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GEOLOGICAL REPORT 11

SEPT - ILES AREA

NORTH SHORE OF ST. LAWRENCE, SAGUENAY COUNTY

by

Carl Faessler

QUEBEC
RÉDEMPTI PARADIS
PRINTER TO HIS MAJESTY THE KING

1942

SEPT – ILES AREA

NORTH SHORE OF ST. LAWRENCE, SAGUENAY COUNTY

by Carl Faessler

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SEPT ILES AREA

NORTH SHORE OF ST. LAWRENCE, SAGUENAY COUNTY

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INTRODUCTION

General Statement

During the season of 1938, the writer mapped the geology of an area along the north shore of the Saint-Lawrence river, beginning at Godbout where he had stopped this work at the end of the 1933 season (1). The method of work adopted in 1938 differed from that employed in previous seasons. Traverses were run almost exclusively along the shore of the river and not into the interior except to places easily reached along certain water-courses. These latter traverses extended only 12 to 15 miles from the shore. This method of work made it possible to map the geology along almost 100 miles of the coast, from Godbout river on the west to Rapides river, chief affluent of Sept-Iles bay, on the east. In former years, when the interior was explored in some detail for a depth averaging ten miles, it was not possible to map more than about thirty miles of the coast each season.

Previous Work

In 1867, James Richardson (2) spent four months examining the north shore of the Saint-Lawrence from the mouth of the Saguenay to Sept-Iles, a distance of about 220 miles in a straight line; he also travelled up the Betsiamites (Bersimis) and Manicouagan rivers for 30 miles and 40 miles, respectively. Covering so much ground, his mapping of the geology was, of necessity, not at all detailed.

During the seasons of 1880 and 1881, Count H. de Puyjalon (3) explored the north shore of the Saint-Lawrence between Tadoussac and Paspebiac, the northeast boundary of Quebec province. This investigation was concerned almost solely with

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(1) FAESSLER, Carl, Geological Exploration on the North Shore, Manicouagan to Godbout; Que. Bur. Mines, Ann. Rept., Part D, 1933, pp.149-165.

(2) RICHARDSON, James, Geol. Surv. Can., Report of Progress, 1866-69, pp.305-311.

(3) DE PUYJALON, Comte H., Return to an address from the Legislative Assembly, dated 21st March, 1882, No.39, Quebec. See also Report on the Copper, Molybdenite, and Labradorite Deposits of the North Shore of the Gulf of St.Lawrence; Report of the Commissioner of Crown Lands, Que., Appendix No.57, 1883.

(*) Translated from French.

the search for deposits of economic minerals. About this time, also, the section of the coast between Saguenay and Ste-Marguerite point was examined by Obalski (1).

In 1911 and 1912, P.E. Dulieux (2) visited almost all the known occurrences of iron ore in the Province of Quebec. His report includes complete data relating to the deposits of titaniferous iron ore of the Sept-Iles region.

Location of Map-Area

The village of Godbout, on the east bank of the river of the same name, is about 250 miles down the Saint-Lawrence from Quebec city. The north shore of the Saint-Lawrence here follows an east-west direction, but nine miles farther down-stream, at Pointe-des-Monts, it turns toward the north and the river widens rapidly at this place. Not until Sept-Iles is reached does the shore resume its east-west trend. The width of the river at Godbout is about 32 miles (distance from Godbout to Matane); at Pointe-des-Monts it is 28 miles; and, at Sept-Iles, the nearest point on the south shore is about 70 miles away.

The east and west sides of the map-area coincide approximately with the 66°30' and 67°30' meridians. The 50th parallel of north latitude crosses the area.

Population

This hundred-mile section of the north shore is relatively well populated, with about 4,000 permanent inhabitants. In addition, some 2,000 men are employed in lumber camps during the winter months. The following table lists the villages of the area with their population and the chief occupation of the people; some of these settlements are the largest and oldest along the north shore.

Name of Village	Population	Occupation of People
Godbout	300 people	Pulpwood industry
Pointe-des-Monts	3 families	Lighthouse and farming
Baie-Trinité	50 "	Pulpwood industry
Caribou Islands	22 "	Fishing and farming
Pointe-aux-Anglais	25 "	Farming and fishing

(1) OBALSKI, J., Report of an Exploration on the North Coast, from Saguenay to "La Pointe Ste. Marguerite"; Report of the Commissioner of Crown Lands, Que., Appendix No. 50, 1883.

(2) DULIEUX, P.E., Les minerais de fer de la Province de Québec. Gisements et utilisation; Dept. of Colonization, Mines and Fisheries, Quebec, 1915.

Name of Village	Population	Occupation of People
Pentecôte	450 people	Pulpwood industry (camps and fishing closed)
Isles-de-Mai	1 family	Lighthouse
Shelter Bay	200 families	Pulpwood industry
Ste-Marguerite	12 "	Fishing and farming
Sept-Iles	120 "	Fishing, farming, and hunting
ISLANDS:		
Ile-aux-Oeufs	1 family	Lighthouse, telegraph office; post-office
Ile-du-Grand-Caouis	1 family	Lighthouse
Ile-du-Petit-Carrousel	1 "	Lighthouse

There is only one village in the interior of the area - Clarke City, about four miles north of Ste-Marguerite on the bank of the river of the same name. It is connected to the Clarke City warf in Sept-Iles bay by a railway nine miles long. Clarke City has a population of about 500.

Timber Industry

Following are the names of pulp and paper companies and the places at which their activities are centred in the map-area.

St. Regis Paper Company, Godbout;
St. Lawrence Paper Company, Baie Trinité;
International Paper Company, Pentecôte;
Quebec North Shore Paper Company (formerly the Ontario Paper Company), Shelter Bay;
Gulf Pulp and Paper Company, Clarke City.

All these companies ship their pulpwood in 4-foot longs, with the exception of the Gulf Pulp and Paper Company, which converts the wood to pulp in its mill at Clarke City. The new mill of the Quebec North Shore Paper Company (formerly the Ontario Paper Company) at Baie Comeau, where newsprint is made, is twenty miles above Godbout, outside the map-area.

All the easily accessible stands of timber along the large rivers of the region are already leased to these various companies. There remains, none the less, much good timber along the smaller streams, such as Petite Trinité, Calumet, and others. The chief species of trees in the region as a whole are spruce and balsam fir. The wide, swampy areas of the Champlain plain in general support no forest growth.

Fishing and Hunting

Fishing for salmon, halibut, mackerel, cod, and herring is carried on a large scale in certain favourable localities.

The village of Sept-Iles is the centre of the fishing industry. There was formerly a plant near the Clarke City wharf at Sept-Iles bay for utilizing waste material from fish, but it was destroyed by fire. Along those rivers that salmon ascend from the Saint-Lawrence are private fishing clubs, such as those on Godbout, Petite Trinité, and des Ra-

pides rivers. There are almost no Indians in the area, and only few of the inhabitants gain their livelihood by hunting. The district where the people are engaged almost solely in fishing and hunting begins at Moisie, a village about 15 miles east of Sept-Iles.

Agriculture

Farming has attracted very few settlers to the area. However, some farming has been carried on for a long time past in the Pointe-aux-Anglais district, at Ste-Marguerite, and around Sept-Iles bay. Colonization schemes have recently brought a few settlers to Baie Trinité and Pentecôte, but the district could support a very much larger number, on good quality land. There are large tracts available along all the streams, but especially on the wide plain which extends between Ste-Marguerite river and Matamec, below Moisie. The land around Sept-Iles bay is already subdivided into lots for settlement, and the ground here is of very good quality. But what is indispensable if these areas are to be of value, whether from the point of view of agriculture or the timber industry, or to attract tourists, is the construction of a highway along the coast which would connect the farming districts with the large villages such as Sept-Iles, Clarke City, Shelter Bay, and others.

Communications

This section of the Saint-Lawrence is well served by systems of river transport, which connect it both with the south shore and directly with Quebec city and Montreal. Two boats of the Clarke Steamship Company, of Quebec, maintain a regular service several times a week between Matane, Rimouski, and this section of the north shore. Two other boats of the same Company afford direct connection between this region and Quebec, Montreal, ports below Sept-Iles, and Newfoundland. A new service was inaugurated during the summer of 1938 by the Charlevoix-Saguenay Navigation Company, between Quebec, Sept-Iles, and all intermediate points. It must be added, however, that these services operate only in summer, with the exception of one boat of the Clarke Steamship Company, which makes a few winter trips between Murray Bay - the terminus of the railway from Quebec - and Newfoundland, calling at intermediate ports on the north and south shores. In the winter, there is an aeroplane service, for mail only, from Rimouski, on the south shore, to various points along the north shore. Usually the mail bags are dropped from the aircraft as they pass over the villages.

Method of Work, and Acknowledgments

The survey was begun at Godbout early in June and finished at Sept-Iles at the end of August.

The whole of the Saint-Lawrence shore-line within the limits of the map-area was traversed on foot, with the

exception of a swampy stretch in Sept-Iles bay. Traverses into the interior were made as follows: (1) Up Godbout river to the 'cache' at Etienne river, 12 miles from the shore. (2) Along the road following Trinité river to Elsa lake, 5 miles from the shore. (3) A 'fly trip' of several days' duration, first up Calumet river for a distance of about 6 miles, then by way of Giasson lake to Petite Trinité river, and down it to the sea, a distance of 12 miles. (4) A 'fly trip' to Pentecôte lake, thence passing outside the boundary of the map-area, to Pentecôte river. Profonde river, and Edouard lake, 20 miles from the shore, next to the Rochers (Shelter Bay) River drainage system to descend MacDonald river to Walker (Thirty Mile) lake, and finally to the village of Shelter Bay by the lumber road. (5) A traverse, lasting several days, from Shelter Bay to Pasteur lake and then to à la Cache and Foin (Morin) lakes; from there toward the valley of Valin river, reached at the head of des Iles lake, and finally down Valin and Ste-Marguerite rivers; this traverse extended 12 miles in from the shore. Other localities in the interior visited were Hall lake and des Rapides lake.

For transport, a 25-foot motor launch was hired for the season. It had an average speed of 5 miles an hour; a sail was sometimes of service in increasing this speed.

The party included Roland Bellemare, student of the School of Mines of Laval University, assistant; and Jos. Vaillancourt, owner of the launch, Walter Giasson, and Maurice Aubé, cook, all residents of Sept-Iles.

The writer extends warmest thanks to the officials of the St-Lawrence Paper Company, Baie-Trinité, and of the Quebec North Shore Paper Company, Shelter Bay, and to Mr. Stanislas Comeau, Godbout, and Mr. Willie Boudreault, Sept-Iles, for many services rendered the party.

The geological map accompanying this report is based on the aerial map of the Bureau of Aerial Photography of the Province of Quebec, on a scale of 40 chains to the inch. The map of the north shore of the Saint-Lawrence, published in 1926 by the Department of Lands and Forests, Quebec (on a scale of 6 miles to the inch) and the map of the Federal Department of Marine and Fisheries, published in 1919 and 1920 on a scale of 2 nautical miles to the inch, were also of great use in the field.

All the chemical analyses referred to in this report were made in the laboratories of the Quebec Bureau of Mines.

PHYSIOGRAPHY

Three distinct physiographic units are represented in the coastal area between Godbout and Sept-Iles. These are: the Laurentian plateau, the Laurentian foreland, and the Champlain plain.

The Laurentian Plateau

The Laurentian plateau forms the shore of the Saint-Lawrence for only 7½ miles, between Godbout and St-Augustin bay. Elsewhere, the margin of this plateau follows the Saint-Lawrence at a distance of from 4 to 6 miles from the shore. Throughout almost all its length, it presents a more or less vertical escarpment, which rises abruptly to a height of 900 to 1,300 feet (see Plate I-A).

The Laurentian Foreland

A chain of low hills extends from the foot of the escarpment of the plateau to the river. It is not present everywhere; its low elevation has allowed the Champlain sea to flood it, so that today it is hidden for the most part beneath a thick deposit of unconsolidated sediments of the Champlain sea. But in several localities, the summits of this chain appear in the form of low, rounded, rocky hills, forming, as it were, islands above the Champlain plain; as, for example, the 'Jambons' near point Ste-Marguerite, a prominence attaining an altitude of 325 feet - a distinctive landmark, well known to all who sail along the north shore.

The largest area wholly occupied by these outliers is between Hall river and des Rapides river, behind Sept-Iles bay. This area is about 30 square miles. The archipelago of Sept-Iles is by hills of the foreland, and it is here that they have their greatest altitude, rising to 736 feet.

Where the foreland forms the shore of the Saint-Lawrence, the coast becomes a rocky border along which the outcrops are very low, and partially or completely covered at high tide. Inland, the foreland is buried beneath Champlain sediments, while seaward it continues offshore and forms the great number of small islands and reefs which render navigation of these waters so hazardous, but which, at the same time, offer to the capable sailors of small boats along the shore, excellent harbours, protected from every wind. Such conditions are found in the district from St-Augustin bay to the Caribou islands, and also from Pentecôte to Theriault point.

The Champlain Plain

Where the escarpment of the plateau or its foreland does not extend to the Saint-Lawrence, the shore is formed of sands or clays of the Champlain plain, and is either a sandy beach or a mud bank such as those of Sept-Iles bay and des Homards bay. Lastly, short stretches are occupied by morainic deposits of the glacial epoch, which form what are known locally as 'battures'. The largest batture in the area is that which extends from Pointe-aux-Anglais to near Ile-aux-Oeufs; it was here that Admiral Walker's fleet was shipwrecked in 1711.

In the map-area, the Champlain plain occupies very

large tracts between the Saint-Lawrence and the margin of the Laurentian hills. The Champlain sea flooded almost the whole of this region, only a few higher parts of the Laurentian foreland standing above the sea in the form of small, rocky islands. In the map-area, the highest of the Champlain terraces stand at an elevation of 420 feet above the present sea-level.

In general, these plains are very poorly drained and they studded with hundreds of small lakes and swamps. Where the river valleys have low gradients, the plains extend long distances into the interior.

Rivers

As soon as the rivers reach the boundary between the Laurentian plateau and the Champlain plain or the foreland, they behave differently according as they flow in their preglacial bed or in a new, superimposed bed. In the first instance, the river crosses the boundary without interruption, flowing in normal fashion in a channel swept clear of unconsolidated Champlain sediments which had occupied it for a long distance back from the shore. All the large rivers of the area are of this type - Godbout, Trinité, aux Rochers (Shelter Bay), and Ste-Marguerite. But, if the rivers are in 'recent', superimposed courses, as is the case with most of the smaller streams, they cross the boundary in a series of falls. On Petite-Trinité, Calumet, and des Rapides rivers there are several falls, each about 200 feet high, at this boundary.

In their course over the foreland and the Champlain plain, all the rivers, without exception, follow, at least in part, post-Champlain superimposed channels. Some of them flow into these channels over quite high falls. There has been almost no down-cutting in the rocks of the foreland, and, as a result, it is characteristic of all these cascades that their water flows in a thin sheet over the polished surface of 'roches moutonnées'.

The Archipelagos

There are hundreds of islands along the coast where it is formed by the Laurentian foreland. Physiographically, therefore, these islands are part of the shore. There are only two true archipelagos in the area here discussed, namely, Ile-aux-Oeufs and Sept-Iles.

Iles-aux-Oeufs archipelago comprises a group of rocky islets above Pointe-aux-Anglais, about a mile and a half off-shore. They extend for a distance of a mile and a half, with north-south alignment. The largest, Ile-aux-Oeufs itself, is half a mile long and averages 600 feet wide. A lighthouse stands on its south end and a light-keeper is stationed there for nine months of the year. He also has under his charge a post-office and a telegraph office. Craft

caught in a storm often shelter behind Ile-aux-Oeufs, which is surrounded by deep water. All these islets are almost devoid of vegetation.

Sept-Iles archipelago is at the mouth of Sept-Iles bay, between Moisie and Ste-Marguerite rivers. It includes Marconi peninsula, six true islands, and some ten small islets and reefs. The six islands are arranged in three groups of two each. Of each pair, one is relatively very small compared to the other, as the following table shows:

Name and Synonym	Area	Elevation
Grand Carroussel, Carroussel de Terre, Manowin	700 acres	457 feet
Petit Carroussel, C. du Large, Ile du Phare	170 "	260 "
Grand Basque, Basque de Terre .	1,300 "	500 "
Petit Basque, Basque du Large .	300 "	300 "
Grande Boule, Boule du Large ..	1,300 "	688 "
Petite Boule, Boule de Terre ..	440 "	433 "

The greatest elevation of the whole archipelago is 736 feet, near point à-la-Chasse on Marconi peninsula. The area of the peninsula is about 7 square miles.

The group of reefs and small islets lying between point à-la-Chasse and Grand Carroussel is known as 'Cayes-de-l'Ouest', and the group between the mainland and Petite Boule as 'Cayes-de-l'Est'. The rock islet composed of limestone beside Grand Carroussel island is known as 'Caye-à Chaux'.

The two islands in each group lie close together, but between the three groups, and between them and the mainland, there are wide, deep-water passages. These channels form the finest natural harbours of the north shore of the Saint-Lawrence and can shelter vessels of any size.

No one lives permanently on any of these islands except on Petit Carroussel, where there is a lighthouse at which, for nine months of the year, a light-keeper is stationed.

GENERAL GEOLOGY

General Statement

All this portion of the north shore of the Saint-Lawrence forms a part of the Canadian Shield and is underlain by Precambrian formations, or formations which in all probability are Precambrian. At two localities, however, very small remnants of overlying Palaeozoic sediments outcrop. Over much of the area, the Precambrian formations

are covered by unconsolidated sediments of Recent age which, at the higher elevations, are solely glacial in origin. At lower levels, in general below 420 feet, these glacial deposits are ordinarily covered by a thick layer of sediments of the Champlain sea.

Table of Formations

Pleistocene and Recent	Recent		Fluviatile deposits
	Champlain		Marine sand and clay
	Glacial		Moraines, varved clay
Long Period of Erosion			
Palaeozoic	Ordovician (Trenton)		Limestone, (fossiliferous), sandstone
Precambrian (?)	Post-Morin-Series Intrusives		Pentecôte granite, syenite, mica-pegmatite
			Intrusive Contact
			Diabase dykes, gabbro
	Intrusive Contact		
Precambrian	Morin Series	Acidic Phase	Grey granite, syenite, granulite, hornblende-pegmatite, aplite
		Intrusive Contact or Transition	
		Basic Phase	Anorthosite, gabbro, titaniferous magnetite
	Intrusive Contact (?)		
	Granitic-Gneiss Series		Granitic gneiss, augen gneiss, aplite, pegmatite
	Intrusive Contact		
	Grenville Series		Paragneiss, quartzite, garnetiferous paragneiss, crystalline limestone, pyroxenite, amphibolite

Grenville Series

Sedimentary rocks of the Grenville series outcrop over quite long stretches of the Saint-Lawrence shore, as for example between Godbout and Trinité bay. The most common rock types are amphibolites and pyroxenites, banded paragneisses with or without garnet, beds of very impure crystalline limestone, and, more rarely, beds of quartzite.

The banded paragneisses, usually garnetiferous, are best exposed along the shore between Raymond brook and St-Augustin cove. The general strike of the bedding is northeast and the beds are everywhere strongly contorted; the dip is generally very steep. Near the west point of St-Augustin cove there seems to be an unconformity between two bands of paragneiss (see Plate I-B).

The crystalline limestone and the pyroxenites and amphibolites are well exposed in the district about l'anse-aux-Aulnes, four miles below des Monts point, where the limestone beds attain a thickness of 50 feet. The limestone here is free from impurities but has intercalations of silicified rock. The pyroxenites and amphibolites are closely associated with the crystalline limestone; there is no evidence at all of their being of volcanic origin, and the writer believes them to be metamorphosed beds of impure limestone. The amphibolite at this same locality is a greenish-black rock of very coarse grain, with hornblende crystals up to a quarter of an inch in length. Microscopic examination reveals that the average rock contains hornblende and augite in about equal amount, with very subordinate plagioclase, the latter highly altered. A specimen from another band in the same outcrop at l'anse-aux-Aulnes was found to contain phlogopite, augite, and hornblende in about equal proportions.

Granitic-Gneiss Series

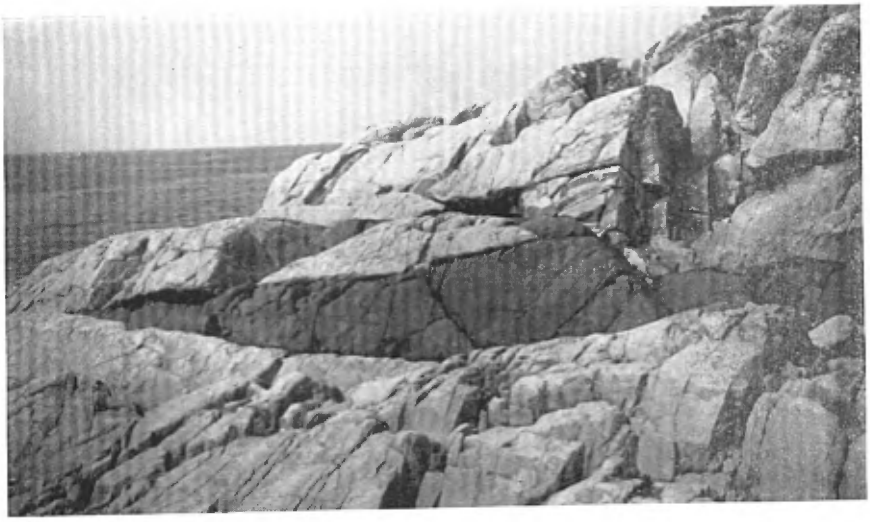
Rocks of this series form the shore of the Saint- Lawrence at Godbout and from Poulin river to the Caribou islands. The granitic rocks in the vicinity of Ste-Marguerite (Jambon) point have also been assigned to this series. It is probable that granitic gneiss underlies most of the interior part of the map-area.

These granitic gneisses, in part augen gneisses, are composed of quartz, feldspar, and biotite, as essential constituents. Frequently, some hornblende also is present. Ordinarily, the feldspar is orthoclase or microcline, but plagioclase is almost always present in small amount. The 'eyes' of the augen gneiss are lenticular crystals of orthoclase. These rocks are almost always red in colour.

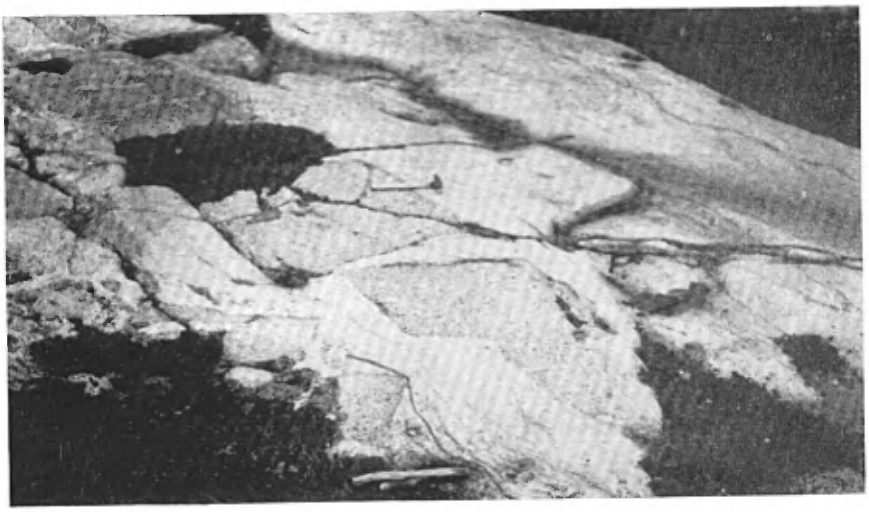
In the vicinity of the anorthosite (Morin series) described on a later page, the granite gneiss grades into augen gneiss and the 'eyes' in the augen gneiss are found to increase progressively in size as the anorthositic intrusion is

A. — Typical abrupt escarpment at margin of the Laurentian plateau; Chute lake, Calumet river.

B. — Apparent unconformity between two bands of Grenville paragneiss; west point of St. Augustin cove.



A. — Diabase dyke, ruisseau Blanc, Godbout.



B. — Contact breccia between Pentecôte granite (intrusive) and anorthosite (host-rock); near Pentecôte church.

A. — Ordovician beds dragged against a fault plane. Carrier point.

B. — La Caye-à-Chaux, Sept-Iles, looking north.

PLATE IV

Photomicrograph of thin section of microcline-perthite pegmatite; west point of St. Augustin cove. Crossed nicols, x 51.

approached. This contact effect is often observable in a zone of the gneiss, several miles wide around the anorthosite mass, and it is evidently a result of the intrusion of the latter. It is concluded, therefore, that the granitic-gneiss series is older than the Morin series.

The gneiss near Godbout river, around Cedres lake, contains augen and anorthosite occurs about two miles distant, on the west side of Godbout river (1). The extensive zone of augen gneiss lying between Trinité and Calumet rivers probably marks a zone of contact metamorphism developed by a large intrusion of anorthosite which does not outcrop, but whose presence at depth is indicated by the occurrence of hornblende-pegmatite dykes on and in the vicinity of Caribou island, half way between Trinité and Calumet rivers. The writer believes these dykes are genetically related to the rocks of the Morin series. Augen gneiss also occurs in the Lake Pentecôte district and around aux Rochers (Shelter Bay) river; at both places, rocks of the Morin series outcrop within barely a mile of the gneiss.

On the other hand, at Ste-Marguerite (Jambon) point, where the granitic gneiss and anorthosite are exceptionally well exposed in continuous outcrop, the contact is gradational with no intermediate band of augen gneiss.

Pegmatite and aplite dykes are very numerous cutting the rocks of the granitic-gneiss series. The aplite is most commonly in dykelets only a few inches wide; its colour is red. The pegmatite dykes are a little larger but they do not appear to be of economic interest. The mica of the pegmatites is everywhere biotite; both the feldspar and the quartz are in small crystals. The pegmatites referred to in the section on Economic Geology seem to be closely related to younger granitic intrusions (Pentecôte granite).

Morin Series

The rocks here referred to the Morin series include a number of intrusive bodies and dykes that are all believed to have been derived from a common magma. They range in composition from basic to acidic, and have, in general, been intruded in that order, following the main anorthosite intrusion. They are definitely of Precambrian age. The principal types of rock represented are: anorthosite, gabbro, titaniferous magnetite, granite, syenite, aplite and hornblende-pegmatite.

Anorthosite

The anorthosite at St-Nicholas cove west of Godbout river, described in the writer's 1933 report (1), does not

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(1) FAESSLER, Carl, Op. cit., Que. Bur. Mines, Ann. Rept., Part D, 1933, p.160.

continue east of that river. Anorthosite is not seen again until 40 miles below Godbout, near Pentecôte river, from where it continues to Ste-Marguerite point. At the latter locality, it gives place to granitic gneiss. This body of anorthosite does not extend into the interior. Along Ste-Marguerite river another body of anorthosite makes its appearance and continues to des Rapides river; this, also, seems to be an isolated mass which probably does not extend to Moisie river.

It is possible that these several occurrences of anorthosite form portions of a large mass continuous at depth, which, for reasons given below, is thought to be near the surface in some places, as for example near the Caribou islands, and, in general, in the region between Trinité and Pentecôte rivers.

The fact that large patches of rocks of the Grenville series are found in districts otherwise underlain by anorthosite, as for instance at Vachon river, seems to show that in most places the rock intruded by the anorthosite magma was Grenville, and it may be presumed that immense quantities of Grenville sediments were completely assimilated by the magma in its advance. In some localities, the rocks of the Morin series have a banded structure which may represents the original bedding of the intruded sedimentary rocks.

The anorthosite is, in general, of a very dark colour, almost black, and of very coarse grain; plagioclase crystals half an inch to one inch and more in diameter are common and, in many places, they attain a diameter of several feet. Frequently, the rock is composed entirely, or almost entirely, of plagioclase, but in some facies crystals of hypersthene a few inches to two feet in diameter are distributed through the rock.

Wherever the black anorthosite has been intruded, its colour along the contact has been changed to white. This is invariably the case at contacts with diabase, with Pentecôte granite, and it is often seen in the contact breccia between the black anorthosite and the granitic facies of the Morin intrusive. Contact metamorphism of the rock is intense in these white varieties and is shown by the almost complete alteration of the plagioclase, which, in the black anorthosite, is always very fresh.

The anorthosite often has a very pronounced granular texture, so much so that some outcrops simulate a breccia in which fragments of plagioclase are embedded in a matrix of the same material but of finer grain.

In the Sept-Iles archipelago, the black anorthosite in many places has a very distinctive appearance. In this rock there are large groups of plagioclase crystals, which may measure several feet in each dimension, formed of very thin crystals lying one on the other like the leaves of a

book; the thickness of each 'leaf' is a quarter of an inch or less, and its area varies with the dimensions of the group as a whole. These groups may be more or less deformed and, if they are, the peculiar arrangement of the crystals gives to the rock a vague appearance of flow structure, especially when the groups of crystals are seen in cross-section. It is probable that these aggregations were formed under a high pressure acting normal to the 'leaves' at a time when the anorthosite magma was still in a more or less plastic state.

Very rarely, the anorthosite has a 'stratified' appearance, but in general the rock is massive and shows no banding or schistosity whatsoever.

The plagioclase usually has the composition of labradorite; no crystals showing iridescence were seen. Mafic minerals, when present, are augite and hypersthene, and, more rarely, hornblende and mica. Olivine seems to be entirely lacking. Both Adams and Dresser (1) mention the presence of olivine in the anorthosite of the Lac Saint-Jean region, but B.T. Denis (2), who mapped a portion of this region for the Quebec Bureau of Mines in 1933, did not observe olivine in any of the specimens of anorthosite he examined. Adams (3) does not include olivine in the list of minerals observed by him in the Morin anorthosite.

Gabbro

With increase of mafic minerals, the anorthosite passes without sharp contact to gabbro. Such rock is much more abundant in the area than the true mono-mineral anorthosite. It is often rich in ilmenite, either disseminated in grains throughout the rock or in segregations of greater or less size.

Titaniferous Magnetite

In places, segregations of ilmenite and magnetite form almost the whole mass of the rock. Such occurrences of titaniferous iron ore are found at several localities in the area; they usually occupy the marginal portions of the anorthosite intrusion, as in the vicinity of Ste-Marguerite and des Rapides rivers (see section on Economic Geology).

Granite and Syenite; Granulite

Frequently, acidic rocks are closely associated with

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(1) DRESSER, J.A., Part of the District of Lake St.John, Quebec; Geol. Surv. Can., Mem. 92, p.25, 1916.

(2) DENIS, B.T., The Northwest Portion of the Lac-Saint-Jean Region; Que. Bur. Mines, Ann. Rept., Part D, 1933, p.76.

(3) ADAMS, F.D., Geology of a Portion of the Laurentian Area North of the Island of Montreal, Geol. Surv. Can., Ann. Rept., Vol.8, Part J, 1895, p.92.

the anorthosite, as between Pentecôte and des Homards bay, between Vachon river and Shelter bay, and in the Sept-Iles archipelago; the rocks of Ile-aux-Oeufs probably belong to the same group. There is usually a gradation, or at least no apparent contact, between the basic phase and the acidic phase; in some instances, however, there is a definite contact.

Syenites and Granites with Gradational Contacts

These rocks are very common in the Pentecôte and Shelter Bay districts; because of the difficulties due to their gradual transition to anorthosite, they are not shown separately on the map accompanying this report but are included with the basic facies of the Morin series.

The rocks consist essentially of feldspar, hornblende, and, in the more acidic varieties, much quartz. The feldspar is mainly 'perthite', but both orthoclase and plagioclase are present in fair amount as individual grains. The quartz is generally blue and opalescent, and in the granitic facies of the rock often forms aggregates several inches in diameter. Accessory minerals are biotite, augite, hypersthene, sphene, apatite, and iron oxide.

These acidic rocks are of an indefinite grey colour, medium brownish or dark, and the grain varies from medium to coarse. Where quartz is very abundant the rock has the appearance of a sandstone, as is the case with the rock which forms several of the isolated hills rising from the Champlain plain back from the shore between Vachon river and Shelter bay.

Granulite

Ile-aux-Oeufs is formed of a coarse-grained granulite which is grey or grey-green in colour. The weathered surface is often brown or reddish. The rock is massive, or rarely, weakly gneissic. Featuring the exposures are plagioclase crystals, up to 8 inches long by 3 inches wide, which, on a clear day, flash brilliantly in the sun. Under the microscope it is seen that these crystals of plagioclase are strongly granulated, as also are the other constituents of the rock, hornblende and quartz.

Syenites and Granites with Definite Contacts

In some localities, and notably in the Sept-Iles archipelago, granite is seen in sharp contact with the basic facies of the Morin series. This granite closely resembles the acidic rocks just described, but differs from them in that the bluish quartz is lacking and, as just mentioned, in that there is always a sharp contact between anorthosite or gabbro and the acid rock. In general, the contact is marked by a band of contact breccia, whose nature shows clearly that

the granite is younger than the anorthosite. Such being the case, these acidic rocks of Sept-Iles should, perhaps, be placed in a group distinct from the anorthosite. However, hornblende-pegmatite dykes - believed to represent the final phase of the anorthosite intrusion - are common in this locality, cutting both the anorthosite and the granite. In view of this, and also of the fact that there is no proof that the granite is an independent intrusive, it has been tentatively classified by the writer as an acidic facies of the anorthosite, and so related to the granites and syenites described above.

Hornblende-Pegmatite

In all districts where the bed-rock is anorthosite and associated basic or acidic rocks, a large number of red aplite and hornblende-pegmatite dykes are found. The pegmatite often contains such an abundance of black hornblende, in large crystals, that the dykes, or the masses of hornblende, look almost like coal seams. The largest mass of hornblende-pegmatite seen outcrops over an area of almost one square mile about three miles below Sproule point, opposite Petit-Caouis island.

These hornblende-pegmatite dykes are considered to be the latest manifestation of the intrusive activity that gave rise to the anorthosite, for they cut not only the anorthosites and the gabbros but also the associated granites and syenites. The presence of some of these dykes at certain places well outside the boundaries of the anorthosite bodies, as for example on the Caribou islands, probably indicates the proximity at depth of the magma-chamber of the anorthosite.

Post-Morin-Series Intrusives

Under this heading are described certain intrusive rocks that are definitely younger than the Morin series. In the table of formations, they are classified as Precambrian(?). Field evidence in the present area and elsewhere suggests they are Precambrian, but direct proof of their age is lacking.

Gabbro-Diabase

Diabase dykes are very numerous all along the part of the coast here discussed. Their glaciated and water-worn surfaces are black and shiny. Some are but a few inches wide, and from this they range to almost 100 feet (see Plate II-A). Their strike is variable, but most commonly it is northeast. Most of them are vertical; however, in the vicinity of Sproule (des Caouis) point they are almost horizontal.

These dykes are definitely younger than any of the rocks yet considered. They were seen cutting the hornblende-pegmatite dykes and all the facies of the anorthosite as well as the granitic gneiss and the rocks of the Grenville series.

The diabase dykes are probably offshoots from large masses of gabbro which, in general, are buried beneath a great thickness of overlying rock. However, at several localities deep erosion has exposed the underlying gabbro. Such is the case on the shore about one and three-quarters miles west of Raymond brook, at des Monts point, at the mouth of Poulin river, on the main shore opposite the Caribou islands, and notably along the mainland opposite Grand-Caouis island, where the genetic relationship between a large gabbro mass and the diabase may be very clearly seen.

The diabase always has an ophitic texture. The plagioclase encloses innumerable microscopic inclusions of black grains in the form of a very fine powder, which gives to the crystals a very characteristic 'peppered' appearance. The mafic constituents are augite and (in some occurrences) olivine, a little biotite, and rarely a minor amount of hornblende and hypersthene. There is always much iron oxide and often some pyrite.

The gabbro has a granular texture. It consists of plagioclase and pyroxene, with or without olivine, and iron oxide.

It has not been possible to assign the gabbro-diabase to a definite place in the stratigraphic column. It is certainly younger than the anorthosite and related intrusives of the Morin series, because it is seen in many places cutting the hornblende-pegmatite dykes, which the writer considers to be the final manifestation of that cycle of intrusive action. On the other hand, it is older than the Pentecôte granite, next to be described.

Pentecôte Granite

Large bosses of granite, which the writer considers to be of like age, occur at Steamship point; near the church at Pentecôte; in Charles cove (l'anse-à-Charles), two miles and a half below Pentecôte; and on the east side of des Homards bay. It is possible that the granitic masses near Shelter Bay, which are mapped as part of the Morin series, belong instead to this group. At Steamship point, this granite intrudes rocks of the Grenville series and the granitic gneiss; in the other localities mentioned, it intrudes anorthosite. The contacts are everywhere very definite and are marked by a clearly exposed zone of contact breccia (see Plate II-B).

The granites in these several occurrences resemble one another very closely. They are red in colour, coarse grained, and in places faintly gneissic. Microcline is the principal feldspar, but with it are plagioclase and perthite; all are relatively fresh. The rock contains little or no orthoclase. Biotite is the chief mafic mineral and there is a little hornblende. Quartz is lacking in some facies of the rock which then becomes a syenite.

This granite is distinguished from the acid facies of the anorthosite by its pronounced red colour. Moreover, the associated satellitic pegmatites are mica-bearing, and not hornblende-bearing as are those related to the anorthosite. As regards its age, there is clear evidence, in the Steamship Point district, that this granite is younger than the gabbro-diabase intrusion. Although direct evidence on this point is lacking at Pentecôte, the occurrence here of mica-pegmatite dykes right in the midst of the anorthosite lends strong support to the belief that the Pentecôte granite is of the same age as that of Steamship point.

The writer has given the name 'Pentecôte granite' to this rock because, of all the outcrops seen, that near Pentecôte church is by far the largest and the best exposed; the main mass outcrops over an area of 800 by 500 feet. Also, the stone here has been quarried and used for local needs.

Age of the Intrusive Rocks

The mutual age relationships of all the rock formations of the area are well established by field evidence and are as shown in the table of formations on page 11. Also, there can be no question that the rocks of the Grenville series, and the intrusive rocks of the granite-gneiss and the Morin series, are all of Precambrian age. The diabase (and gabbro) and the Pentecôte granite may be Precambrian, but so far as the field evidence goes all that can be said regarding their age is that they are with certainty post-Morin-Series and that they are probably pre-Ordovician. It may be noted, however, that in composition, and probably in age, the Pentecôte granite corresponds to the Chatham-Grenville stock, studied by Osborne (1) and considered by him to be probably Precambrian.

Trenton Limestone and Sandstone

Palaeozoic formations outcrop over fairly large stretches at Carrier point, three miles below Pentecôte, and at Caye-à-Chaux of the Sept-Iles group. At both localities the rocks are fossiliferous, and, according to Billings, the fossils show that they belong to the Trenton group (2). The rocks are sandstone and limestone.

At both places, the occurrences are in 'graben', or blocks down-sunken along faults. Against the faults, the

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(1) OSBORNE, F.F., The Chatham-Grenville Composite Stock, Quebec; Trans. Roy. Soc. Can., Vol.28, Sect. 4, 1934, pp.49-64. Also Que. Bur. Mines, Ann. Rept., Part E, 1932, pp.53-56; Part E, 1933, p.13; Part C, 1936, pp.19, 20.

(2) RICHARDSON, James, Geol. Surv. Can., Report of Progress, 1866-69, p.307.

beds are dragged to a steep dip, but they return to the horizontal away from the faults. The corresponding 'horsts' are formed of rocks belonging to the Morin series. The age of the faults is post-Trenton.

The Ordovician remnant at Carrier point has a surface measurement at low tide of about 500 feet along the shore by 100 feet wide. High tide covers the horizontal beds almost completely and leaves exposed only a kind of 'needle' about 15 feet high with a base of 1,000 square feet. The rock is an impure siliceous limestone.

The occurrence at Caye-à-Chaux, mainly limestone, is described in the section on Economic Geology (p. 23).

Pleistocene and Recent

Polished rock surfaces, large numbers of kettle-holes, glacial grooves, striae, etc., which are found all along the Saint-Lawrence shore, reveal very intense action on the part of the Pleistocene glaciers. Two series of glacial striae are clearly distinguishable, one in a southwest direction, the other southeast. Above the level of the Champlain plain (420 feet), the whole region is blanketed with morainal deposits, only here and there dissected to bed-rock. These include thick deposits of varved clays.

In the lower lying lands, not above 420 feet in elevation, the morainal deposit is overlain by sediments of the Champlain sea. These marine sediments begin with a thick clay deposit followed by a great thickness of sand. In some places this sand contains great numbers of Tellina Groenlandica and other fossils of the Champlain sea, such as the bones of whales.

STRUCTURAL GEOLOGY

Throughout the area, the stratified rocks of the Grenville series have a fairly constant general strike in a northeast-southwest direction, with steep dip to the south or, very rarely, to the north. In many places these rocks are highly contorted.

At the west point of St-Augustin cove there appears to be an unconformity between two bands of Grenville paragneiss (see Plate I-B). The lower series, composed of alternating bands of white quartzite and black micaceous and hornblende-rich gneiss, strikes E.-W. and dips at 25° to the north. It is overlain by garnetiferous gneiss which also strikes E.-W. but dips at 65° to the south.

A zone of faults and fissures parallels the Saint-Lawrence along this section of the coast, as for instance between Pentecôte and des Romards bay, there the zone strikes N.25°E. to N.50°E. This zone of faulting is marked in many places along its course by a well defined breccia band.

Where it was possible to observe the displacement, it was found that the movement was not only vertical but also horizontal. At Carrier point, a fault-plane may be seen as a vertical scarp about 30 feet high facing the Saint-Lawrence. The scarp is gabbro of the Morin series, and lying against it are beds of Trenton limestone (see Plate III-A). The fault strikes N.50°E.

The Sept-Iles archipelago lies in a region of strike and dip faults. In a general way, the islands are horsts and the deep channels between them are graben. The Caye-à-Chaux, which is formed of Trenton rocks, mostly limestone, lies within one of these graben. Only a small marginal portion of this downthrown rock projects above water-level; the greater part lies submerged at a depth of sixty fathoms. In this marginal part, the beds are steeply tilted toward the island of Grand Carrousel, the horst, which is composed of the granitic facies of the Morin series. Away from the horst, the beds approach the horizontal. It is certainly incorrect to say, as does Richardson (1) in speaking of the Caye-à-Chaux, that the limestone beds "repose on reddish gneiss".

As some of the Trenton strata are cut by the faults of Carrier point and by those of the Sept-Iles archipelago, it follows that these faults must be post-Trenton.

In addition to the fault fissures, there are others on which there has been no appreciable displacement, apart from opening. Some of these fissures have been occupied by vertical diabase dykes, which more often than not trend northeasterly parallel to the stratification of the Grenville rocks they traverse. Some of these dykes, however, occupy east-west trending fissures. Some of the diabase-filled fissures, particularly those trending northeasterly were apparently re-opened sometime after the emplacement of the diabase and new openings of a few inches in width along the walls of the dykes were filled by calcite. Other fissures, with no definite strike but usually vertical are commonly filled with calcite, which in purity approaches Iceland spar. This calcite is usually in narrow stringers only, although on one of the Caribou islands a calcite vein two feet wide was observed.

It is probable that the fissures filled by diabase dykes are pre-Trenton, and possibly they are even Precambrian. In some localities, however, fissures that are believed to be related to post-Trenton faulting were seen, and these are younger than the diabase dykes.

ECONOMIC GEOLOGY

Ochre

Deposit of ochre at St-Augustin cove have been known for many years. They were described in 1883 in a report by

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(1) Loc. cit., p.307.

Obalski (1). The 'ochreous runnings' are found at the head of the cove, almost at sea-level, at the foot of a very steep slope. This slope is formed of clay to a height of about ten feet above high-tide, and above that of sand. The ochre forms at the outflow point of numerous little oozings and springs which emerge at the contact between the sand and the clay; but because of the very limited lodgment room between the discharge of the springs and the high-tide mark, almost all the ochre is carried into the waters of the bay as quickly as it forms. For this reason, these deposits are of no economic interest.

There is another small ochre deposit four miles southwest of Shelter Bay, about three-quarters of a mile from the shore. It is reached by a foot-path which starts at des Pêcheurs bay and runs northwest. The ochre deposit is near the junction of two small brooks which drain a swamp. These brooks have cut quite a deep channel in the sand and clay deposits of the Champlain plain, and on one slope of the valley, on the side nearer the swamp, numerous small springs issue from the sand-clay contact. At their outflow points, these springs deposit large quantities of ochre. But because of the narrowness of the valley and its steep sides, a very large percentage of the ochre is carried away by the brooks, and the deposits remaining on the slopes are of very limited volume. In some places, the ochre has been shown to have a depth of six feet, but the thickness is far from uniform. The deposit covers an area about 700 feet by 60 feet, and bore holes sunk by the writer indicate that it contains about 50,000 cubic feet of ochre. The ochre is of very good quality.

Ochre of good quality, but in small amount, also occurs along Rouge brook (ruisseau de la Peinture), a small tributary entering Ste-Marguerite river on its east bank, a mile and a half from the Saint-Lawrence.

Peat

In the Champlain plains there are considerable tracts of peat-bearing land, as for instance behind des Monts point, where the peat bed exceeds (probably by a great deal) ten feet in thickness.

In the long Des Caouis plain which extends almost uninterruptedly from Pentecôte to Moisie river, a distance of about sixty miles, peat is known to occur at several localities. Systematic boring would probably show that the deposits here are very extensive.

Feldspar

In the vicinity of des Monts point there are numerous pegmatite dykes in which, generally, the quartz and feldspar

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(1) Rept. of the Comm. of Crown Lands, Quebec, Appendix No.50, 1883, p.121.

are in graphic intergrowth. In some of these dykes, however, the two minerals are well separated, with large masses of pure feldspar alongside large masses of pure quartz.

At the west point of St-Augustin cove, two miles west of des Monts point, two pegmatite dykes, 5 feet and 20 feet wide, are exposed for a length of about 100 feet, and both contain individual crystals of perfectly white feldspar one to two feet in diameter. This feldspar is of the microcline-perthite variety (see Plate IV). Analysis of a specimen gave the following result:

K_2O	Na_2O	CaO	Al_2O_3	SiO_2
11.29%	3.44%	0.32%	19.08%	65.32%

The normative composition of a feldspar of this analysis would be microcline: 68 per cent; albite, 30 per cent; anorthosite, 2 per cent.

In other dykes in the same district, the feldspar is red and is mostly perthite. These perthite-pegmatite dykes are invariably of relatively small width, and the individual crystals of perthite seldom exceed 8 inches in diameter.

Limestone

The Grenville crystalline limestone in this map-area always contains silicate minerals in large amount. The few beds of Palaeozoic limestone on Carrier point are also very siliceous. As a consequence, these occurrences are of no economic interest as a possible source of lime. However, fairly large quantities of pure limestone are available on Caye-à-Chaux, in the Sept-Iles district. This occurrence is of special interest because of the possibility that this region may, at some future time, become an important agricultural centre.

The Caye-à-Chaux is a rock-islet entirely devoid of vegetation, lying northeast of Grand Carrousel island (1), to which it is joined at low tide by a morainal bar about 100 feet long. At low tide, the Caye-à-Chaux is about 1,500 feet long and has the shape of a flattened oval, with a diameter of 150 feet at the widest part. The central portion of the rock projects about 20 feet above low-tide level (see Plate III-B). At high tide, the rock becomes three small islets, the largest, about 500 feet long by 120 feet wide, standing 10 feet above water level in its central part.

The rock on this principal islet is chiefly rather thin-bedded limestone, the beds being 6 to 10 inches thick. A few beds of arenaceous limestone occur at the base of the outcrop, below water at high tide, and at the top a total

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(1) Also known as Carrousel-de-Terre, or as Manowin island, although the latter name is not used locally.

thickness of one and a half to two feet of sandstone is intercalated between the limestone beds. The presence of these sandstone beds considerably diminishes the economic value of the deposit. The limestone is white or greyish-white. Chemical analysis of a sample of the stone gave the following result:

CaO	MgO	CO_2	FeO	S
52.43%	0.18%	41.40%	0.13%	Trace

The limestone is highly fossiliferous. This renders it rather friable, and hence the stone cannot be used for any purpose where mechanical strength is essential. It would, however, made an excellent 'agricultural' limestone, for use as a neutralizer for acid soils. The stone available could supply the needs of a good sized local market for many years. However, exploitation of the deposit on a large scale would be impossible because of the small extent and low elevation of the rock, which is exposed to the pounding of the waves during the heavy northeast storms. This is the only occurrence of high-calcium limestone seen by the writer in the vicinity of Sept-Iles.

Titaniferous Iron Ore

As noted on page 15, in the section on General Geology, the gabbroic facies of the anorthosite often contains much disseminated ilmenite, and in several localities almost the whole mass of the rock consists of ilmenite and magnetite. Such bodies of titaniferous iron ore are usually found at or near the margin of the anorthosite, as along Ste-Marguerite and des Rapides rivers.

The problem of the genesis of the ilmenite or titaniferous iron ore deposits associated with anorthosite intrusives in the Province of Quebec and elsewhere has engaged the attention of numerous investigators (1), and there is considerable lack of agreement, at least on matters of detail, in the various opinions that have been advanced. It was not the purpose of the present investigation, nor was time available, to make a special study of this problem in the area here discussed, but the writer if inclined to associate himself with those who hold that the deposits represent segregations from the anorthosite magma. This opinion is based largely on the fact that all gradations are met with, from gabbro with disseminated, and obviously primary, ilmenite, to the massive bodies composed entirely, or almost entirely, of titaniferous iron ore.

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(1) OSBORNE, F.F., Certain Magmatic Titaniferous Iron Ores and Their Origin; Econ. Geol., Vol.23, 1928, pp.724-761 and 895-922. Also Que. Bur. Mines, Ann. Rept., Part C, 1935, p.75 et seq.

GILLSON, J.L., Genesis of the Ilmenite Deposits of St. Urbain, County Charlevoix, Quebec; Econ. Geol., Vol.27, 1932, pp.554-577.

In the present area, bodies of such massive ore are few in number and of small size. For descriptions, the reader is referred to the report by Dulieux (1). They are found only along des Rapides river, which flows into the Saint-Lawrence at Sept-Iles bay, and along Ste-Marguerite river, at the foot of the first falls just below Clarke City. The largest body is at the foot of the second falls of des Rapides river, about one mile from its mouth. Analysis of a selected sample from the Molson mine (or Cran-de-Fer Falls mine) at this locality gave the following result:

$Fe^{(\varkappa)}$	TiO_2	P_2O_5	S
51.00%	22.78%	4.04%	0.85%

As stated above, these masses of titaniferous iron ore are relatively small and could not, of themselves, form the basis of an iron industry. Of much greater economic importance, in the writer's opinion, are the bodies of ferriferous gabbro such as form the marginal portion of the anorthosite over long stretches in the Sept-Iles district. Although, considered as ore, they are low-grade, they are very extensive. Analyses indicate they contain between 15 and 20 per cent iron, and, from tests carried out by Dulieux, it would appear that the preparation from them of a concentrate carrying 50 to 60 per cent iron and 10 to 15 per cent titanium would present no special difficulties. In the district lying between des Rapides lake, Hall lake, and Sept-Iles bay, outcrops of the ferriferous gabbro are so frequent as to indicate the presence of a very large tonnage of this low-grade 'ore' over an area of about twenty square miles.

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(1) DULIEUX, P.E., Les Minerais de Fer de la Province de Québec: Gisements et Utilisation; Dept. of Colonization, Mines and Fisheries, Quebec, 1915.

($\varkappa$) Fe_2O_3, 22.29 per cent; FeO, 45.56 per cent.

ALPHABETICAL INDEX