about twenty miles west of Matamek Factory. The latter settlement can be reached from Seven Islands by boat, or by motor to the village of Moisie and thence by boat, a distance of seven miles.

Within the area, travel is difficult. The map-area lies on the southern edge of the Laurentian plateau and all the rivers that cross it are short, with their source not more than thirty to thirty-five miles inland. They vary seasonally from small torrential streams during rainy weather to boulder-strewn creeks in dry weather. For the most part, they have a very steep gradient, with numerous rapids and chutes.

The most accessible portion of the area is that drained by Matamec river. Portages have been cut along the river between its mouth and Matamec lake, and, northward from the latter, the main river is navigable as far as the point where Tchinicaman river enters it from the west, about $2\frac{3}{4}$ miles south of Key lake. The Tchinicaman has numerous rapids and chutes, and about one mile from its mouth it is made impassable by a chute, with a fall of 100 feet, which is bounded on either side by cliffs from 200 feet to 300 feet high. La Croix lake, immediately east of Matamec lake, may be reached from Matamec river without portaging.

Loups Marins river, which enters the St-Lawrence some ten miles east of Matamec after flowing due south completely across the map-area, has numerous rapids and chutes and along most of its course is unnavigable. An exception is a four-mile stretch southeast of the nearby Claveau lake (near the northern boundary of the area), where the river meanders over a flat, sandy valley.

Pigou river, which enters the St-Lawrence at a point about $5\frac{1}{2}$ miles east of Loups Marins river, and $1\frac{1}{2}$ miles from the eastern boundary of the map-area, is almost as difficult to travel as is Loups Marins river, except for a stretch of about five miles, starting two miles north from its mouth. None of the northern tributaries of this river are navigable. Although some of them have a low gradient, they are generally choked with alders.

Cross-country travel is difficult except in the strip about two miles wide along the shoreline. In the northern half of the area, deadfall, combined with the rough, incised character of the topography, makes walking very difficult.

Settlement

There are only two families living within the area. Mr. A. Levesque lives at Matamek Factory and acts as caretaker of the biological station located there. The station was not open in 1940 but was still owned at that time by Mr. C. Amory, of Boston, Mass. Mr. Peter Wright and family live at Rivière Pigou, on the coast at the extreme eastern boundary of the map-area, just east of Cormoran island. There is sufficient soil at these two localities to grow vegetables and enough hay to feed a few cattle.

Natural Resources of Area

Black spruce, birch, and balsam are the common trees of the area, with mountain ash and hemlock less abundant. Only the black spruce and balsam are of economic value, and forests of these are of relatively small extent. A few good stands were noticed along the valley of Matamec river, above Matamec lake, and along the upper part of Pigou river, about four miles north of Noirolle lake. A large part of the area is under timber-lease to the Gulf Pulp and Paper Company. From about 1918 to 1920, the Company logged along Pigou river, as far north as the sharp S-bend in the river, east of Noirolle lake. Logging was confined to the sand flats along the river valley, and on these a dense second growth of balsam has since sprung up.

Fur-bearing animals are rather scarce in the area. Evidence of the presence of beaver, otter, mink, and caribou was noted. Porcupine, muskrats, and rabbits were seen, but they do not appear to be numerous. A few trappers operate in the country around Matamec lake during the winter months.

Fishing for halibut is carried on in a small way along the coast, and also for salmon in the stretch between Matamec and Moisie rivers, and up the Matamec for about two and a half miles above its mouth. Trout are scarce in the streams and lakes, except at the outlet of Matamec lake.

There has been very little if any prospecting within the area, but sulphide mineralization was observed in several localities during the present investigation. These occurrences are described in the concluding section of this report.

Field Work and Acknowledgments

The field work was carried on for a period of nearly four months during the summer of 1940. Aerial photographs of the map-area were available, as well as a preliminary map for plotting. A final compilation of the map, based on surveys made for the Quebec

Department of Lands and Forests and on the photographs, was prepared by that Department in time for the writing of this report.

Traversing was by pace and compass. Lines were run as systematically as possible, spaced about half a mile apart. A systematic traverse system was necessary, because of the gradational nature of most of the geological contacts. In some of the northern parts of the area, particularly in the northwest, traverse lines were more widely spaced, because of the inaccessibility of the area by canoe, and the resulting necessity of making much longer traverses than could be completed in a single day.

The field map was plotted on a scale of one-half mile to an inch. In the final map, accompanying this report, the scale has been reduced to one mile to an inch. Outcrops are indicated on the map by a cross (X). Where these crosses are continuous and equally spaced on the map, nearly continuous rock outcrop is indicated.

The writer was ably assisted by J. Claveau in the capacity of senior assistant, and by E. Bérubé and L. Simard as junior assistants. J. Giasson acted as cook and canoeman.

Special acknowledgment is due to Mr. A. Levesque, of Matamek Factory, and Mr. P. Wright, of Rivière Pigou, for their kind hospitality and for courtesies rendered during the course of field work.

Dr. A.F. Buddington and Dr. H.H. Hess, of the Department of Geology, Princeton University, have given helpful aid and criticism during the preparation of the report.

Previous Work

James Richardson (1), in 1866, made a reconnaissance survey along the north shore of the St-Lawrence from Saguenay river eastward to Seven Islands bay, the latter about twenty miles west of the area described in the present report.

In 1894, A.P. Low (2) mapped the geology along the upper part of Romaine river and the lower part of Saint John river, some fifty miles east of the Matamec Lake area.

Since 1928, as already mentioned, a systematic programme of mapping of the country along and adjacent to the north shore of the St-Lawrence has been undertaken by the Quebec Bureau of Mines. This work has been carried on by Carl Faessler, whose reports have appeared in annual reports and preliminary reports of the Bureau from 1928 onward. In 1939, Faessler (3) mapped an area immediately west of that dealt with in the present report.

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(1) RICHARDSON, J., A report (without specific title) on the north shore of the Lower St.Lawrence; Geol. Surv. Can., Rept. of Progress, 1866-1869, pp.305-311.

(2) LOW, A.P., Explorations in the Labrador Peninsula; Geol. Surv. Can., Ann. Rept., Vol.VIII, 1895, pp.236-237.

(3) FAESSLER, Carl, Moisie Area; Que. Dept. Mines, Geol. Rept. No.21, 1945.

GENERAL CHARACTER OF THE AREA

Topography

The Matamec Lake map-area, as almost any other area bordering the north shore of the gulf of St-Lawrence, may be subdivided into three physiographic units: the Champlain lowland, a foreland, and the Laurentian plateau. Underlying, and in many places rising above, the Champlain lowland is a basement of 'Laurentian' rocks, forming a foreland lying south of the Laurentian plateau.

The Champlain lowland (Plate II-A) is underlain by sand and gravel of Pleistocene age, and is in general a flat surface. Faessler (1) states that, in the adjoining Moisie area to the west, the surface of the plain rises to heights of four hundred feet above sea level, and comparable heights are to be found in the present map-area. In many places in this region, the Laurentian plateau attains an elevation of 1,000 feet or more within ten miles of the shoreline, but in the Matamec Lake map-area the elevation varies considerably from place to place. The foreland topography is generally sharply divided from the plateau by a distinct break in elevation between the two, but in places there is a more or less gradual merging of the two physiographic units.

The front of the Laurentian plateau (Plate II-B), where it enters the map-area from the west, follows the east-west section of Rats Musqués river, southwest of Thom Lake, and continues eastward to the sharp elbow in Matamec river about a mile below Matamec lake. It there swings northeastward along the western side of Matamec lake and the western side of Matamec river as far north as Key lake, where it turns back sharply southward to follow first the east side of Matamec river and then the east side of La Croix lake. Between La Croix lake and Loups Marins river, the foreland area and the plateau merge into one another and no definite front is seen until about two miles south of Cliff lake, where, on the west side of Loups Marins river, it again emerges as a distinct physiographic feature, trending southeastward to the mouth of Pigou Est river. From there, it continues eastward to the boundary of the map-area, maintaining a distance of about two miles from the shore.

North of this front is the Laurentian plateau. The plateau is much dissected by deep valleys and has rugged relief. Northwest of Matamec lake, a few monadnocks rise above its general level. In some of the deeper valleys, particularly in the northeastern part of the area, small remnants of Champlain sand and gravel are still present. South of the front is the foreland area of Precambrian rock, with scattered remnants of the Champlain sands and gravels lying on it. The foreland area, with elevations up to 500 feet, has a somewhat rolling topography, often with narrow, deep valleys, but nowhere as rugged as the plateau area. The largest remnants of the Champlain sands are found in the southwest corner of the map-area, bordering Moisie bay and southwest of Thom lake. Other, smaller patches occur in the valleys of Matamec, Loups Marins, and Pigou rivers.

Within the map-area, wherever a strong platy foliation is present in the bedrock, it is reflected in the topography, giving a 'ploughed field' effect. Examples of this may be seen west of Thom lake, north of Moisie bay, and again about two miles north of Cormoran island at the eastern boundary of the map-area. This feature

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(1) Que. Dept. Mines, Geol. Rept. No.21, 1945.

is usually developed in Grenville gneiss, or in fine grained granite gneiss.

Drainage

The area is well drained. Swamps of appreciable extent are confined to the foreland.

The drainage is effected by three main rivers: Matamec river, with its branches, Rats Musqués and Tchinicaman; Loups Marins; and Pigou river, with its branch, Est Pigou. They are all relatively short, their headwaters being some thirty to thirty-five miles north of the St-Lawrence, into which they empty. Also, due to the local source of their water, and because they flow down over the Laurentian front, they are for the most part rough and unnavigable. Rapids and chutes are more prevalent than quiet water (Plate II-C).

The rivers are all in the youthful stage of development, flowing for the most part in gorges in the bed-rock. Except locally, where the gradient is very low, there are no stream deposits of sand and gravel. Where such deposits do occur, they are probably of Champlain age. Along such stretches of low gradient, the stream meanders over the sands and oxbows and cut-offs are common. Such is the case on Matamec river between Matamec lake and the mouth of Tchinicaman river. Here, the river meanders over a broad, flat valley underlain by sand. The upper part of Loups Marins river affords another example, and small stretches of sandy bottom occur locally on Pigou river.

Loups Marins river has certain features that distinguish it from the other rivers of the area. It follows a straight north-south direction for about eight miles, lying in a gorge for the most part of this length. Its direction is evidently controlled by jointing rather than by shearing or faulting, since outcrops of un-sheared rock cross the river and not infrequently have a gneissic structure at right angles to its course.

Foliation planes, faulting, and jointing are the three main controls of the drainage pattern, with the last named the most important. Foliation control of topography is developed best in the Grenville gneisses. A striking example of this may be seen in the Grenville gneiss surrounding an intrusive plug of mica diorite about a mile northeast of Moisie bay. Platy foliation has been developed in the gneiss concentrically to the margin of the intrusive mass, and the drainage subsequently developed has the same concentric pattern. Shearing is not usually evident as a drainage control within the area. Locally along the lower part Pigou river, however, shearing controls the direction of the river channel.

As stated above, jointing has been the most prominent structural feature controlling the drainage pattern. This is, perhaps, best exemplified by the drainage developed along radially arranged joint systems in the intrusive plug of mica diorite mentioned above.

Matamec lake is the largest lake in the area, being about three miles long and two and a half miles wide. Other fairly large lakes are La Croix, Méchant, and Claveau. The majority of the lakes lie within the 'plateau' section of the area, where there are many small lakes, evidently gouged out by the Pleistocene ice sheet as it moved southward. A characteristic of these lakes is their steep-walled or cliffed north shores, and the absence of sand beaches. Some of them have a coarse boulder beach. West of Méchant lake, the plateau surface is not deeply dissected, and here small depressions form fairly shallow lakes which are strikingly different from the deep lakes elsewhere in the map-area.

GENERAL GEOLOGY

General Statement

The consolidated rocks of the area are all of Precambrian age. Amphibolites, gneisses, and quartzites of Grenville type make up about fifty per cent of the bed-rock. These are intruded by bodies of augen granite gneiss, olivine gabbro, anorthosite, diorite, and fine-grained granite and granite gneiss. Related to these last are pegmatite and lamprophyre dykes. Diabase dykes of probable Keweenawan age cut all the foregoing types.

Table of Formations

Pleistocene and Recent		Marine sand and gravel
Precambrian	Keweenawan (?)	Diabase dykes (not shown on map)
	Post-Grenville Intrusives	Lamprophyre dykes Pegmatite dykes Granite and granite gneiss Mica diorite Olivine gabbro Anorthosite Porphyritic granite gneiss
	Grenville	Pyroxene- and hornblende-amphibolite Quartz-biotite-plagioclase gneiss Injection gneiss Quartzite

Grenville

The Grenville-like rocks of this and adjoining areas to the west do not correspond very closely to the Grenville of the type locality in Grenville township, Quebec, where this series of rocks was first studied, and was named, by Sir William Logan (1). There, the Grenville is represented by great bands of limestone interstratified with amphibolite and with rusty-weathering gneiss, which is often highly garnetiferous and is usually rich in sillimanite. However, subsequent work has shown that, in other Grenville areas of western Quebec and eastern Ontario, limestone is not nearly as abundant as in the type area, but that paragneiss and quartzite form the major part of the series.

In the order of their abundance, the Grenville-like rocks of the Matamec Lake map-area are pyroxene- and hornblende-amphibolite, quartz-biotite-plagioclase paragneiss, injection gneiss, and impure quartzite. No limestone outcrops were seen in the area, and the closest recorded occurrence of Grenville limestone is about 130 miles to the southwest, on the west side of Manicouagan river, near its mouth (2). These rocks are believed to be all of sedimentary

(1) LOGAN, Sir William, Grenville County, Quebec; Geol. Surv. Can., Rept. of Progress, 1858, pp.8-45.
(2) FAESSLER, C., Geology of North Shore, Manicouagan to Godbout; Que. Bur. Mines, Ann. Rept., 1933, Part D, p.160.

origin. Because they are the oldest in the area, and because they resemble rocks that, elsewhere, have been assigned to the Grenville series, they are here also believed to be of Grenville age.

Amphibolite

Distribution.- At least one-half of the Grenville occurring in the area is amphibolite. A belt, or the southern part of a belt, of this rock extends completely across the northern part of the area, and continues beyond it to both west and east. Within the area, the belt is of irregular width, but in a general way the width increases from about two miles on the west to some eight and a half miles in the eastern part.

From the western boundary to just beyond Tchinicaman river, the rock is pyroxene amphibolite, but from there to the eastern boundary it is hornblende amphibolite. The two types apparently grade into one another, intermediate varieties containing both pyroxene and hornblende occurring between Tchinicaman river and Key lake and to the northeast of Méchant lake. Associated with the amphibolite, and replacing it along fractures, are narrow bands of coarse porphyritic granite gneiss. The contact between the two rocks is often gradational, the one passing to the other through a zone of porphyritic gneiss (Plate V-B) with an amphibolite matrix. Further reference to this feature is made on a later page.

Amphibolite occurs elsewhere in the area as narrow bands associated with and grading into Grenville rocks of other types.

Petrography.- The amphibolite is a fine-grained (0.1 to 0.7 mm.), massive rock, occasionally exhibiting a gneissic structure. Both types are dark grey to black in colour, often with a salt-and-pepper appearance, and it is impossible to differentiate between them in the field. South and east of Randin lake, lighter coloured zones up to 100 feet or more in width, with a predominance of plagioclase, are intercalated with the amphibolite, into which they apparently grade.

Study of thin sections showed that the amphibolite is of two distinct types, pyroxene amphibolite and hornblende amphibolite, with gradations between the two. Although, in the field, the rock generally appears to have a granular structure, in thin section it almost invariably shows a gneissic banding, due to alignment of the mafic minerals, pyroxene, amphibole, or biotite. The minerals are mostly granoblastic (that is, they are metamorphic and of equal size), and some show the effect of granulation. Rarely, the plagioclase grains are euhedral and the rock has a diabasic texture.

The pyroxene amphibolite (Plate III-A) consists essentially of andesine plagioclase (An_{32-42}) with pyroxene. The plagioclase is of two types, one relatively coarse and sericitized or saussuritized, the other finer grained, clear, and definitely granoblastic. The pyroxene is in part hypersthene, showing pale pink to green pleochroism, and in part diopside, which also may exhibit a pink pleochroism, probably due to a small content of titanium. Brown pleochroic biotite is present in minor amount, either as small plates or as a dactylitic (1) growth around pyroxene. Pale green pleochroic hornblende forms an alteration rim around pyroxene, particularly as the gradational type into hornblende amphibolite is approached. Accessory minerals include apatite, zircon, sphene, and ma-

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(1) Dactylitic - "Relating to finger-like projections of minerals from the sides of crystals of different species" (Sederholm).

gnetite. Zircon is rare, but apatite or sphene are fairly abundant in some of the thin sections examined.

The hornblende amphibolite (Plate III-B) consists essentially of andesine plagioclase (An_{30-40}), with common hornblende and biotite. As in the pyroxene amphibolite, the plagioclase is of two types; in one, the grains are relatively coarse and altered, in the other they are smaller, fresh, and granoblastic. The fresh grains contain few inclusions and are generally untwinned. Hornblende, a green, strongly pleochroic variety, occurs as equidimensional sub hedral to anhedral grains and is the predominant mafic mineral. In some sections, it has broken down to a fine-grained aggregate of hornblende, quartz, and plagioclase. The brown pleochroic biotite plates often have a rudely planar orientation. A small quantity of quartz may be present. Accessory minerals are apatite, sphène, magnetite, occasional pyrite grains, and, rarely, minute crystals of zircon.

A well banded specimen taken from one of the zones of plagioclase-rich amphibolite (Plate IV-A) near Randin lake was found to consist of plagioclase (sodic andesine) with more or less well defined bands rich in mafic minerals, either small rounded grains of hypersthene or pale brown pleochroic biotite. A few bands consisting of small granoblastic quartz grains were also noted in the thin section examined. Between the bands there is a considerable amount of graphite, indicating a probable sedimentary origin for this rock.

Table I gives the estimated mineral composition of the amphibolite from various localities within the area, as determined by Rosiwal analyses, and also, for comparison, the 'modes' of Grenville amphibolites from two localities in the Adirondacs.

Table I.-Mineral Composition of Amphibolite

	1	2	3	4	5	6	7	8
Quartz.....					4.0	1.5	6.8	6.2
Orthoclase.					0.7	1.5		
Plagioclase	60.9	49.8	57.4	35.0	34.6	39.8	36.5	31.0
Hornblende.		8.3	26.0	48.8	52.5	54.1	38.7	60.2
Pyroxene...	32.7	28.1	16.5					
Biotite....	3.4	11.7		14.2	3.9	4.3	11.2	0.2
Apatite....				0.5	0.9		0.8	0.5
Scapolite..							4.7	
Pyrite.....		.1	.1			2.0		
Magnetite..	2.5	1.8		0.3	3.3	1.0		1.6
Sphene.....	0.4			0.7			0.7	

1.-Pyroxene amphibolite, near north boundary of map-area
2.-Pyroxene amphibolite, 1½ miles north from mouth of Tchinicaman river
3.-Amphibolite (intermediate type), north of Mechant lake
4,5,6.-Hornblende amphibolite, east of Key lake
7.-Amphibolite (meta-gabbro), Adirondacs (Buddington, Geol. Soc. Am., Mem.7, 1939, p.186)
8.-Amphibolite (Grenville), Adirondacs (Buddington, loc. cit., p.12)

Nos.1 to 6 in the Table are arranged in order of decreasing pyroxene and increasing hornblende content. As will be noted, they indicate that the change from pyroxene amphibolite to hornblende amphibolite is gradational, and also that, in passing from the former to the latter, there is in general a decrease in the plagioclase content of the rock. The biotite content seems to be entirely erratic. The writer is of opinion that the two types of amphibolite are metamorphic facies of the same rock, and that the pyroxene amphibolite is the higher temperature facies.

Quartz-Biotite-Plagioclase Gneiss

Distribution.-Quartz-biotite-plagioclase gneiss outcrops along or adjacent to the western boundary of the map-area in a zone from one to four miles wide. From the southwest corner of the area, the gneiss continues eastward as a belt of varying width which extends as far as East Pigou river, near the eastern boundary, except for a short stretch between Loups Marins river and Noirolle lake, which is occupied by injection gneiss. This belt is separated almost everywhere from the belt of amphibolite to the north by bodies of intrusive rock. Its northern margin crosses the lower part of Thom and Matamec rivers at points respectively three and a half miles and two miles north of the St-Lawrence shore. Then, turning northeasterly, it touches the southern end of Matamec and La Croix lakes and reaches Loups Marins river just west of Larochelle lake. On the south, the belt extends to within a mile or so of the St-Lawrence throughout the western part of the area (as far east as Loups Marins river), and it reaches the St-Lawrence over a stretch of two miles in Moisie bay, immediately south of the body of mica diorite to be described later. East of Loups Marins river, where the belt is relatively narrow, its southern margin is five miles or more from the St-Lawrence.

Both on the north and the south, the belt is bounded in most places by bodies of intrusive rock, but here and there, and particularly along its south side, the marginal rock is injection gneiss.

Petrography.-The quartz-biotite-plagioclase gneiss (Plate IV-B) has a grey to white colour, depending on the biotite content. The grain is medium to coarse. Types vary from banded gneiss, in which the dark minerals are rudely segregated, to entirely granoblastic varieties. Locally, the term schist would apply better than gneiss. Quartz, oligoclase, plagioclase, and biotite are the essential minerals. The quartz and oligoclase are usually predominant, with the latter ranging in composition from An_{10} to An_{28} in the thin sections examined. Green, pleochroic hornblende may be present, but is always in minor amount. Accessory minerals are apatite, zircon (sparse), sphene, magnetite (which may be titaniferous), and pyrite. Near granite intrusions, the rock may contain some introduced muscovite, microcline, and orthoclase, and also replacement antiperthite, and here, also, magmatic solutions have altered the biotite and hornblende to chlorite.

Locally, these paragneisses grade into a garnetiferous variety which has not been listed in the Table of Formations because of its minor development in the map-area. Rocks of this variety are found in the paragneiss along its contact with anorthosite west of Randin lake and, again, east of Pigou river about two miles north of the mouth of the East Pigou. They differ from the typical quartz-biotite-plagioclase gneiss only in the presence of garnet, which, moreover, is never abundant.

Injection Gneiss

Distribution.-Lit-par-lit injection gneiss occurs in several parts of the area, generally, although not always, near intrusions of granite, as is the case, for example, both north and south of Ross lake. About one mile northeast of this lake, a narrow band of the gneiss is completely surrounded by granite, and the same is apparently true of a band which, paralleling Matamec river and from one to one and a half miles east of it, extends northward for some four and a half miles from a point two miles northeast of the north end of La Croix lake to a point a mile and a half east of the south end of Key lake. However, outcrops here are sparse and although, on the accompanying map, the gneiss is shown in direct contact with the granite that occurs to east and west of it, these mapped contacts are wholly assumed. Two miles east of the 'cross' of La Croix lake, injection gneiss occurs near the southern margin of a mass of granite, and still farther east the gneiss extends eastward for some three miles from Loups Marins river, past Larochelle and Pontois lakes, to the east side of Noirolle lake, lying between augen granite gneiss to the north and granite to the south.

Along the southern, coastal boundary of the area, injection gneiss containing bands and twisted lenses or schlieren of amphibolite extends along, and for one mile inland from, the shore for a distance of about two miles eastward from the mouth of Matamec river, and it appears again as a belt of similar width along the stretch from two miles west of Point St-Charles to the mouth of Loups Marins river.

In areas where outcrops are scarce, it is often difficult to say which is the predominant rock, injection gneiss or granite.

Petrography.- The lit-par-lit injection gneiss (Plate V-A) apparently formed where the original paragneiss had a banding well enough developed to be 'injected 'band by band' by granite. These alternating bands of host rock and of injected granite vary in width from a fraction of an inch to one or two feet. Where digestion of the host rock by the intruding granite was more complete, migmatites tended to form. The paragneiss bands of this composite gneiss are quartz-biotite-plagioclase gneiss or amphibolite, in which there is more or less segregation of the light and dark minerals. In one of the thin sections examined, the host rock was found to be composed of quartz, calcic oligoclase (An_{25}), biotite, and hornblende, with accessory magnetite, apatite, and zircon. Some potash-feldspar has been introduced, which veins and replaces the other minerals. The intrusive portion of the rock consists of orthoclase, microcline, and quartz.

Quartzite

Impure quartzite, in bands up to ten feet or more in width, is occasionally found interbedded with the quartz-biotite-plagioclase gneiss and with the injection gneiss. A zone known to be at least 200 feet wide outcrops along the eastern margin of the anorthosite mass north of Matamec lake. The rock is finely banded and, in addition to quartz, contains a little garnet, small biotite plates segregated along the planes of banding, a few needles of hornblende, and some magnetite and zircon. A small quantity of orthoclase is also present. On the west side of La Croix lake, below the arm of the 'cross', a narrow band of quartzite, about half a mile in length, is included within olivine gabbro. It is a fairly pure, friable quartzite of medium grain, containing scattered biotite flakes.

Relationship and Structure of the Grenville Rocks

The relationship of the several types of rock making up the Grenville series is difficult to decipher. They have been subjected to repeated intrusion, folding, and metamorphism, and the original bedding has generally been obliterated by recrystallization. As seen in the field, the several types appear to grade into one another. Reference has already been made to this feature in the case of the amphibolite.

With the exception of the amphibolite, the rocks of the series generally exhibit a steeply dipping platy foliation or banding, but as a rule this is well marked only in zones adjacent to bodies of intrusive rock, where it parallels the margin of the intrusive body. This might indicate that the intrusions took place along zones paralleling original bedding planes or pre-existing planes of foliation, or that they caused a doming of the Grenville rocks, with consequent development in them of concentric foliation or banding. Good examples of this may be seen in the quartz-biotite-plagioclase gneiss in a zone up to half a mile wide surrounding the anorthosite mass on the west side of Matamec lake; in the similar gneiss surrounding the rudely circular body of mica diorite that lies between Moisie bay and La Croix lake; and in the paragneiss extending eastward from La Croix lake past the north side of Cliff lake to Pontois and Noirolle lakes, bounded on the south by granite.

Folding on a small scale was observed in the Grenville rocks at a number of places. Such folds in the gneiss southwest of Méchant lake have a north-south trend and their axes pitch to the south, beneath the northern margin of the adjacent mass of anorthosite. A mile and a half west of here, a synclinal fold with similar trend pitches to the north, and a sheet of granite, about a quarter of a mile thick, is intruded along its steeply dipping limbs. The injection gneiss west of Point St-Charles is tightly folded on a small scale, the axes of the folds, which strike northeast, being horizontal. Shallow anticlinal and synclinal folds, with a general north-south trend, are common in the gneiss to the east of Pigou river about a mile and a half north of the point where it is joined by East Pigou river.

Origin of the Grenville Rocks

All of the rocks which are here assigned to the Grenville series are believed to have been originally sedimentary. In the case of the impure quartzites, there can be little or no doubt of this. The quartz-biotite-plagioclase gneiss is often interbedded with quartzite, and in some places it contains graphite. It was possibly formed by the metamorphism of original argillaceous and calcareous sandstones, with, probably, some addition of material from the magmas that intruded these sedimentaries. The high content of apatite and sphene in some of these gneisses certainly indicates addition of fluorine and titanium at least.

Various hypotheses have been advanced concerning the origin of amphibolite. Each may be applicable to the particular area for which it was postulated, but no one theory will explain all amphibolite occurrences. Following are some of the theories:

(a) Metamorphism of diorites and gabbros
(b) Metamorphism of volcanics of intermediate to basic composition - andesite or basalt
(c) Reconstitution of impure limestone, with some addition of material from thermal solutions
(d) Replacement of limestone through the agency of thermal solutions

(a) In many places in the 'Laurentian' region of eastern Canada and in the Adirondacks of northern New York State, amphibolite has been formed by the metamorphism of pre-existing diorite or gabbro. Buddington (1) says that "such amphibolites can be proven of igneous origin only by transitions to rock still preserving typical igneous texture". That is, one would have to find cores in the amphibolite mass with the dioritic texture preserved. Such a texture was noted at a few places in the hornblende-amphibolite of the Matamec Lake map-area. One of the best examples seen is near the contact of the amphibolite with the mica diorite mass southeast of Claveau lake.

(b) Osborne (2) suggests that the amphibolites in the Shawinigan Falls area of Quebec were originally volcanic rocks, either andesite or basalt. He believes that, in some places, volcanic structures are still preserved in these rocks. Such structures were not observed in any of the amphibolites in the present area. However, their uniform composition over wide stretches of the area would suggest that they might be metamorphosed volcanic rock.

(c) Buddington (3) states that calcareous slates near the Coast Range batholith of Alaska have been metamorphosed to banded amphibolites and schists, with bedding still preserved. Probably some material has been added. It is possible that parts of the amphibolite of the present area had such an origin, although no indication of such was found.

(d) Adams and Barlow (4), in 1910, suggested that some of the Grenville amphibolites in the Haliburton-Bancroft area of Ontario were formed by metasomatism or reconstitution of limestone by invading granite magmas. He was able to trace limestone into a 'skarn' zone and thence into amphibolite. Barth (5), in 1928, suggested a similar origin for the amphibolites of Osgebirge, in southern Norway, and gave a detailed description of the steps by which the change had been effected. He showed that reconstitution and metasomatism of the limestone by thermal solutions had given rise to a series of rocks changing progressively to marble, scapolite-pyroxene skarn, scapolite-hornblende skarn, and, finally, andesine-hornblende amphibolite. Where the magma which provided the reconstituting thermal solutions came up along fractures in the amphibolite, coarse pegmatite has been emplaced, and between the amphibolite and the pegmatite is a zone of porphyritic gneiss, which apparently consists of an amphibolite matrix into which thermal solutions have moved, forming coarse microcline augen.

Amphibolite with somewhat analogous relationships are found in the Matamec Lake map-area. It is true that no limestone or true skarn is known to occur within the area, but, as already noted, there are pyroxene amphibolites which grade into hornblende amphibolites. Also, reference has been made to the fact that dykes and narrow zones of coarse, porphyritic granite gneiss are found cutting the amphibolites, and that, in such places, a gradational zone of

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(1) BUDDINGTON, A,F., Adirondack Igneous Rocks and their Metamorphism; Geol. Soc. Am., Memoir 7, 1939, p.13.

(2) OSBORNE, F.Fitz, Petrology of Shawinigan Falls Area; Geol. Soc. Am., Bull., Vol.47, Pt.A, 1936, pp.197-228.

(3) BUDDINGTON, A.F., oral communication.

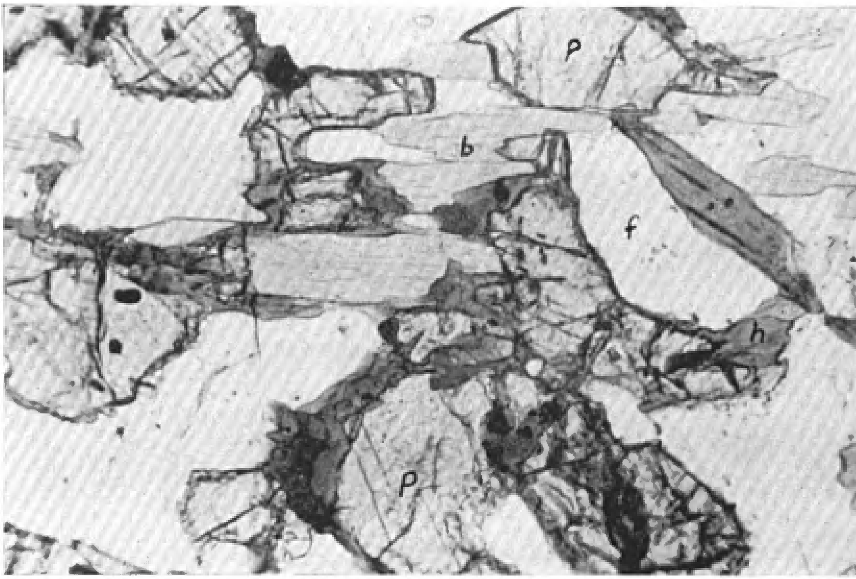
(4) ADAMS, F.D., and BARLOW, A.E., Haliburton and Bancroft Areas; Geol. Surv. Can., Mem. 6, 1910, p.104.

(5) BARTH, T., Zur Genesis der Pegmatite im Osgebirge; Chemie der Erde, 1928, pp.96-136.

A.—Grenville gneisses of "Laurentian foreland" in foreground, with Champlain sands and gravels forming horizon in background, at Matamek Factory.

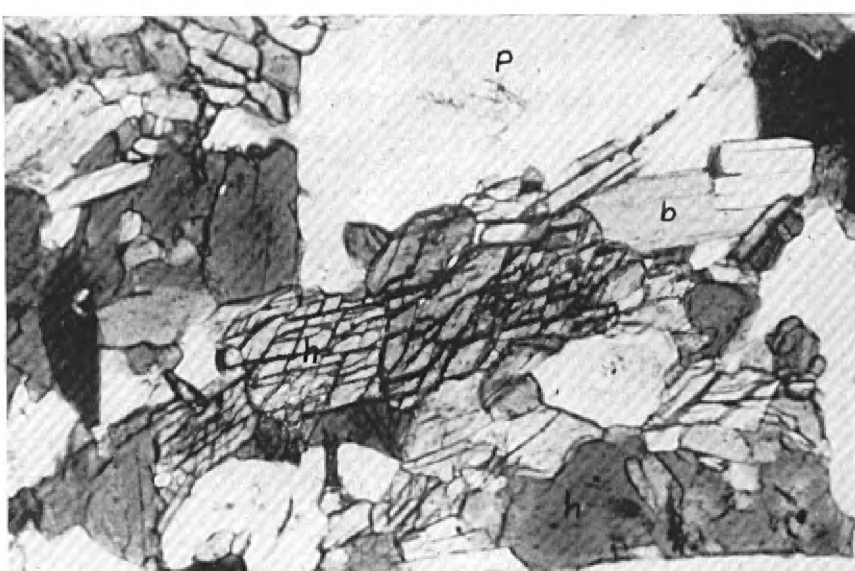
B.—Front of Laurentian plateau rising above Champlain sands in Matamec River valley at the outlet of Key lake.

C.—Thirty-foot chute one mile from mouth of Pigou river.



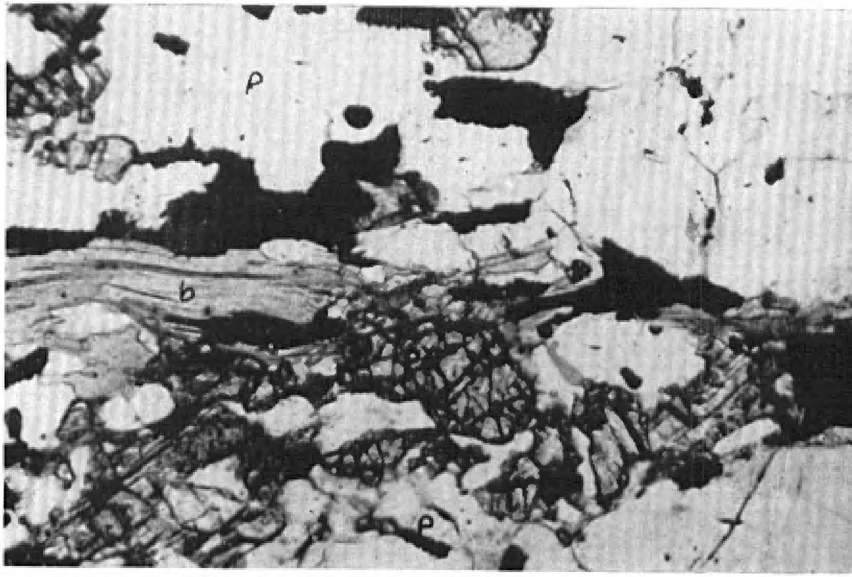
A.—Photomicrograph of pyroxene amphibolite.
Ordinary light. x 125

p = pyroxenite, b = biotite, h = hornblende, f = plagioclase



B.—Photomicrograph of hornblende amphibolite.
Ordinary light. x 125

h = hornblende, b = biotite, p = plagioclase.



A.—Photomicrograph of banded plagioclase-rich amphibolite.
Ordinary light. x 125

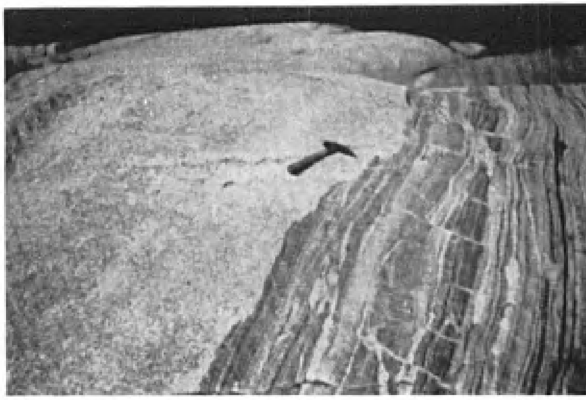
px = pyroxene, b = biotite, p = plagioclase, g = graphite.

B.—Photomicrograph of quartz-biotite-plagioclase gneiss.
Crossed Nicols. x 40

q = quartz, b = biotite, p = plagioclase.

A.—Injection gneiss, with small granite vein cutting across gneissic structure.

B.—Porphyritic gneiss.
a = amphibolite matrix, o = orthoclase or microcline phenocrysts, q = opalescent quartz "eyes".



A.—Coarse porphyritic granite gneiss cutting banded Grenville paragneiss; east side of Moisie bay.

B.—Blocky jointing in olivine gabbro; Matamec lake.

porphyritic gneiss (Plate V-B) usually occurs between the amphibolite and the porphyritic granite gneiss (Plate VI-A). However, the wide distribution and the uniform character of the amphibolites in the present area make it difficult to believe that they have originated in the manner suggested by Adams and Barlow and Barth.

Thus the problem of the origin of these rocks must remain unsettled until a wider regional study has been made and more data are available.

Post-Grenville Intrusives

Porphyritic Granite Gneiss

Distribution.-Within the area are several bodies of coarse porphyritic granite gneiss, similar to those described by Faessler(1) in the Moisie map-area immediately to the west. Some of this granite-gneiss is in a wedge-shaped mass of which the southwestern end occupies a one-mile stretch along the St-Lawrence shore, about two miles westerly from Point St-Charles. From this coastal section, the mass trends northeasterly, with a width of about half a mile, for a distance of two miles, beyond which it turns abruptly north and thins out to its northern tip, about four miles north of Point St-Charles. Another, larger, mass extends along the shoreline from Loups Marins river to Cormoran island varying in width from almost two and a half miles in the west to about three-quarters of a mile at Cormoran island. A band of porphyritic granite gneiss a mile and a half wide extends from the mouth of East Pigou river to the eastern edge of the area, and has a small westward extension on the west side of Pigou river. A fourth,and the largest, mass of porphyritic granite gneiss extends from a point just west of Larochelle lake to the eastern boundary of the map-area - a distance of seven miles - and it continues for an unknown distance beyond this boundary. It is three and a half miles wide in its western part, where it stretches northward from Pontois and Noirolle lakes; it narrows eastward until it is only half a mile wide just east of Pigou river, but it widens again to two and a half miles at the eastern edge of the map-area.

Previous reference has been made to the narrow dykes and bands of coarse porphyritic granite gneiss which cut the Grenville series and are particularly abundant in the areas underlain by amphibolite.

Petrography.-The porphyritic granite gneiss is a coarse-grained rock, pink to reddish in colour. The porphyroblasts (2) vary from a quarter of an inch to one inch in diameter, and they generally have a rude alignment, to which the rock owes its gneissoid structure. Locally, however, they are absent, and the rock is a very coarse granite. The porphyroblasts, which form the predominant mineral in the rock, may be either orthoclase or microcline. The interstitial material is mainly quartz and an oligoclase plagioclase, but some orthoclase may be present, either as small blebs in the quartz or as a patchy replacement of oligoclase, forming antiperthite. Occasionally, quartz occurs in the rock as small, opalescent, blue 'eyes', but these are more common in the gradational zone of porphyritic gneiss (Plate V-B), formed between amphibolite and porphyritic granite gneiss. Dark minerals are present in very minor amount. They are green hornblende and secondary biotite, the latter partially or completely replacing hornblende. Dactylitic growths of biotite around the hornblende are fairly common. In some of the thin sections examined, the hornblende has been broken down

(1) FAESSLER, Carl, Que. Dept. Mines, Geol. Rept. No.21, 1945.

(2) Porphyroblasts - crystals resembling the phenocrysts of a porphyritic igneous rock, but formed by recrystallization.

to a granular aggregate of green amphibole and quartz grains. This texture is evidently due to shearing or granulation caused by movement in the material interstitial to the feldspar augens. Zircon and apatite, along with some magnetite, are invariably present as accessory minerals.

Structure.-Regional structures in the porphyritic granite gneiss, indicated by gneissoid foliation and alignment of porphyroblasts, are relatively simple. The elongated mass lying northwest of Point St-Charles shows banding dipping consistently northwestward at an angle of about 75 degrees. In the coarse granite gneiss which extends along the St-Lawrence from Loups Marins river to Cormoran island, the banding is generally vertical and strikes northeast to due east. In the western part of this mass, foliation is not so obvious, and the rock is really an augen granite. The mass which crosses Pigou river just above its junction with East Pigou river forms a shallow northward-dipping sheet with dips varying between 10 and 50 degrees northward. The sheet curves northwestward at its western end, and northeastward toward the eastern edge of the map-area. The coarse granite gneiss lying north of Noirolle lake between Loups Marins river and Pigou river shows banding dipping at a fairly low angle outward under the surrounding Grenville gneisses on all except its south side, where northward dips were found (there are, however, some southern, outward dips in the southern part of this mass about half a mile north of its southern margin). In general, the mass indicates a structural dome. Structures in the extension of the mass on the east side of Pigou river are more complex.

The porphyritic granite gneiss in several places clearly cuts rocks of the Grenville series (Plate VI-A). In other places, however, the contact, instead of being sharply defined, is gradational.

Anorthosite

Distribution.-A body of anorthosite occupies about thirty square miles in the western part of the area. It has an oval shape, elongated northward, in which direction it extends from a point two miles up Matamec river from its mouth to a point one mile southwest of Méchant lake, a distance of about nine miles. It attains its maximum width - about four miles - at the south end of Matamec lake. It forms the western shore of this lake and from there extends to within one or two miles of the western limit of the map-area.

Petrography.-The typical rock consists of plagioclase with 5 to 10 per cent of dark minerals. Locally, there are gradations to gabbroic types on the one hand, and to an almost pure plagioclase rock on the other. The rock is generally light grey in colour, the shade depending on the percentage of mafics present. Grain size varies from coarse to medium, and some individual feldspar crystals over a foot in length were observed. Zones within the mass show extreme granulation and shearing, and most thin sections of the rock show some mortar structure.

The plagioclase is of fairly uniform composition, averaging $An_{48.5}$ in the mass as a whole and An_{44} in the eastern border facies (see Figure 1). The anorthosite is thus of the general Adirondack type (1), similar in composition to the St-Regis-Marcy mass, in which the plagioclase averages An_{45}. The rare anomalies noted in

(1) BUDDINGTON, A.F., Adirondack Igneous Rocks and their Metamorphism; Geol. Soc. Am., Memoir 7, 1939, p.31.

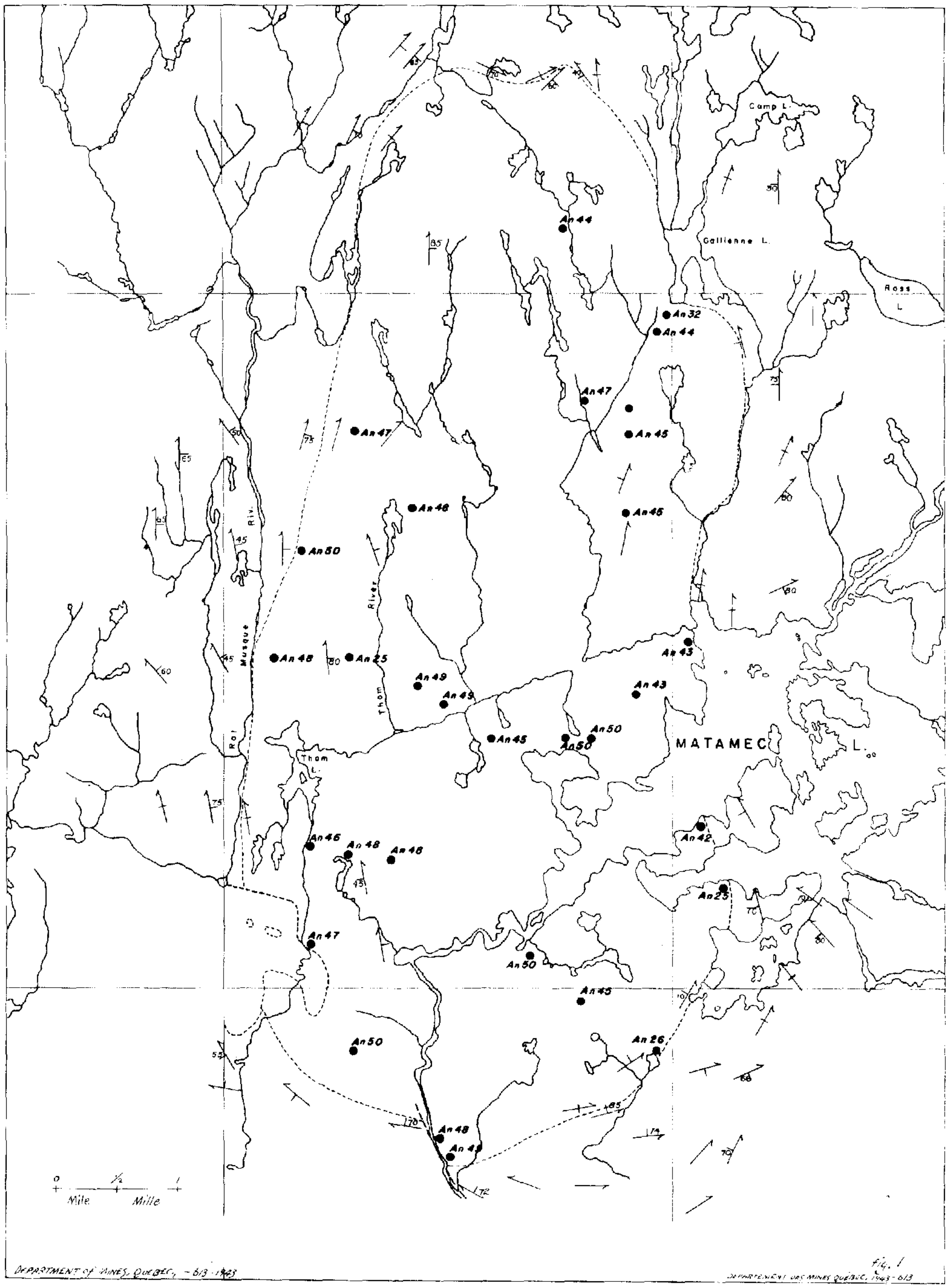


Figure 1.-Matamec Lake anorthosite, showing structure and variations in composition of the plagioclase.

the composition of the plagioclase (An_{25} in two or three determinations) are interpreted as due to alteration by invading granitic solutions, related to nearby pegmatites.

The associated mafic minerals are primary augite and some hypersthene. In one thin section, hypersthene containing broad laths of exsolved augite was noted. Generally, the primary pyroxenes have been altered to green pleochroic hornblende, containing an occasional pyroxene remnant. A little biotite may be present. In the anorthosite showing mortar structure, interstitial granular aggregates of hornblende, biotite, and quartz are common.

Accessory minerals are apatite, zircon (rare), ilmenite, and, in very minor amount, pyrite and chalcopyrite.

Scapolitization of the plagioclase is common in altered zones, and saussuritization, with the development of calcite, sericite, and clinozoisite, was noted in some of the thin sections examined. Where strong shearing has been effective, causing a gneissoid foliation, the rock is granulated, but still contains a few remnant plagioclase crystals. Such a zone occurs in a north-south direction about one mile east of the western margin of the mass. The rock contains minor amounts of garnet, sphene, and titaniferous magnetite.

<u>Field and Structural Relationships</u>.-The margin of the anorthosite mass is in general smooth and regular, and, except at two places, the adjacent rock is Grenville paragneiss. For a short distance along the western contact it is fine-grained granite and, although the actual contact was not observed, it is believed that the granite is the younger and that it intruded the anorthosite. Similarly, two small outcrops of granite occur on the south side of Gallienne lake, on the northeast side of the anorthosite body but not actually in contact with it. They are too small to be shown on the accompanying map. Where the contact with the Grenville gneiss has been observed, the anorthosite over a narrow zone adjacent to the contact contains inclusions of the gneiss. Thus, along the eastern contact, north of Matamec lake, blocks and fragments of Grenville paragneiss and quartzite are common in the anorthosite. Where the contact crosses Philippe and Chisholm bays in Matamec lake, Grenville rocks and anorthosite form a zone of alternating bands.

For a width of about half a mile adjacent to the anorthosite, the Grenville rocks are characterized by a banding that parallels the contact. This banding either has a vertical attitude or dips steeply toward the intrusive mass. Within the anorthosite itself, the gneissic banding dips toward the centre of the mass. This would seem to indicate that it was intruded as a steeply dipping body - not a lopolith.

Study of the composition of the plagioclase (see Figure 1) indicates that the anorthosite mass is not of uniform composition throughout. For a zone about a mile wide adjacent to its eastern margin, the rock is more sodic (and hence more acidic) than in the central and western part. To the writer, this suggests that some differentiation has taken place after the mass was intruded. Thus, although the banding in both the anorthosite and the adjoining country rock appears to have been produced by the intrusion of a steeply dipping body, differentiation, on the other hand, suggests the possibility of a flat-lying body, later tilted with the top, more sodic, facies toward the east. There is no indication that the anorthosite is itself a differentiate of a magma of more basic composition. It appears to have been intruded as an anorthosite magma, or perhaps as a mush of plagioclase crystals, as indicated by mortar structure in many places, although in a few of the sections examined no evidence of such granulation was seen.

Block structure - that is, inclusions of anorthosite in anorthosite or gabbroic anorthosite - has been noted by Mawdsley (1) in the St-Urbain anorthosites, and by many other observers in the Adirondack anorthosites. This structure was not observed by the writer in the anorthosite in the present area.

Olivine Gabbro

Distribution.-Two bodies of olivine gabbro occur in the area. The larger of these extends northward for some six and a half miles from the south shore of La Croix lake. At the south, it has a width of four milès, from the islands in Matamec lake to about one mile east of La Croix lake. Flanking both sides of Matamec river, it continues northward with diminishing width and finally wedges out at a point about one mile north of the mouth of Tchinicaman river. It has an outcrop area of approximately sixteen square miles.

The second mass is at the eastern boundary of the area, beyond which it extends for an unknown distance. Here, some eight miles north of the St-Lawrence, the gabbro outcrops over an area about one mile north-south and three-quarters of a mile east-west.

Petrography.-The typical olivine gabbro is a coarse to medium grained equigranular rock. It is generally dark in colour, with a characteristic purplish tinge, this being the colour of the plagioclase it contains. Outcrops of the rock show differential weathering, with the plagioclase standing in relief. In thin section, the rock is seen to have an ophitic texture. Plagioclase, with olivine and interstitial bronzite and augite, form the essential minerals. Accessory minerals are apatite, which may be present as large crystals, magnetite, and some pyrite.

Twenty-one determinations of the plagioclase by the single variation method showed a range in composition from $An_{52.5}$ to $An_{71.5}$, with most of it falling within the range An_{64} to An_{68}.

Secondary or deuteric effects, similar to those described by Brogger (2) for the olivine hyperites of Norway, are characteristic. Coronas or reaction rims have developed around the olivine grains. They consist of two well-defined rings, the inner one of fibrous to tabular hypersthene, the outer one a vermicular intergrowth of hornblende, or augite, and plagioclase, with the percentage of mafic mineral decreasing toward the outer rim. The intergrowth was too fine grained to make accurate determinations. Brogger (3) states that such coronas form through a simple reaction between olivine and plagioclase, the hypersthene forming in the olivine, and the intergrowth in the plagioclase. In support of this, it has been noted that, where bronzite is in contact with olivine, there is generally no corona, or it is represented only by the inner hypersthene ring. Magnetite and bronzite grains are often surrounded by a narrow hornblende corona.

Where shearing has occurred, the gabbro is considerably altered. In one occurrence, where shearing has been particularly

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(1) MAWDSLEY, J.B., St.Urbain Area, Charlevoix District, P.Q.; Geol. Surv. Can., Mem. 152, 1927, p.28.

(2) BROGGER, W.C., On Several Archaean Rocks from the South Coast of Norway; Norske Videnskaps, Akad. 1, Oslo, 1935, Pt. II, pp.24-37.

(3) Op. cit., p.31.

severe, the rock was observed to be highly schistose, with segregation of the light and dark minerals. The plagioclase is saussuritized with development of epidote, some zoisite or clinozoisite, chlorite, and sericite. Magnetite grains form small lenses paralleling the schistosity, and the olivine and bronzite have been entirely replaced by coarse aggregates of hornblende grains. In other places, where shearing has not been so intense, the plagioclase shows only a slight development of mortar structure, but the olivine and bronzite have been altered to green hornblende, with a few scattered grains of magnetite.

Field and Structural Relationships.-The olivine gabbro exhibits neither primary nor secondary foliation. This, and the scarcity of outcrops in the eastern and northern parts of the larger mass, has made any interpretation of its structural form difficult. Secondary foliation in the Grenville gneisses surrounding the intrusive is parallel to the gabbro contact for the most part; it dips steeply away from the west contact, but is ill-defined on the east contact. The general shape of the mass suggests a great anticlinal sill, plunging steeply to the southwest. Faulting has complicated the picture considerably in the vicinity of La Croix lake. The gabbro cuts Grenville rocks and is cut by granite. Its age relationship to the porphyritic granite gneiss is not known, no contacts with this rock having been seen. Similarly, in the case of the small gabbro mass near the eastern boundary of the area, no contacts were seen with the porphyritic granite lying to the south of it.

A feature of outcrops of the olivine gabbro is a well developed blocky jointing (see Plate VI-B).

Mica Diorite

Distribution.-There are two bodies of mica diorite, with small associated more acidic facies, in the map-area.

One mass outcrops northeast of Moisie bay, its southwestern margin being about half a mile from the shoreline. It has a nearly circular form and a diameter of about three miles. The second mass, a long, narrow, dyke-like intrusion trending in a north-south direction, lies from a quarter of a mile to one mile east of Loups Marins river in the northern part of the area. The northern end of this body is about half a mile east of Claveau lake and from there it extends southward for about five miles, with a width varying from three-quarters to less than one-quarter of a mile. Its boundaries are only approximately known, partly due to the presence of drift and partly to lack of opportunity to reach this contact zone in as many places as might be desired.

Petrography.-The mica diorite is a light brown to grey rock with visible black biotite flakes. The plagioclase often has a greasy lustre. The rock is medium to fine grained, with a granitic texture. Essential minerals are plagioclase, orthoclase, biotite, orthorhombic and monoclinic pyroxene, and hornblende. The plagioclase in the typical diorite is subhedral, generally in coarser grains than the other minerals, and it may show strong zoning. It is calcic oligoclase, with composition An_{25} to An_{30}, the borders of the grains being slightly more sodic than the interior. Toward the centre of the mass, also, the plagioclase becomes more sodic - an acid oligoclase - than in the marginal rock, and at the same time the percentage of pyroxene decreases very appreciably. Orthoclase is never abundant. In some of the coarser facies of the rock, replacement antiperthite rims surround grains of plagioclase. Except at the margin of the mass, biotite is the predominant dark mineral. It sometimes forms a dactylitic growth around quartz-chlorite-sericite aggregates. The pyroxenes are hypersthene and purplish augite or diopside.

Accessory minerals are apatite and magnetite, which may be titaniferous since leucoxene is present in some of the sections examined. Rutile and sphene occur as inclusions in plagioclase.

Although the more acidic facies of the rock met with toward the centre of the Moisie Bay mass have a lower than normal proportion of dark minerals, they do not contain a correspondingly higher percentage of potash feldspar. Oligoclase-plagioclase, perthite, and biotite are the essential minerals, and secondary chlorite is usually present. Evidently the potash has been introduced late, as some thin sections showed a complex replacement by orthoclase, and myrmekite (an intergrowth of quartz and plagioclase occurring in orthoclase, at the contact between orthoclase and plagioclase crystals) was very common in one section.

Field and Structural Relationships

The mica diorite bodies of the area intrude the Grenville complex and are themselves cut by pegmatite, which is likely a late differentiate of the younger granite. No intrusive relationships of the diorite with other rocks were found in this area.

The dyke-like body of diorite east of Loups Marins river appears in part conformable and in part transgressive to the scant gneissic foliation in the surrounding amphibolite.

The mass north of Moisie bay is worthy of particular mention because of its clear-cut form (see Plate I). The tracing, which has been made to superimpose on the aerial photograph, shows well the outline of the intrusive, its distinctive radial jointing, and the marked conformity of the gneissic banding in the adjacent country rock. These features are in part traced from the photograph and in part based on field observations. In general, the diorite is massive, so that any hypothesis concerning the form or nature of the mass must be based on the gneissic banding in the surrounding country rock. Except on the northwest side of the mass, these bands have a vertical attitude or dip steeply beneath the intrusive; on the northwest side, they dip steeply away from it. Taken as a whole, the intrusive has the form of a plug. The dips suggest that its centre pitches northwest, but the off-centre position of the radial jointing (see tracing) further suggests that a portion of the plug on the northwest side is still buried by a Grenville cover. A more detailed study would undoubtedly give a more accurate picture of its true form.

As already mentioned, in some of its facies the rock is more acidic than a normal mica diorite. In the mass northeast of Moisie bay, such facies were observed toward the centre of the plug. Field evidence suggests that they are gradational, and no attempt was made to map them separately.

Within or adjacent to the northeastern part of the diorite mass southeast of Claveau lake are some small outcrops of granite. These, however, may possibly represent a separate intrusion rather than a facies of the diorite.

Granite and Granite Gneiss

Distribution.-Bodies of granite and granite gneiss, easily distinguished from the augen granite by the relative fineness of their grain, occur in several parts of the area. They are difficult to delimit because of the complex manner in which they have invaded the more fissile varieties of country rock, particularly the paragneisses. As a consequence, areas shown on the map, as occupied by granite (or granite gneiss) may include patches and bands of injected gneiss or augen gneiss.

One body of the granite or granite gneiss outcrops along the west side of Rats Musqués river eight to eleven miles north of the St-Lawrence shore. A sheet-like mass intrudes the folded paragneiss two miles farther north, or about three miles west of Méchant lake. A third mass lies in the area between the bodies of anorthosite and olivine-gabbro and extends from a point a mile and a half north of Matamec lake to about three-quarters of a mile north of Ross lake. An eastward extension of this body probably crosses Matamec river to join with a fourth and larger mass lying between Matamec and Loups Marins rivers, east and northeast of the olivine gabbro. Outcrops are scarce in this part of the map-area, but it appears that this fourth mass is of irregular outline and that it extends from the northeast side of La Croix lake to the vicinity of Claveau lake. A fifth, and the largest, of these intrusive bodies outcrops in the southeastern part of the area, extending from a point two and a half miles west of Loups Marins river to and beyond the eastern border of the map-area. Its southern margin lies from a quarter of a mile to two miles north of the St-Lawrence shore. It has a maximum width of about five miles in a north-south direction, but, east of Pigou river, it is split into two separate bodies by a long, wedge-shaped mass of porphyritic granite (augen) gneiss. A narrow band of granite, probably once forming part of this body but now separated from it also by augen gneiss, follows along or near the St-Lawrence shore from a point two miles west to a point one mile east of the mouth of Pigou river.

Petrography.-These granites and granite gneisses are fine to medium grained rocks, generally pink to light grey, but varieties near the mouth of Pigou river are often reddish due to numerous inclusions of red iron oxide in the plagioclase.

The essential minerals are quartz, orthoclase or microcline (or both of these), oligoclase-plagioclase (An_{10} to An_{25}), and biotite. Hornblende may be present as a minor constituent as also may be chlorite, probably formed by late hydrothermal alteration. Perthite was noted in a few thin sections. Accessory minerals are apatite, sphene, and magnetite, the last including titaniferous varieties. A few grains of zircon were seen in some of the thin sections studied, and tourmaline was noted in one section and garnet in another.

Secondary minerals include chlorite, some scapolite, sericite, muscovite, calcite, and, rarely, epidote and leucoxene.

Field and Structural Relationships.-These granitic rocks have been found cutting every major rock type in the area, with the exception of the anorthosite and mica diorite. However, pegmatite dykes which must belong to a late stage of their intrusion are found cutting both these rocks. Thus there seems little doubt that they are the youngest major intrusive rocks in the area.

Wherever the granite has invaded Grenville paragneisses, injection gneisses have been formed within the latter adjacent to the contact. Contacts in such cases are generally difficult to delimit, but usually they parallel the banding in the country rock. This statement applies particularly to the smaller intrusives, which are in general sheet-like intrusions, in part conformable and in part transgressive to the planes of banding of the Grenville gneisses. The western portion of the large mass of granite lying in the southeastern part of the map-area is a homogeneous granite, but the northern border zone of this mass is composed of a fine-grained granite gneiss. In the southernmost eastward prolongation of this mass, fresh homogeneous granite is found in narrow bands alternating with and cutting fine-grained granite gneiss. This granite gneiss may possibly be granitized Grenville paragneiss, or there may have been more than one intrusion of granite. Whatever its origin, it has the same composition as the granite.

Granite is found cutting olivine gabbro, particularly northeast of La Croix lake. Joint blocks of the gabbro are abundant in the granite along the contact zone. Small granite intrusions in the gabbro at the junction of the 'cross' in La Croix lake have not been shown on the map.

Pegmatite and Granite Dykes

Pegmatite and related granite dykes cut all the previously mentioned rock types. They are widespread throughout the whole map-area. The granite dykes, which are of the same texture and composition as the granites just described, are probably more common than the pegmatites in the amphibolites of the northern part of the area.

The greatest concentration of pegmatite dykes is along the shore of the St-Lawrence, in the stretch between the mouth of Loups Marins river and a point about two miles west of Point St-Charles. Individually, these dykes exhibit much variation in trend, although some parallel the strike of the gneisses they intrude. They range in width from a few inches to one hundred feet or more. Exposures were best seen along the shore for a mile and a half west from Point St-Charles, but none was traced any appreciable distance along its strike because of swamps and vegetation back from the shore.

The pegmatites, which are commonly in vuggy dykes, vary from pink medium-grained types to coarse-grained rocks with occasional orthoclase crystals up to a foot in length. The rock consists of quartz, orthoclase, albite, biotite, and muscovite. The biotite forms 'books' up to one inch or more in diameter and up to one-eighth of an inch thick. Quartz and orthoclase may form graphic intergrowths. In some specimens, small specks of a dark brown to black radioactive mineral with brownish haloes extending out into the surrounding silicates were noted. In places, these dykes are traversed by vein-like zones of pegmatite much richer in plagioclase than the normal pegmatite. Pyrite was observed along some of these zones.

It is believed that these dyke rocks represent a late residual phase of the younger granite magma.

Lamprophyre Dykes

A few lamprophyre dykes were found cutting the augen granite gneiss and the younger granite along the St-Lawrence near the mouth of Pigou river, and again at the 30-foot chute a mile up the river.

The lamprophyre is a 'malchite' according to Grout's (1) classification. It consists of essential andesine-plagioclase, common hornblende, and abundant dark, pleochroic biotite. Accessory minerals are apatite, magnetite, and sphene, the last named very abundant in one of the thin sections examined.

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(1) GROUT, F.F., Petrography and Petrology; McGraw-Hill Inc., 1932, p.122.

Grout (op. cit., p.121) considers lamprophyre and pegmatite dykes to be complementary. At numerous localities in the area, both types were seen cutting the granite, but nowhere were they observed cutting each other. It is also noteworthy that they invariably follow the schistosity in the country rock and are themselves schistose. Therefore it seems likely that they were intruded while their host-rock was still plastic and under conditions of stress.

Keweenawan (?)

Diabase Dykes

Diabase dykes occur in all parts of the area and were seen cutting all other rock types, including the lamprophyres. They are closely similar to, and are here tentatively correlated with, certain diabase dykes that, in other parts of the Precambrian shield, are considered to be of Keweenawan age. Where these dykes cut lamprophyre dykes, they strike at right angles to the latter and thus also to the trend of the banding or schistosity in the country rocks. They have comparatively flat dips and apparently forced their way along late tension fractures after the host-rock had cooled. Whether or not this is a regional characteristic is not known. The dykes rarely exceed twenty-five feet in width; most of them are only about five feet wide. Because of their narrowness, none was traced far along its strike and, consequently, they are not shown on the accompanying map.

The diabase is a dense, fine-grained rock. It consists essentially of small, closely spaced calcic-andesine plagioclase laths in a sub-microscopic groundmass in which biotite and magnetite are visible. A few grains of a green mineral, which may be aegirine-augite or hedenbergite, were noted. Accessary apatite is sparingly present.

Summary of Age Relationships of the Igneous Rocks

The sequence of intrusion of igneous rocks in this area has not been wholly established. The porphyritic granite gneiss is placed as the oldest of the intrusive rocks. It is known to be older than the other granites; but its age relationship with the anorthosite, olivine gabbro, and mica diorite is unknown. A similar granite gneiss in the adjoining area to the west is considered by Faessler (1) to be the oldest intrusive rock in that area. Also, in the 'Laurentian' of southwestern Quebec, the oldest intrusive rock is a granite gneiss.

The younger fine-grained granite is known to cut olivine gabbro, and pegmatites that are probably related to this granite cut anorthosite and mica diorite; but, unfortunately, the age relationships between the anorthosite, gabbro, and mica diorite are unknown. In other Laurentian areas, gabbro is known to cut anorthosite, but usually, where such is the case, it is closely related to, and gradational in composition with, the anorthosite. The gabbro in the present area, however, is an olivine type, and its plagioclase is much more basic than that of the anorthosite. Small dykes of a similar olivine gabbro cut anorthosite in the northwest Adirondacks, but no similar occurrences have so far been described in the Laurentian of Canada. Therefore, until further data are available, the sequence of these several intrusions as presented in the table of formations (p.8) must remain tentative.

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(1) FAESSLER, Carl, Moisie Area; Que. Dept. Mines, Geol. Rept. No.21, 1945.

Within the younger granites there is evidence of more than one period of intrusion, but no attempt was made to map separate units.

Pleistocene and Recent

Unconsolidated deposits of sand and gravel, formed when the Champlain sea covered part of the Matamec Lake map-area, are found as isolated patches. The two largest of these are in the southwestern part of the map-area. Sand plains stretch westward from Matamec river along Moisie bay beyond the limit of the map-area to Moisie river, a distance of seven miles, and northward for a distance of one and a half to three miles to the lower part of the Rats Musqués river. Another, smaller stretch of sand plain lies about a mile southwest of Thom lake. Here, old beach levels may be seen, leaving no doubt that the deposits are of marine origin. The valley of the upper Matamec river, from Matamec lake to Key lake, is also underlain by sand and gravel deposits. In some of the river cuts these show coarse cross-bedding, and it seems likely that they, too, are of marine origin, deposited when a long arm of the Champlain sea extended as far north as Key lake. Less extensive sand and gravel deposits occur locally in the valleys of Loups Marins river and Pigou river. Those near-shore, at least, were deposited from the Champlain sea, but it is impossible to tell whether those found in the upper reaches of these two rivers are late Pleistocene deposits or are Recent deposits. The Champlain sea must have extended over most of the southern half of the map-area, but, after uplift, erosion has apparently removed most of the deposits. A few dissected remnants are still left in the area south of Matamec and La Croix lakes.

Although the Pleistocene ice sheet moved southward over the whole area, it has left behind very little morainal material, and in most of the area, where the bed-rock is not exposed, there is usually a covering only of decayed vegetation for a thickness of a foot or so. Locally, however, there are some glacial deposits. Between Matamec river and Loups Marins river, from Claveau lake on the north to Cliff lake on the south, ground moraine of varying thickness covers the region, and here outcrops of bed-rock are sparse and widely separated. About three miles southeast of Claveau lake, there is a small area covered by low, parallel, sandy ridges which may be drumlins. The sand ridges have a local relief of not more than ten feet and are in a low area, with higher bed-rock ridges outcropping to the east and west. These drumlin-like sand ridges have a general trend of S.20°W.

Glacial striae were not found inland, probably because most of the exposures in the interior are cliff faces or are small and partly covered. But glacial striae and grooves may be seen at many places in the bare outcrops along the St-Lawrence shore between Matamec river and Point St-Charles. In the vicinity of Matamec their trend varies between due south and S.10°W., and toward Point St-Charles it is between S.18°W. and S.30°W.

STRUCTURE

Local structure of the Grenville rocks and of the several bodies of intrusive rock have been discussed on earlier pages.

The amphibolites are the least intruded members of the Grenville series, and they might be expected to give an indication of any regional structural trend, but while, in the northern and western parts of the map-area, they have a north-northwest gneissic foliation which is fairly consistent, in the eastern part of the amphibolite belt there is a sharp departure to a general east-west trend, with no apparent relation to the northerly foliation. In other parts of the map-area, the many local intrusions have induced local structures in the surrounding Grenville host-rocks, thus rendering impossible any generalization on the nature of any regional structures that might ever have prevailed there.

Faulting

Faulting has probably been most pronounced in the vicinity of Matamec and La Croix lakes. At the mouth of the bay at the northwest end of Matamec lake, the eastern margin of the anorthosite mass seems to be displaced at least 500 feet eastward along the south side of an east-west fault. The remarkably straight valley which crosses the anorthosite mass and trends westward from this point to Thom lake is probably a continuation of this fault zone.

There may be a fault trending S.25°E. just west of and paralleling that part of Matamec river which has a straight course in this same direction about two miles north of the St-Lawrence. There appears to be a displacement of the formations here, with those on the east side of the possible fault having moved southeast in relation to those on the west side.

The cross-shaped character which gives its name to La Croix lake may be the result of north-south and east-west faults. That there may be a north-south fault is indicated by disruptions in the bands of Grenville rocks which are included in the olivine-gabbro along the west side of the lake. Evidence of east-west faults is offered by a strong shear zone trending in that direction on the southwest side of the junction of the north-south and east-west arms of the lake, and again by two shear zones trending N.85°W. and crossing the lake 3,500 feet and one mile, respectively, south of the cross-arm. Again, a complicated shear-zone contact between the south end of the gabbro and the Grenville gneisses near the south end of the lake is suggestive of another easterly trending fault zone.

A number of small faults have been assumed along the porphyritic granite-younger granite contact between Loups Marins and Pigou rivers, about two miles north of the gulf of St-Lawrence. The faults have been assumed because of the obvious displacement of the contact as encountered along adjacent traverse lines, while the strike of the foliation remains consistently east-west.

Jointing

A glance at the drainage system of the map-area will show that it is controlled largely by two very pronounced systems of jointing. One system has a slightly west-of-north direction, and is best expressed by the valley of Loups Marins river. The other system has a northeast trend, which swings north to north-northwest about four miles south of the northern limit of the map-area. These regional jointing systems have probably been accompanied by some faulting, although no definite evidence of such was found. The recognized shear zones in the area have no directional relation to the joint systems. Neither the faulting nor the regional jointing has been dated, except as being post-younger-granite.

ECONOMIC GEOLOGY

The Matamec Lake map-area and adjacent areas along the north shore of the gulf of St-Lawrence are as yet virtually unprospected. Within the Matamec Lake map-area itself no metallic deposits of economic importance were discovered during the course of the field work, although some sulphide mineralization was noted in shear zones. Some of the non-metallics, however, such as feldspar and building stone, are of possible future economic interest.

A few specks of molybdenite were seen in narrow (one-quarter-inch) quartz stringers which traverse coarse porphyritic granite at a point a third of a mile west of Pigou river and a mile and a quarter north of the mouth of the East Pigou branch. The occurrence is of mineralogical interest only.

Sulphide mineralization was noted in shear zones within anorthosite and olivine gabbro, Grenville gneisses, and granite, and polished sections of specimens from several localities were studied. One of these, from a shear zone in, and near the western border of, the olivine gabbro, exposed for ten feet along a southward flowing creek about three-quarters of a mile west of the mouth of Tchinicaman river, was found to contain pyrrhotite (iron sulphide), pentlandite (iron-nickel sulphide), and chalcopyrite (copper-iron sulphide). These sulphides, together with pyrite and a little secondary marcasite, and also some ilmenite, all scattered through a groundmass of silicate minerals, were seen also in polished sections of specimens from a shear zone in olivine gabbro which is exposed over a width of four to five feet on the northeast side of Matamec lake, about 3,400 feet southeast of where Matamec river enters the lake; and from a similar zone, about twenty feet wide and fifty feet long, in anorthosite exposed on the west side of Thom river at a point half a mile south of Thom lake. A coarse pegmatitic anorthosite at the contact of anorthosite and Grenville gneisses on the south side of Matamec lake contains small scattered blebs of chalcopyrite and pyrrhotite in the plagioclase, and is cut by a narrow (half-inch) vein of ilmenite.

The sulphides do not make up more than one per cent of the rock in any of the polished sections studied, but it is possible that further work along such shear zones would uncover material of ore grade.

Some of the pegmatite dykes within the area are of possible economic importance as a source of feldspar. These dykes are especially numerous along the St-Lawrence from Point St-Charles westward for nearly a mile and a half and for about a mile north from the shoreline. The granite pegmatites are composed chiefly of quartz and potash feldspar, which in some of the dykes are in graphic intergrowth. The dykes range in width from a few feet up to 50 feet (rarely 100 feet), but none was traced for more than 300 feet along the strike, since inland from the shore they are covered by vegetation. The average grain size is half an inch or less, but occasional feldspar crystals are a foot or more in length. Cutting the main pegmatite dykes and forming about 5 per cent of the whole are stringers and narrow dykes, up to two feet in width, of pegmatite of more complex composition which, in addition to quartz and orthoclase, contain appreciable amounts of albite and muscovite. No rare minerals were found in any of the pegmatites, but, as already mentioned, small specks of a brown radioactive mineral were seen in some specimens. If these pegmatites are ever of commercial value, it will likely be primarily as a source of potash feldspar.

The anorthosite and olivine gabbro have possibilities for use as building stone and decorative stone, respectively. The anorthosite in certain other localities in the Province has been, and is, used as a building stone, and also as monument stone, under the trade name of 'black granite'. Also, since these anorthosites consist almost entirely of feldspar, they might have a future use in crushed form as an abrasive. The olivine gabbro has an attractive purplish colour, which is rendered more conspicuous by polishing. It might well be used as an interior decorative stone, as similar rocks are in various parts of the world. The block jointing in the gabbro in the present area would facilitate quarrying operations.

ALPHABETICAL INDEX