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PART I - NORTH SHORE OF SAINT-LAWRENCE FROM MINGAN TO AGUANISH, SAGUENAY COUNTY - PART II - LIMESTONE DEPOSITS OF THE MINGAN ISLANDS AREA, SAGUENAY COUNTY

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GEOLOGICAL REPORT 42

PART I

NORTH SHORE OF THE SAINT-LAWRENCE FROM MINGAN TO AGUANISH

SAGUENAY COUNTY

by

W. Warren Longley

PART II

LIMESTONE DEPOSITS OF THE MINGAN ISLANDS AREA

SAGUENAY COUNTY

by

G. W. Waddington

QUEBEC
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1950

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PART I

NORTH SHORE OF THE ST-LAWRENCE

MINGAN TO AGUANISH

SAGUENAY COUNTY

By W. Warren Longley

INTRODUCTION

Location of Area

The writer spent seven weeks during the field-season of 1943 making a geological investigation of the section of the north shore of the gulf of St-Lawrence that lies between Mingan and Aguanish, a straight line distance of approximately 85 miles. The village of Havre St-Pierre, which is about twenty miles east of Mingan and 430 miles below Quebec city, served as the base of supply and operations.

Means of Access

During the summer and autumn, the Clarke Steamship Company, Ltd., maintains a regular freight, mail, and passenger service from Montreal and Quebec to centres along the coast.

Canadian Pacific Air Lines provides mail and passenger service during the winter months.

Previous Work

Many occurrences of minerals of economic interest have been reported within the area. De Puyjalon did a considerable amount of investigation along this section of the shore in the 1880's. In later years, geological mapping and examination of mineral deposits along parts of the shore and on adjacent islands was carried out by Obalski, Walker, Twenhofel, and others.

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Field-Work

The purpose of this investigation was to examine the many reported mineral occurrences in the area, and to make a geological map that might aid in future prospecting.

A pace-and-compass survey of the shore was made from Sauvage point eastward to Aguanish, a straight line distance of about 45 miles. Due to the monotonous character of the flat-lying sedimentary rocks that extend along the shore from Sauvage point westward to Mingan, a distance of about 40 miles, and to the small probability of their containing mineral deposits of economic importance, this section of the shore was not systematically traversed.

Travel along the coast was accomplished by means of a large, motor-driven fishing barge (Plate I-A). The barge was owned by Walter Cormier, of Havre St-Pierre, who served as boatman.

Acknowledgments

The base-map on which the geology of the area was plotted was supplied by the Quebec Department of Lands and Forests.

Abstracts of literature on the geology of the North Shore, compiled by Dr. I.W. Jones, Chief of the Geological Surveys Branch, Quebec Department of Mines, were most helpful.

Ovide Maurice, assistant, Adelard Labranche, cook, Walter Cormier, boatman, and Azade Boudreau, assistant boatman, discharged their respective duties in a satisfactory manner.

The writer wishes to express his appreciation to the Cine-Photography Branch of the Province of Quebec for their excellent work in printing the photographs taken by the writer.

DESCRIPTION OF THE AREA

Topography

The shore of the eastern part of the area is very irregular but not of a rugged character, the surface rising very gradually from the water's edge (Plates I-B and II-A). This irregular shoreline, with its innumerable islands, is characteristic of a submerged coast that has undergone little erosion since its submergence.

The shoreline of the western part of the area is much more regular. The greater part of this section is underlain by Palaeozoic sedimentary rocks with a very low southward dip, which have been somewhat eroded since glacial times, producing cliffs in places.

Elevations along the shore of over 100 feet are rare. The most prominent are Ste-Geneviève or Table mountain, some 23 miles east of Havre St-Pierre, which is the highest knoll in the immediate vicinity of the shore, rising to slightly over 300 feet; a knoll at the head of Pontbriand bay that rises to an elevation of slightly over 200 feet; and Watshishou knoll, at the mouth of the river of the same name, which is less than 200 feet high.

Population and Industry

There are four villages along this section of the shore. Of these, Havre St-Pierre (Plate II-B) is by far the largest, with a population of about 1,500. The others, with their population, are Aguanish, 235; Johan Beetz (Plate XV), 125; and Mingan (Plate XVI), 75. Havre St-Pierre is the site of a large modern hospital, a normal school, and a cold-storage plant maintained by the Provincial Government (Plate III-A).

A telegraph line is in operation along the coast, connecting the main centres with Tadoussac and Quebec city.

Both Havre St-Pierre and Mingan are deep-water harbours with good dock facilities.

Marine fish, which are abundant along the coast, provide the chief means of livelihood for the inhabitants of this area. Salmon are caught in nets along the shore and cod and halibut with trawl-lines from the banks off-shore. A few fishermen are equipped to net mackerel. Salmon, as well as trout, abound in the numerous rivers and streams entering the gulf. Whales and porpoise are plentiful in the off-shore waters but up to the present no attempt has been made to found an industry on these. Clams are dug from a silt bar north of St-Charles island and are canned for market in a small home cannery, located on the island.

There are no moose or deer along this section of the coast, and only a few caribou. Fur-bearing animals, chiefly fox, mink, and muskrat, are trapped during the winter months.

Wild duck are abundant, particularly eider duck, which nest in great numbers along the coast.

The majority of the families along this section of the coast cultivate their own vegetable gardens, which are well cared for and appear to be very productive. Some families are able to grow enough vegetables each season for a whole year's supply. The chief crops are potato, turnip, and cabbage.

Farming enterprises are seriously handicapped by the scarcity of suitable soil. The gardens of some of the families living in Johan Beetz are more than a mile from the village, as there is no suitable soil available in the immediate vicinity.

Some livestock, chiefly cattle, is kept. A considerable

amount of wild hay, which provides winter feed for the cattle, is gathered from the swales that are found at the heads of many of the innumerable small bays along the coast. During the high, fall tides, the fishermen gather this hay in their fishing barges and transport it to their homes.

There is no timber of pulpwood size near the coast. To obtain firewood, the people of the district have to go some distance into the interior along the valleys of some of the rivers, where there are considerable stands of timber, chiefly spruce. The major part of the lumber used within the area is brought in from other parts of the Province.

GENERAL GEOLOGY

General Statement

Rocks are extensively exposed along the shore, particularly between Sauvage point and Pashashibou point, along which stretch interruptions in the exposed rock are small and infrequent. The section of the shore from Pashashibou eastward to Aguanish is essentially a narrow sand beach, but there are numerous rock exposures along it. From Mingan eastward to Sauvage point, the shore is sheltered by the Mingan islands. In this section, rock is exposed across most of the headlands, whereas, in general, the bays are occupied by sand, which in places forms cliffs of considerable height.

The consolidated rocks underlying the area are of two general types: Palaeozoic sedimentary rocks and Precambrian metamorphosed sedimentary rocks and intrusives. Palaeozoic sandstones, limestones, and shales are exposed on the islands, and across the headlands, from Mingan to Sauvage point and on some of the islands east of Sauvage point. They overlie the Precambrian rocks unconformably. To the north and east, the underlying complex is exposed. Precambrian rock is also extensively exposed along Romaine river as well as at the mouth of Mingan river. The present Precambrian surface east of Sauvage point probably represents the approximate surface on which the Palaeozoic sediments were deposited, as frequent 'sandstone dykes' (Plate IV), which resemble the basal sandstone of the Palaeozoic sedimentaries, were observed filling fissures in the Precambrian rocks as far east as the mouth of Little Watshishou river, a distance of more than twenty miles. It is assumed by the writer that these 'dykes' did not extend any considerable distance below the surface of the unconformity.

East of Sauvage point, the rocks exposed along the coast - with the exception of the sandstone dykes mentioned above - are all

of Precambrian age, for the most part metamorphosed sedimentary rocks and banded gneisses, the latter (probably also of sedimentary origin) occupying the greater part of this eastern section of the area. These are intruded by granite and concordant dykes of gabbro and pegmatite. Such dykes are found throughout the area, and small inclusions of schist are common in the gneiss. The pegmatite dykes are largest and most abundant in the vicinity of Quetachou bay; basic dykes are abundant in the same vicinity and also in the neighbourhood of Pashashibou point. Banded rocks of sedimentary origin are most abundant in the section of the shore from Johan Beetz eastward to Watshishou knoll, and across the head of Appititatte bay.

Table of Formations

<table>
<tr><td>Cenozoic</td><td>Pleistocene and Recent</td><td>Till, marine sediments, river gravels</td></tr>
<tr><td colspan="3">Great unconformity</td></tr>
<tr><td>Palaeozoic</td><td>Ordovician</td><td>Limestone, dolomite, shale, sandstone, conglomerate</td></tr>
<tr><td colspan="3">Great unconformity</td></tr>
<tr><td rowspan="6">Precambrian</td><td rowspan="3">Post-Grenville(?) Intrusives</td><td>Pegmatite</td></tr>
<tr><td>Granite</td></tr>
<tr><td>Gabbro</td></tr>
<tr><td colspan="2">Intrusive contact</td></tr>
<tr><td>Probably recrystallized Grenville(?) sedimentary rocks</td><td>Banded gneiss, augen gneiss</td></tr>
<tr><td>Grenville(?)</td><td>Quartzite, quartz-biotite schist</td></tr>
</table>

Precambrian Sedimentary Rocks (Grenville?)

Precambrian sedimentary rocks of this area have not, as yet, been definitely correlated with similar rocks of other regions, but there is a tendency to regard them as being of Grenville age. They are fine-grained quartzites and quartz-mica schists, with some interbedded conglomerate. The schists are of a siliceous character, and gradations from pure quartzite to schist were observed. These metamorphosed sedimentary rocks are intruded extensively by concordant dykes of gabbro and pegmatite. No area of considerable size in which such dykes were absent was observed.

Small, aligned inclusions of schist are common in the rocks throughout the eastern half of the area, but only in two places is there any considerable development of the sedimentary rocks. The larger of these is between the western part of Quetachou and Watshishou knoll, which is about a mile east of the mouth of Watshishou river. The other is at the head of Appititatte bay. There is also a narrow belt of metamorphosed sedimentary rocks about a mile west of the village of Johan Beetz. These belts are not continuous but are interrupted by numerous sills, dykes, and irregular bodies of gabbro, pegmatite, and granite.

The metamorphosed sedimentary rocks are marked by a pronounced bedded structure, and cross-bedding was observed in a few places (Plate III-B). There is considerable variation in the mineral composition of the rock. A thin section of a specimen taken on an island southwest of the mouth of Watshishou river contains about 98 per cent quartz, whereas another from the head of Quetachou bay contains only 25 per cent. In the latter there is about 65 per cent of feldspar, so the rock should be classed as an arkose. In some of the sections there is no feldspar. Mica ranges in amount from 2 to 10 per cent, and magnetite from scattered specks to 4 per cent.

In all thin sections examined, the quartz is in small grains, from one-twentieth to one-half of a millimeter in diameter, and in any one section the range in size is small. The grains show a somewhat rounded outline. The feldspar is clouded due to alteration, and is in irregular grains, the shape of which is controlled essentially by the interstitial space between the quartz grains. Biotite and muscovite occur as small aligned blades, both along grain contacts and cutting through other mineral grains. Magnetite is a common constituent. In the arkose referred to above, there is a definite compositional banding in the rock, with bands one to two millimeters thick. The outstanding characteristic of these bands is that one group contains much quartz and little magnetite, whereas the other contains no quartz and about 10 per cent magnetite. The magnetite is in small rounded grains, from one-fiftieth to one-tenth of a millimeter in diameter.

Some conglomerate occurs interbedded with the quartzite in the area between Watshishou knoll and Quetachou bay. The largest exposure is on the northwestern side of an island a mile and three-quarters west of the mouth of Watshishou river. This exposure is a large inclusion in gabbro and has a stratigraphic thickness of at least 50 feet. Pebbles up to one foot in diameter were observed. These have been elongated slightly in the direction of strike, and considerably so in the direction of dip. They are mainly quartzite, from coarse-grained to fine-grained and occasionally banded. Scattered pebbles of fine-grained granite or rhyolite were observed, but no pebbles of dark rock. It is possible that the granitic and rhyolitic pebbles are recrystallized arkose, rather than of igneous origin.

About half a mile to the northeast, on the eastern side of a small point, there is an exposure of conglomerate about five feet across. Many of the pebbles in this rock are well rounded, and they range from about one inch to four inches in diameter (Plate V-A). They are chiefly quartzite, but some may be a fine-grained granite.

The schist facies of the metamorphosed sedimentary rocks is not common. One of the best exposures of this type seen is in the belt half a mile west of Johan Beetz. Here the schist is injected by many small bodies or irregular dykes of pegmatite (Plate V-B) intruded strictly parallel to the bedding. The intrusive rock is irregular, with much pinching and swelling (Plate VI-A and B). Swellings to more than a foot in width are not common, and some of the dykelets are mere stringers. The spacing between the dykes is from about one foot down to a complete lit-par-lit injection, with minute lenses and stringers of pegmatite constituting as much as 50 per cent or more of the volume of the rock (Plate VII-A and B).

Gneiss

Most of the exposed rock along the shore of the eastern part of the area is gneiss. Similar rock is exposed at the mouths of Mingan and Romaine rivers, and it is assumed that gneiss is the predominant rock underlying, and exposed to the north of, the Palaeozoic formations of the area. There are many dykes of gabbro, pegmatite, and granite, as well as inclusions of schist, in the gneiss.

Two general kinds of gneiss occur within the area. These are differentiated on the map as banded gneiss and augen gneiss, but all gradations between the two types are met with. An average was made of the estimated mineral composition of nine thin sections of augen gneiss, four of banded gneiss, and nine of granite. It was found that the averages for the three groups were so similar that the

rocks could not be differentiated on this basis. For the augen gneiss, which is most similar to granite, the average was 30 per cent quartz, 35 per cent orthoclase, 20 per cent microcline, 10 per cent plagioclase, and 5 per cent biotite. One difference of some significance between the granites and the gneisses is in the composition of the plagioclase. The index of refraction of the plagioclase in some thin sections of gneiss is higher than that of Canada balsam, whereas the plagioclase in the granite sections has a lower index than balsam. This indicates an acidic (high soda) composition for the plagioclase of the granite and a medium composition for at least some of the plagioclase of the gneiss.

The gneisses of both types are characterized by a strong banding. In the typical banded gneiss, bands and lenses consisting of feldspar and quartz, with a maximum thickness of about an eighth of an inch, are separated by streaks of biotite which makes up about 20 per cent of the rock as a whole. Injected into this gneiss is a series of concordant, pink dykes in the form of long, thin lenses, there being, as an average, one dyke for every foot or so of stratigraphic thickness. Usually, these dykes are from one-eighth of an inch to an inch in width, but rarely they widen to as much as two or three inches and then have a true pegmatitic character. The thinner portions of the dykes grade into the gneiss. In places there are also concordant dykes of fine-grained pink granite.

The augen gneiss is well developed in the area from Sauvage point to Victor bay; on the southeastern point of Appititatte bay and on Puyjalon island; and from the mouth of Corneille river eastward to about a mile west of Johan Beetz. The most extensive stretch of this gneiss, however, is from about a mile east of the mouth of Watshishou river to Pashashibou bay. There are two major breaks in this stretch, one at Pontbriand bay and the other at Mascanin bay, where rock exposures are predominantly banded gneiss. Scattered bands and lenses of augen gneiss occur in the banded gneiss.

The augen gneiss varies in appearance from place to place, but where best developed it consists of lenses of pink felsitic material in a greyish, banded matrix. Lenses up to two inches long and an inch wide are common, and in the aggregate they make up as much as 50 per cent of the total volume of the rock (Plate VIII-A).

The matrix of the augen gneiss consists of well-sheared biotite and some hornblende in irregular stringers and lenses from a quarter of an inch to two inches long and from one-eighth to one thirty-secondth of an inch wide. These are separated by rather continuous, fine- to medium-grained, granulose lenses of glassy quartz and white feldspar, from one-eighth to one-half of an inch wide, the usual width being about one-quarter of an inch. Both the feldspar and the quartz

show pronounced granulation. Pink feldspar (orthoclase and microcline) occurs as conspicuous thick lenses, or 'augen', and as innumerable small stringers and elongated streaks. The quartz is most abundant in the immediate vicinity of the biotite, and orthoclase fills the central parts of the lenses.

Well-developed augen gneiss shows little resemblance in appearance to well-developed banded gneiss. A gradation from banded schist through banded gneiss to augen gneiss, by increasing amounts of pegmatitic material, together with recrystallization of the schist, was, however, observed. Bands and lenses of augen gneiss were seen in the banded gneiss, the contacts between the two types being gradational. In both cases an important factor in their formation has been the injection of magmatic fluids. In some places, the injection of material is clearly demonstrated by the presence of definite, irreguler, dykes of pegmatitic character, injected along the bedding planes of the schist (Plates V-B and VI-A). In other places there are irregular small dykes, with definite pegmatitic characteristics, along with innumerable small stringers and lenses, all strictly parallel to the banding of the schist (Plate VII-A). This rock marks an intermediate stage between schist and augen gneiss. Another stage in the change can be seen where the rock grades into one containing a large percentage of the minute stringers and lenses of pink felsitic material (Plate VII-B). The similarity of these to the matrix of the rock described above can leave little doubt but that this rock represents a more advanced stage in the change from schist to gneiss.

A further indication of a genetic relationship between the gneiss and pegmatite is shown by the character of the contact, where pegmatites cut across the structure of the gneiss. The characteristic contact has the pegmatite feathering into the gneiss, showing no sharp contact (Plate VIII-B). This is quite in contrast to the sharp contact found between the gneiss and dykes of granite (Plate IX-A).

Microscopic examination of thin sections of some of the rocks whose sedimentary origin is beyond doubt shows that they are rich in feldspar. It is the opinion of the writer that the more permeable sedimentary rocks were thoroughly penetrated by aqueo-igneous solutions, which brought about an extensive and rather complete recrystallization of the original minerals and at the same time added considerable new material to the rock, particularly in the form of innumerable small, irregular dykes, stringers, and lenses of pegmatite. This recrystallization apparently was selective, with rocks high in quartz undergoing little change. The sedimentary rocks with a high ferromagnesian content seem also to have undergone little change, other than for the formation of much hornblende.

Similarly, the writer believes that both the banded gneiss and the augen gneiss, as well as their gradational facies, are recrystallized sedimentary schists which were injected and saturated to varying degrees by pegmatitic material. The present close similarity in composition between these gneisses and the granite of the area is due, not so much to the various processes of metamorphism, as to the original composition of the sediments concerned.

Anorthosite

Anorthosite is exposed at the mouth of Romaine river, outcropping at intervals over an area about half a mile long and a quarter of a mile wide. The outcrops are on the northern side of an island and on the mainland west of the river. Although the exact areal limits of the mass are not known, it is believed by Retty[1] to be a relatively small body apparently separated from the extensive mass of anorthosite that lies two to eight miles north of the shore in the western part of the area.

Gabbro

The rock here described has the appearance of gabbro, and much of it is true gabbro, but the petrographic dividing line, on the basis of feldspar composition, would place part of it as diorite. The composition of the plagioclase varies from dyke to dyke, and in the larger ones from place to place within the dyke, with range from andesine to sodic labradorite. It is quite possible that, during the alteration which the rock has undergone, there has been some change in composition of the plagioclase toward the sodic end of the series, and that the original feldspar was more calcic than that now found in the rock. Possibly all of the original rock was a normal gabbro.

Concordant dykes of gabbro are common throughout the areas of gneiss and abundant in the areas of quartzite and schist. The width of any individual dyke is rather constant, but the range in width is considerable. The majority are less than 50 feet wide and a width of less than five feet is rare; a few with a width of as much as 500 feet were seen. On the eastern side of the head of Pontbriand bay, in a distance of 1,000 feet across the strike of the banded gneiss, 32 dykes of gabbro were crossed. Besides being exceptionally abundant, they are narrower here than is usual in the area. They range in width from six inches to twenty-five feet, the majority being from three to six feet wide.

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[1]Retty, J.A., Lower Romaine River area, Saguenay County; Que. Dept. Mines, Geol. Rept. 19, Map No. 582, 1944, p.13.

The most extensive area of gabbro outcrop is from Pashashibou river to Pashashibou point, a distance of about four miles. For the greater part, the exposures along this section of the coast are gabbro. It is quite probable that they represent a wide dyke trending west of north, in which case the gabbro body would not be as large as might be suggested by the extensive outcropping along the shore. Between Quetachou bay and Watshishou knoll, eight zones are predominantly gabbro. Several large dykes of gabbro are found at the head of Appititatte bay, and on the eastern side of Mascanin bay. In the latter locality they are coarse-grained and have a diabasic texture.

The gabbro intrudes the Precambrian sedimentary rocks and gneisses of the area. In many places pegmatite dykes were observed cutting the gabbro, and granite dykes cutting gabbro were also seen. This places the gabbro as definitely younger than the Precambrian sedimentary rocks and gneiss, and older than the pegmatite and granite. A striking example of pegmatite cutting gabbro may be seen on the point on the eastern side of Quetachou bay, where the gabbro is intruded by large and small irregular bodies of pegmatite which have a general alignment parallel to the trend of the gabbro dyke (Plate IX-B).

One composite dyke about ten feet wide that is well exposed at a point approximately two miles west of Mascanin bay has both rounded and irregularly-shaped blocks of gabbro in a matrix of medium-grained granite (Plate X-A). This dyke was followed southeastward for a distance of more than 1,000 feet. The contacts between the gabbro blocks and the granite matrix are irregular but definitely not gradational. The margins of the dyke are invariably granite. The origin of this composite dyke is somewhat of a problem.

The majority of the gabbro dykes are fine-grained (basaltic) along their walls, but they grade into typical coarse-grained gabbro within a very short distance from their margins. In some of the larger dykes this change in grain size is accompanied by a change in the composition of the feldspar.

A study of thin sections of the gabbro shows that the plagioclase content varies between 50 and 25 per cent. The remainder of the rock is chiefly hornblende, with chlorite, uralite, and epidote as alteration products. In some sections, skeletons of original pyroxene crystals remain. The hornblende is fresh in appearance and is frequently in euhedral crystals. These factors suggest that the hornblende is a product of recrystallization, and that the original rock consisted of plagioclase and pyroxene.

Granite

Granite was seen cutting quartzite, schist, gneiss, and gabbro. In general it is cut by pegmatite, but granite cutting pegmatite was also observed. It is probable that the granite and pegmatite are genetically related. In view of the massive character of the granite, it must be accepted as being of intrusive origin, in contrast to the sedimentary origin assumed for the gneisses, which are of similar mineral composition.

Massive granite was observed at four places in the area. The largest body extends from the large islands at the mouth of Corneille river westward to about a mile east of Appititatte bay, a distance of four miles. A body of similar granite is exposed at the village of Johan Beetz. This extends eastward from the village for about a mile and westward for about half a mile. There is also a small area of granite on the eastern side of Watshishou knoll. From half a mile to a mile and a half west of the mouth of Watshishou river, three dykes, each about 500 feet wide, of fine-grained granite porphyry intrude the sedimentary-gabbro complex. Many dykes of fine-grained, massive granite and aplite occur in the areas of gneiss but such dykes are much less common in the sedimentary-gabbro areas.

All of the granite exposed is medium-grained, and pink in colour. Much of it is massive, but in some places an obscure foliation was observed. All the thin sections of the rock that were examined contain microcline. The amount present ranges from 20 to 40 per cent, with 25 to 30 per cent in most of the sections. Quartz and orthoclase each range from 25 to 40 per cent, with an average of 35 per cent. Other constituents are sodic plagioclase and biotite, both in small amount, and apatite and zircon as common accessory minerals. The microcline has undergone little alteration, whereas in most thin sections the orthoclase is considerably altered, chiefly to sericite and kaolin. This suggests that the microcline is a product of recrystallization.

Pegmatite

Pegmatites, with associated fine-grained aplites, are the youngest Precambrian rocks in the area. They were observed cutting all of the other Precambrian rock-types, and inclusions of gneiss and gabbro were seen in pegmatite.

Pegmatites are common in the areas of quartzite, schist, gabbro, and gneiss. In the schists, in particular, pegmatites are

injected in lit-par-lit fashion and in the form of small bands, stringers, and lenses (Plates V-B, VI-A and VI-B). These intrusions have saturated the schists to various degrees, and the writer believes, as mentioned earlier, that the banded, augen, and granitic gneisses of the gneiss complex have originated as the result of varying degrees of permeation of sedimentary schists by pegmatite (Plates VII-A, VII-B and VIII-A). There are also pegmatites which cut across the structure of the rocks they have invaded. The pegmatites cutting gabbro are, in general, of a more massive character than those injecting the sedimentary schists.

Although pegmatite bodies are common throughout the area, they are most abundant, and of greatest size, in the immediate vicinity of Quetachou bay, where many are more than 50 feet wide. Large pegmatite dykes occur also in the area between Quetachou bay and Watshishou knoll. The widest mass of pegmatite observed occupies the full extent of Gull island, which is immediately south of Quetachou bay and is about 1,000 feet wide.

The larger dykes are characterized by frequent pinching and swelling along their strike.

On an island at the head of Victor bay there is a cliff exposing pegmatite that is about 50 feet wide at the top of the cliff but pinches to a very narrow dyke at the bottom. From this observation, the writer infers that there is much pinching and swelling of the pegmatite bodies in the vertical plane as well as along their strike.

The pegmatites vary greatly in grain size. The most coarsely crystalline types observed are in the vicinity of Quetachou bay where, in many of the pegmatites, feldspar crystals up to a foot across are common and some measuring as much as three feet were seen. These very coarse-grained pegmatites are composed predominantly of microcline and orthoclase. Quartz occurs interstitial to, as well as in graphic intergrowth with, the feldspar. Some biotite and muscovite are present and, locally, the latter is abundant. The muscovite crystals are of large size, but have been sheared by dynamic stresses and are completely shattered. The largest flake of muscovite the writer succeeded in obtaining during the summer was less than three inches across. Other minerals locally present include tourmaline, garnet and, more rarely, beryl.

The headland of which Watshishou knoll is a part (Plate X-B) is formed largely of pegmatite dykes striking northeast and dipping about 60° to the northwest. The pegmatite here differs from that encountered in any other part of the area in that is has been

thoroughly brecciated and re-cemented with opaque, milky-white quartz in an intricate mesh of small veinlets. In places, over half the volume of the rock is quartz. Considerable hydrothermal alteration, probably related to the introduction of the quartz, has taken place in this zone. Quartz ridges extend northeastward, along the line of strike of the zone, for more than two miles[1].

Palaeozoic (Ordovician)

All of the Mingan islands, which hug the shore along the western part of the map-area for a distance of about 45 miles, are underlain by Palaeozoic sedimentary rocks of Ordovician age. In addition, a narrow strip of the coast between Pointe aux Morts and Sauvage point is underlain by similar rocks, though exposures here are almost entirely confined to out-jutting points. Inland exposures are scarce, the most important being Mont Ste-Geneviève, about two miles inland from the west side of Appititatte bay.

There is a sharp unconformity between the Palaeozoic rocks and the underlying Precambrian crystalline complex. In places, the basal member of the Palaeozoic series is a fine-grained sandstone which consists of uniformly-rounded, well-sorted grains of quartz cemented by calcareous material. This sandstone rests unconformably on a rather regular surface of the underlying Precambrian rocks. The contact is well exposed at Sauvage point (Plate XI-B).

The sandstone 'dykes', which here and there for a distance of twenty miles east of Sauvage point fill fissures in the underlying Precambrian complex, and which were described on an earlier page of this report, are a portion of this basal sandstone.

Twenhofel[2], who has studied these rocks in considerable detail, divides the Mingan Islands sequence into two formations — the Romaine below and the Mingan above — these being separated by a well-defined unconformity.

According to Twenhofel, the Romaine formation, about 260 feet thick, is composed mainly of microscopically-crystalline to fine-grained, massive dolomite, with a little shale. Generally the beds are thick, ranging up to ten feet. Some horizons are nicely bedded, but more generally the bedding is uneven and, in some places, the beds

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[1]Claveau, J., Quartz Deposit at Watshishou Hill, Lower St. Lawrence River; The Mining Industry of the Province of Quebec in 1944, pp.43-45, 1945.

[2]Twenhofel, W.H., Geology and Paleontology of the Mingan Islands, Quebec; Geol. Soc. Am., Special Papers, No. 11, 1938.
Twenhofel, W.H., Geology of the Mingan Islands; Geol. Soc. Am., Bull., Vol. 42, No. 2, pp.575-587, 1931.

appear to be kneaded together. Fossil remains are scarce and, where present, are almost always poorly preserved.

The overlying Mingan formation, about 150 feet thick, is composed chiefly of fine-grained limestones (Plate XI-A), in which fossils are abundant in many horizons. The bedding planes are quite even and some of the beds are as much as five feet thick. The basal portion of the formation consists of a variable thickness of conglomerate, sandstone and shale, although in some exposures one or other of these is lacking.

A total of 111 species of fossils have been described from these rocks – 37 from the Romaine formation and 74 from the Mingan. The Romaine is correlated with the upper part of the Beekmantown and the Mingan with the Chazy of the Lake Champlain region.

In general, the Palaeozoic sedimentary rocks have a very low dip to the south. This is reflected in the topography of the islands, which tend to have a gentle slope on their southward side and an erosion scarp on their northern side. Over extensive areas, however, the dips are negligible and the strata are essentially horizontal.

Pleistocene and Recent

Innumerable glacial striae and polished rock surfaces give abundant evidence of glaciation in the region covered by this report. Much of the polished and striated rock surface is irregularly rounded, having the general appearance of small 'roches moutonnées', and, in many places, fluting of the rock surface is quite striking (Plate XII).

Unconsolidated sediments, deposited during the Champlain stage of the Pleistocene epoch, are present, particularly in the vicinity of Mingan and Havre St-Pierre, because at these places a large amount of sediment was carried into the Champlain sea by Mingan and Romaine rivers. Elsewhere, little surface débris or soil covers the bed-rock.

STRUCTURAL GEOLOGY

Some indication of the structure of the region, at least adjacent to the coast, is afforded by a study of the rock exposures along the shore. However, considerable work will have to be done in the interior before a reliable picture can be obtained.

Little evidence of faulting was observed, and the area is also remarkably free of shear zones. Any change in the strike of the bedding and banding is usually gradual, although, in a few localities, abrupt changes were observed. The structural trend of the rocks of the coast can almost invariably be ascertained from the attitude and orientation of the bays, points, and clusters of small islands hugging the shore. The dip of the bedding and foliation structures of the Precambrian rocks is almost everywhere steep.

The exposed rocks of the western part of the area are predominantly Palaeozoic sedimentary rocks. These have a very low southward dip, and are capped by massive limestones. In places, the undercutting action of the waves has resulted in the formation of steep cliffs.

The Precambrian rocks exposed near the shore of the mainland in the western part of the area have a general northeast to east strike. From Sauvage point to Appititatte bay, inclusive, the formations strike nearly east-west. At the head of the bay, the dip of the east-striking schists and quartzites varies from steeply south to vertical. Determinations on cross-bedding (Plate III-B) show that the tops of the strata are to the north, so that the beds that apparently dip south must be overturned.

The strike of the gneisses immediately east of Appititatte bay is from east to northeast. There the gneisses give place to massive, fine-grained granite, which extends eastward to Corneille river. East of this river the foliation of the gneiss has a general northeast strike which becomes north-northeast with a vertical dip near the Precambrian sedimentary rocks west of Johan Beetz.

A narrow belt of schist on the west side of the mouth of Piashti river strikes almost north-south, whereas east of the mouth of the river, and all around Quetachou bay, the quartzite and schist strike northeast and have a predominant vertical dip. The sharp change in strike between the mouth of Piashti river and Quetachou bay suggests that there may be a fault along Piashti river.

In the sedimentary belts between Quetachou bay and Watshishou knoll there is, going eastward, a progressive change in strike from northeast to east-northeast, and the dip gradually lessens from nearly vertical to about 60° to the northwest. West of the mouth of Watshishou river, determinations on cross-bedding show that the tops of the strata are to the northwest.

The strike of the metamorphosed sedimentary rocks, concordant basic intrusives, and pegmatite dykes in the section of the

shore from Piashti river to east of Watshishou knoll is northeasterly, and their dip is steep to the northwest. However, the Watshishou, Little Watshishou, and Piashti rivers, which near the coast follow northeastward courses parallel to the trend of the formations, tend to assume, not far from the shore, courses (not shown within the limits of the present map) which swing toward the north and north-northwest and which likely reflect a similar change in the strike of the underlying rock formations. Such a change in strike was suggested by Claveau[1] from previous reconnaissance work through the inland region lying north of Quetachou bay. Claveau recognized through that region an anticlinal structure, the axis of which trends S.25°E. through Beetz lake, which is 15 miles due north of Quetachou bay. He suggested that, southeast of Beetz lake, the trend of the anticlinal axis gradually swings from S.25°E., through south, and finally to S.35°W. in the vicinity of the St-Lawrence shore.

The writer feels confident that the changes in direction of the courses of Watshishou, Little Watshishou, and Piashti rivers reflect the similar changes in the strike of the rock formations, as suggested by Claveau, and that the sedimentary belt lying between Quetachou bay and Watshishou knoll belongs to the extensive structure which he described.

Continuing eastward along the coast, the gradual change in the strike of the formations continues, and, at the mouth of Little Watshishou river, the trend is approximately east-west. East of the mouth of this river, it changes rather abruptly to southeast and south. East of Pontbriand bay, the strike changes sharply from northeast to north, suggesting a flexure to the south, around the mouth of Pontbriand bay. The elongation of 'augen' in the gneiss suggests that the fold has a steep southward plunge.

The general slightly west of north strike of the formations east of Pontbriand bay continues, with minor variations, to Pashashibou river. On the west side of Mascanin bay there is an axis, trending slightly west of north, marked by changes in both strike and dip. West of this axis, the strike is about north-northwest and dips range from 35° to 50°west. East of the axis, the strike is slightly east of north, and dips range from 30° to 60° to the east. These features indicate an anticlinal structure plunging to the south.

At the mouth of Nabésipi river, the foliation in the gneiss strikes north-south and has a steep westward dip. Other than at this location, there are not enough exposures of rock from Pashashibou point to Aguanus river to form a clear picture of the structural trend.

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[1]Claveau, J., Special Report on the Area from Forgues Lake to Johan Beetz; Que. Dept. Mines, P.R. No. 180, p.14, 1943.

ECONOMIC GEOLOGY

Occurrences within the map-area of copper minerals, molybdenite, feldspar, fluorite, and beryl have been known for many years, and have been reported and described by earlier investigators.

Metallic Minerals

Copper

Chalcopyrite was observed in several localities, and bornite at one place, along this section of the shore. Malachite staining accompanies some of the chalcopyrite.

The bornite occurs on the northeastern corner of a small island, about 1,000 feet long, three-quarters of a mile west of Watshishou river. The predominant rock of the island is a fine-grained granite porphyry. The mineralization is in slightly-sheared pegmatite along the contact between this rock and a small gabbro dyke. The zone of mineralization trends northeast and is vertical. It has been the scene of some prospecting and has been exposed by blasting across a six-foot-high face.

The zone is mineralized for a length of about fifteen feet and over a width of about two feet. It definitely does not continue to the northeast but may continue to the southwest. The bornite, with some chalcopyrite, is in small irregular pockets and fractures in the pegmatite; no mineralization was observed in the gabbro. A grab sample, assayed in the laboratories of the Quebec Department of Mines, yielded 6 per cent copper and 0.742 oz. silver per ton.

About 200 feet to the northeast, on the mainland, a fissure vein, up to an inch wide, in massive granite porphyry is filled with quartz and chalcopyrite. There are several pockets of massive chalcopyrite in this vein, the longest observed being about four inches in length. The vein contains about 10 per cent of chalcopyrite. There is no evidence of hydrothermal alteration along its margins.

On the southern end of the island, a zone of quartz about ten feet long and a foot wide extends into the granite porphyry from the southern end of a schistose gabbro inclusion. The quartz zone contains lenses of massive chalcopyrite as much as several inches long.

These three mineralized zones, occurring along a distance of about 1,200 feet, are practically aligned along the strike of the structure in the vicinity.

The most persistent zone of copper mineralization observed is along the south and southeast side of Watshishou knoll. It is probably related to a small, irregular body of fine-grained, considerably-altered granite that is exposed on the eastern side of the knoll. Scattered specks and irregular patches of chalcopyrite were seen at several places in schistose zones, and also in massive rock.

Scattered small pockets of chalcopyrite were also observed in gabbro on the islands off the point forming the eastern side of the mouth of Watshishou river. The zone is along the contact between a large body of gneiss and a belt consisting largely of quartzite. Its possible extension to the northeast constitutes a favourable location for prospecting.

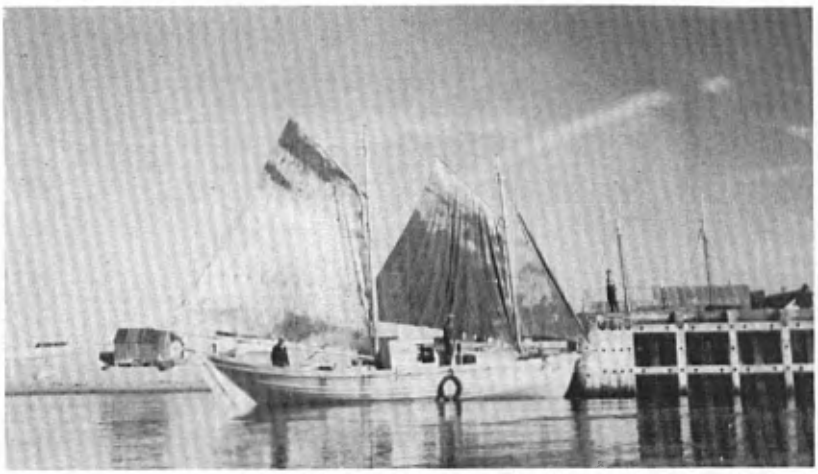
Several scattered, small pockets of disseminated chalcopyrite were seen in a narrow zone in granitic gneiss on the southern part of an island a mile and three-quarters east and one-third of a mile south of the southernmost tip of Puyjalon island. Assay of a sample from one of the pockets yielded approximately 3 per cent copper and 0.01 oz. gold per ton. The rock in the vicinity is sufficiently well exposed that there is little possibility of an immediate extension of the zone having been overlooked.

Many small quartz veins and shear zones in the metamorphosed sedimentary rocks and gabbro exposed across the northern part of Appatitatte bay are sparsely mineralized with pyrite, and occasionally with chalcopyrite.

A mile and a quarter southwest of Johan Beetz, on the western shore of a long, narrow bay, a small zone of fissure veins, mineralized with calcite, quartz, fluorite, and chalcopyrite, occurs at the water's edge, though it is completely exposed only at low tide. The zone, which is about 30 feet wide and is exposed for a length of 100 feet, is in gneiss cut by small pegmatite dykes. It trends approximately north, and the veins themselves about 20° west of north. The veins have a maximum width of four inches, with an average of one inch. The openings are lined with clear quartz crystals with dimensions of about half an inch by one-quarter of an inch, but for the most part the fissures are filled with transluscent calcite. In many places, they contain the small amount of clear green fluorite. Scattered crystals and irregular grains of chalcopyrite also occur in the veins.

Grab samples from five of the showings, assayed in the laboratories of the Quebec Department of Mines, yielded from 0.002 to 0.01 oz. gold per ton, but only one specimen contained over one per cent of copper.

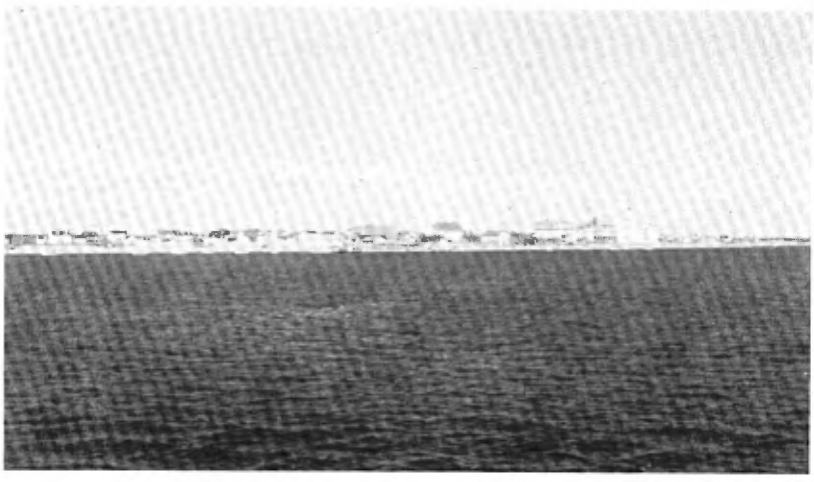
Plate I



A—Walter Cormier's fishing barge, Havre St-Pierre.

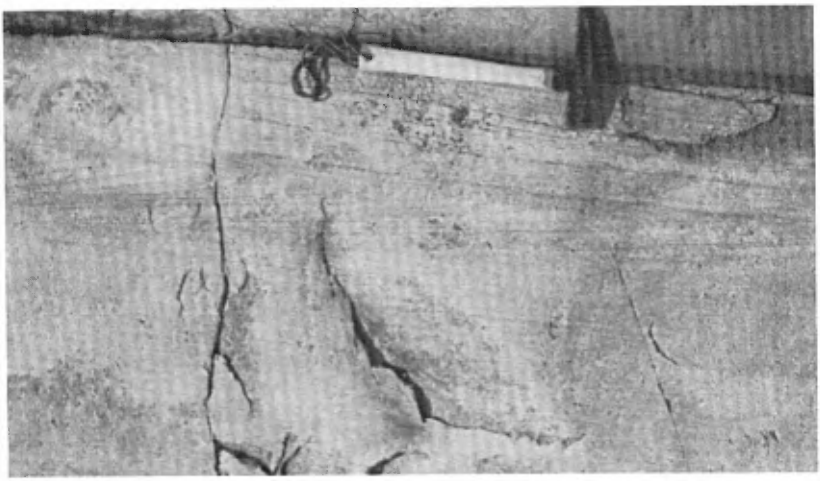
B—Flat, irregular shoreline, west of Watshishou knoll.

A—Flat, irregular shoreline, east of Watshishou knoll.



B—Waterfront of Havre St-Pierre, showing normal school and hospital on right.

A—Dock at Havre St-Pierre, Right to left, government storage warehouse, cold storage plant, Labrador Fisheries' general store.

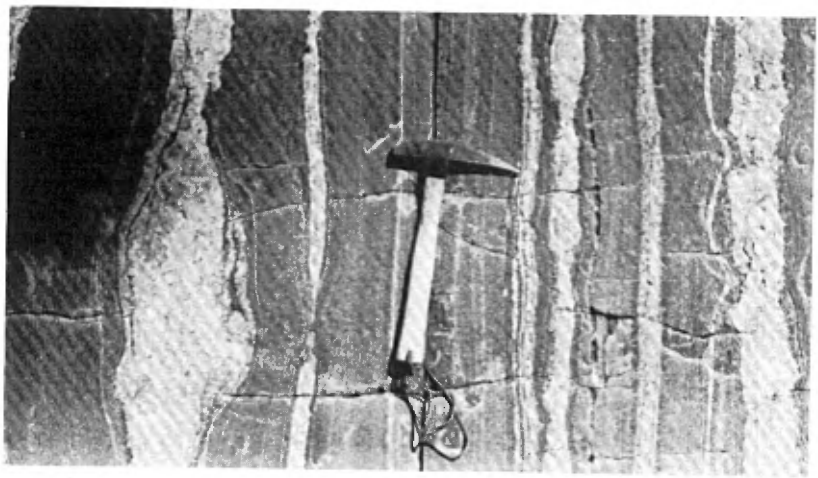


B—Cross-bedding, in Precambrian sedimentary rocks, north side of Victor bay. Point of hammer to north.

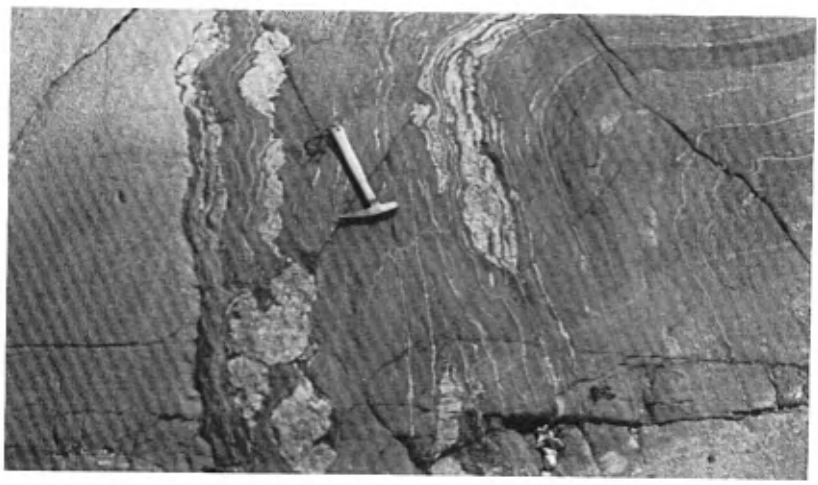
"Sandstone dyke", north shore of Victor Bay.

A—Conglomerate, west of Watshishou river.

B—Irregular pegmatites injected in schist.



A—Close-up of irregular pegmatites, injected in schist.



B—Irregular pegmatites in schist.

G.R. 42-

Aargau gneiss : Roche rose à grain grossier, feldspath, gly biotite, très bonne foliation

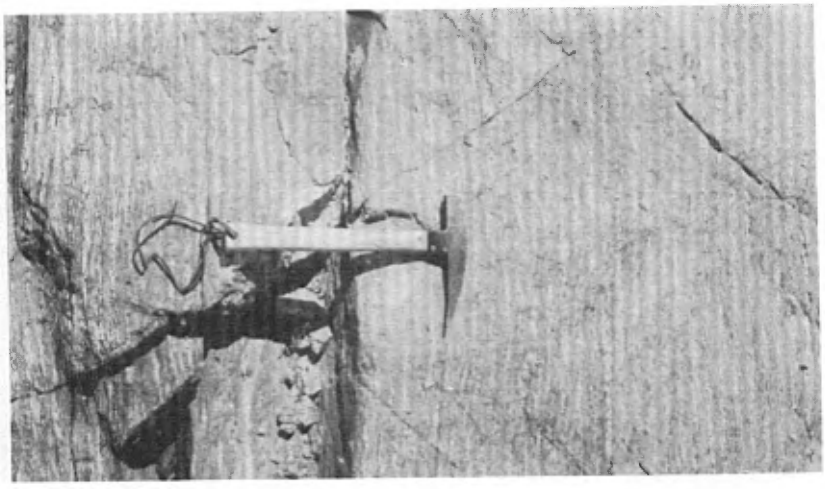
certains echant ressemble au granite porphyroïde du lac Bertz lorsque la foliation est moins marquée et % de biotite moins fort
Par contre très différent si % marqué augmente on devient en vrai gneiss oeillé.

Hobbo : roche noire g. moyen % de biotite fort, feldspath lenticulaire peut être gly (5)

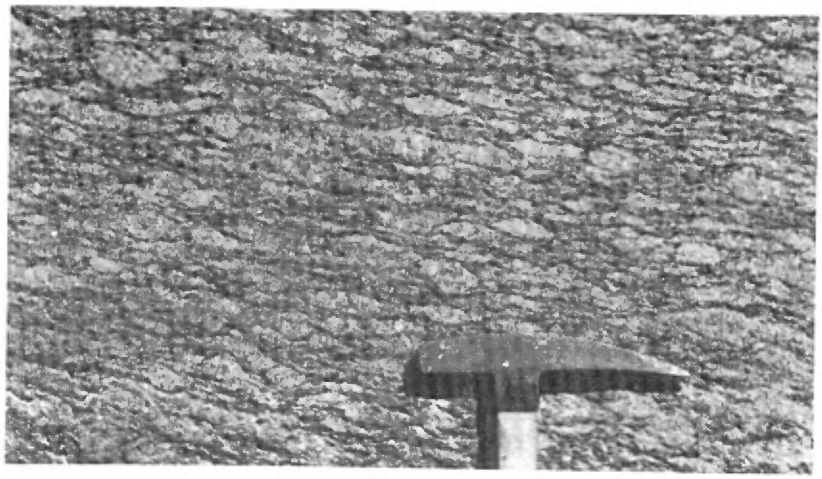
Banded Gneiss [2] roche rose à grain moyen bonne foliation ressemble au granite [2]

[11] roche noirâtre grossière bandes riches en gly ½" à moins alternant avec bandes noires fort % biotite
ressemble quelque peu au gneiss de Whitehorn Lake

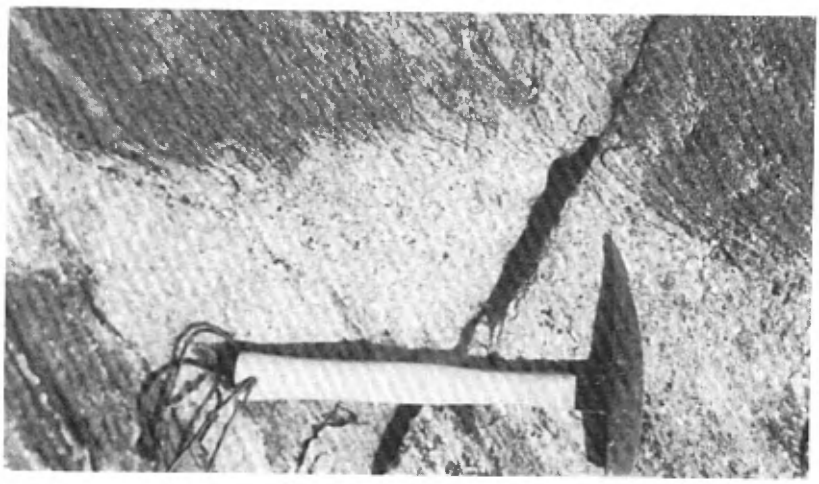
A—Irregular dykes, lenses, and stringers of pegmatite in schist.



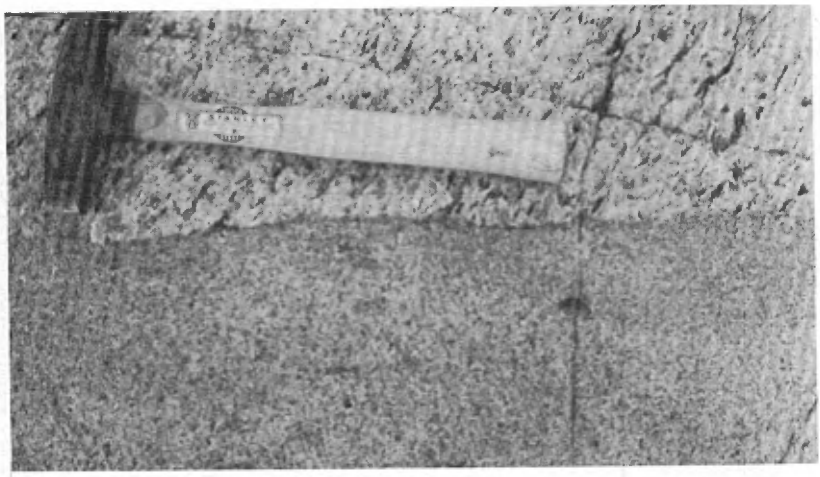
B—Irregular lenses and stringers of pegmatite in schist.



A—Augen gneiss.

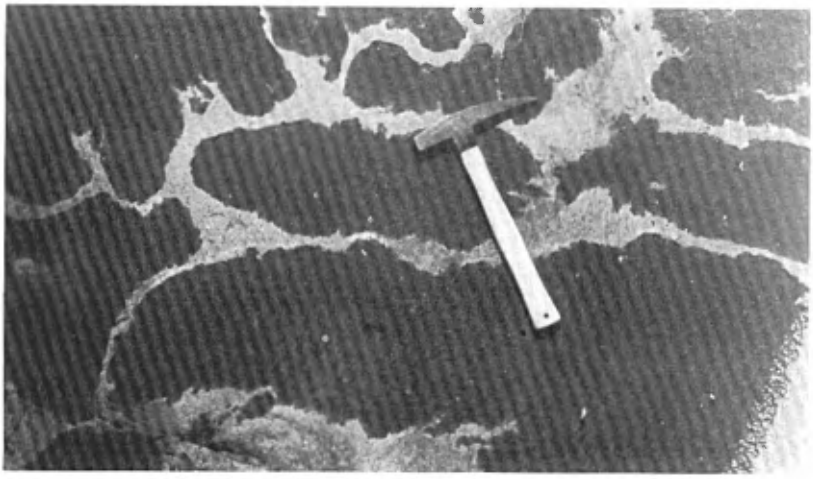


B—Gradational injection contact between augen gneiss and pegmatite.

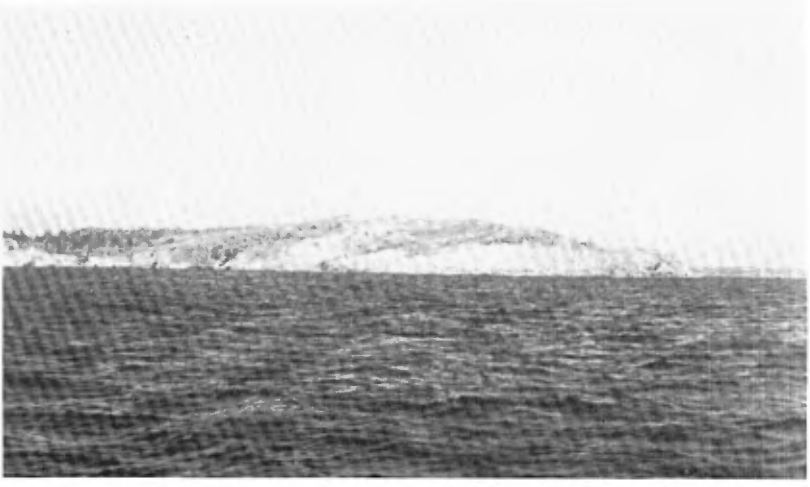


A—Sharp contact, granite cutting augen gneiss.

B—Large, irregular pegmatites, (light colour) intruding gabbro dyke, "Thelminia Mines".



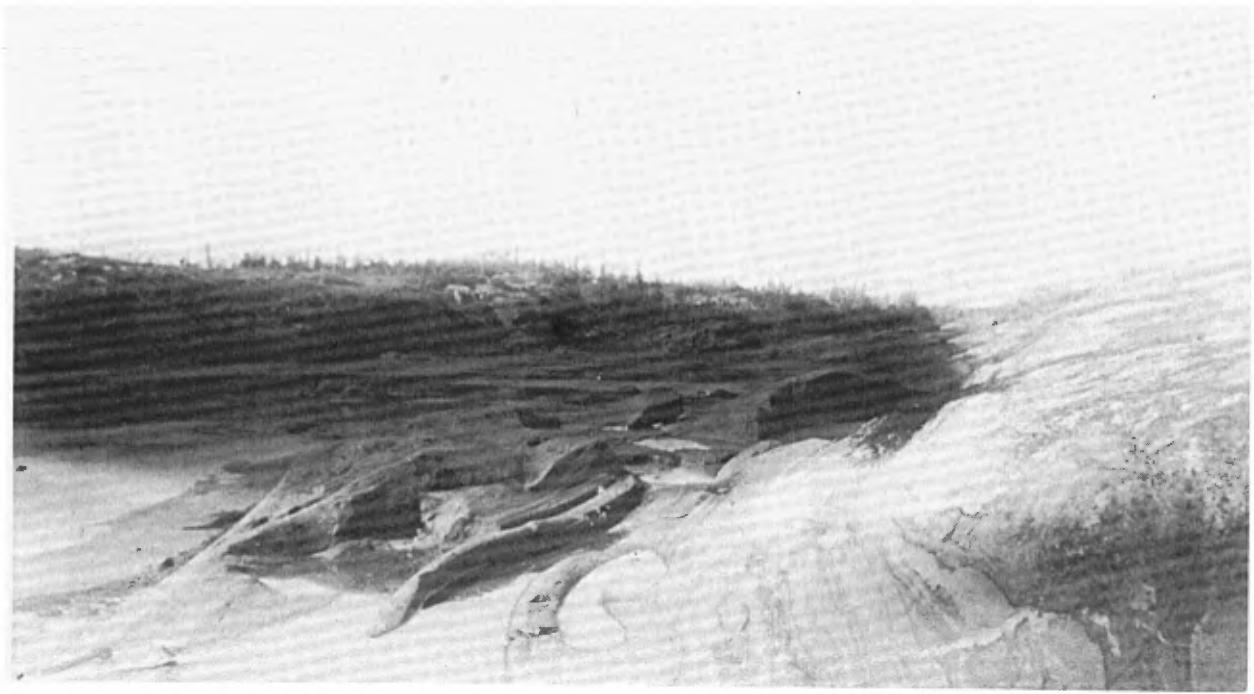
A—Irregular, rounded blocks of gabbro, surrounded by a matrix of granite.



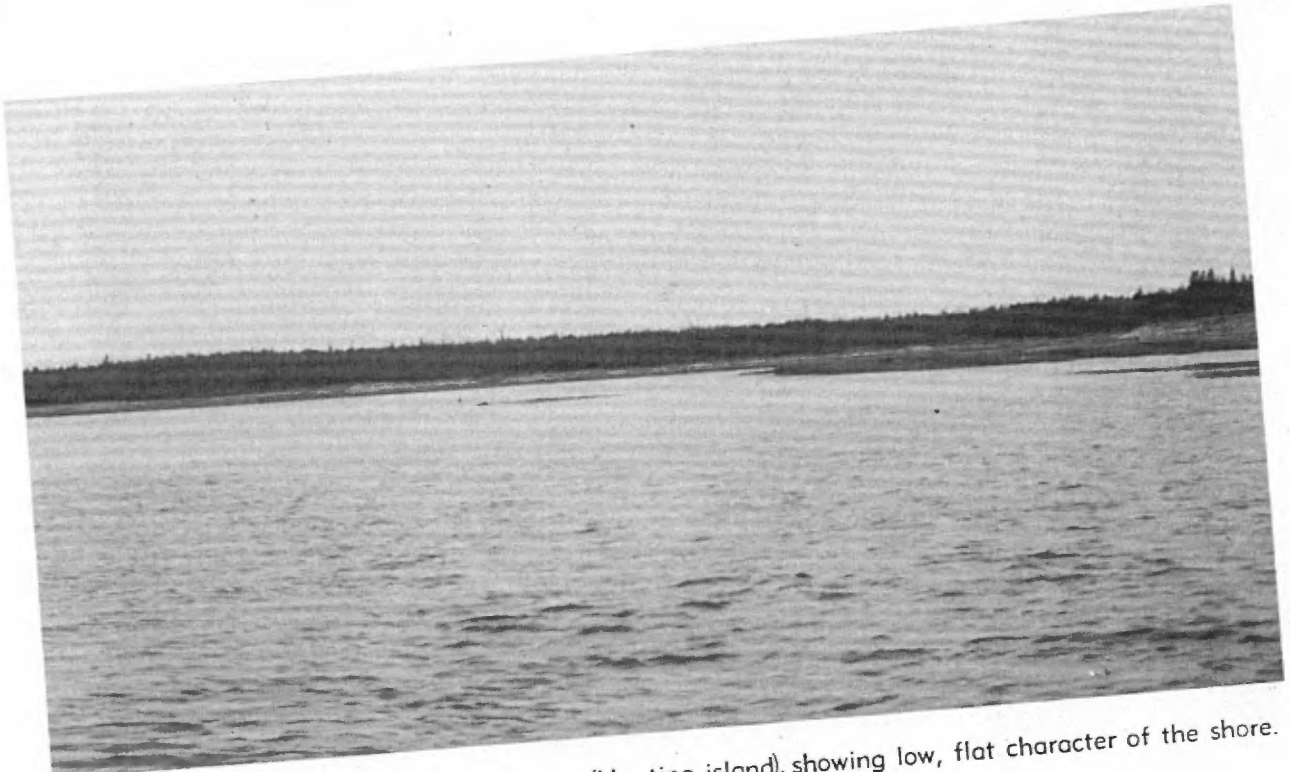
B—View of Watshishou knoll.

A—View showing massive, blocky character of limestone capping Havre-Mingan island.

B—Unconformity between Palaeozoic sedimentary rock and Precambrian gneiss. The hammers are resting on the gneiss.

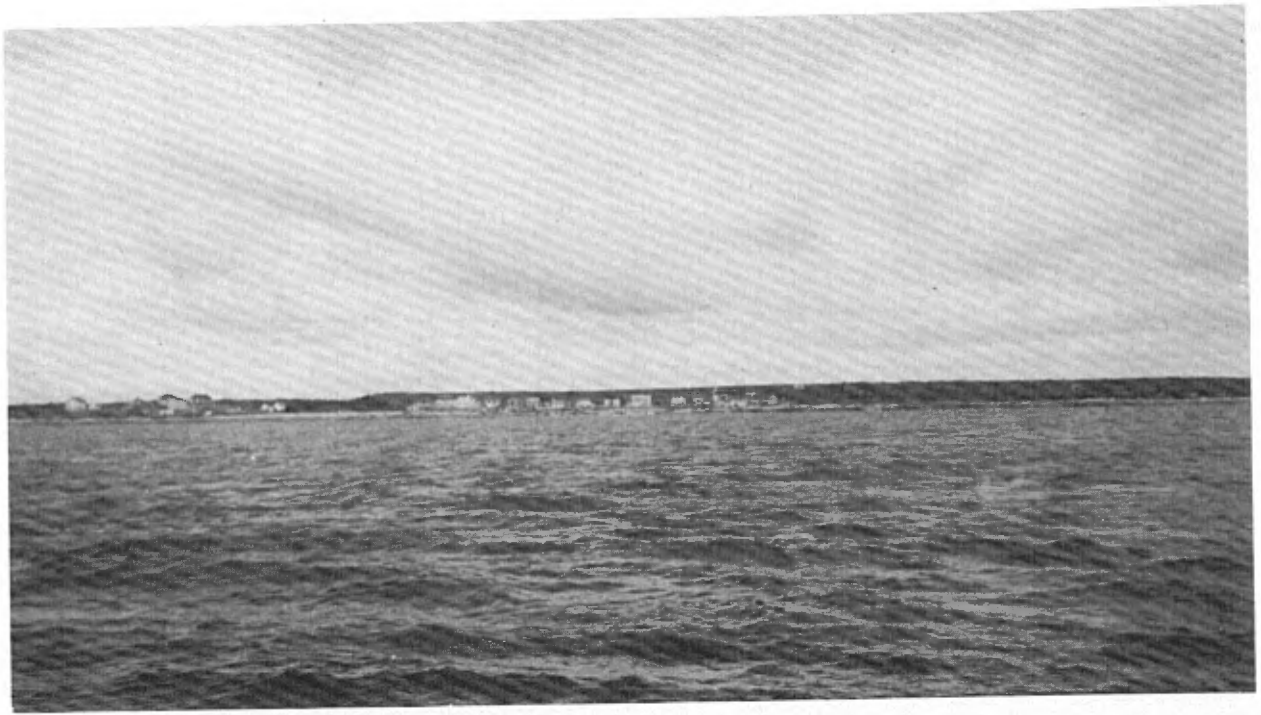


Rock fluting caused by glacial erosion. The rounded tongue is about a foot wide and rises about a foot above the water.

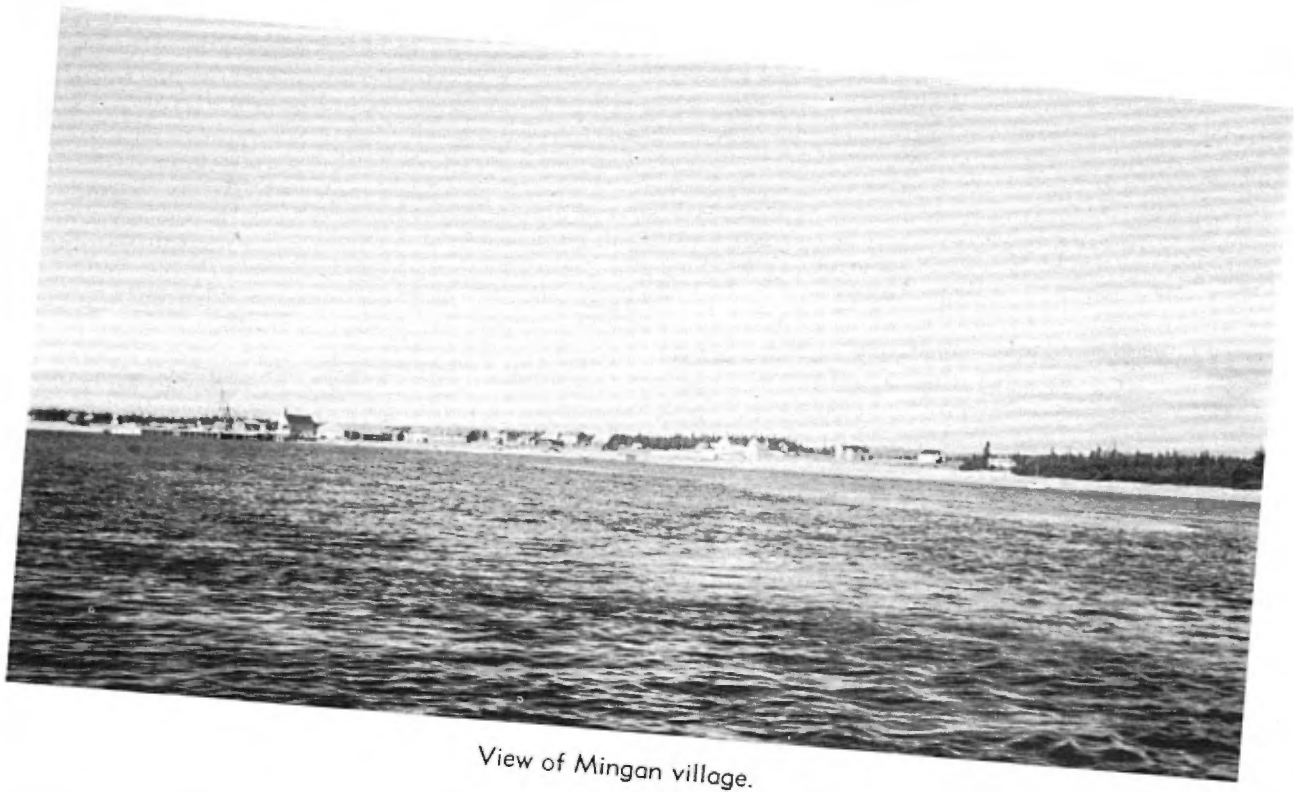


View of MacLeod harbour, île à la Chasse, (Hunting island), showing low, flat character of the shore.

Quarry at "Thelminia Mines".



View of Johan Beetz village.



View of Mingan village.

Small crystals and specks of chalcopyrite were observed in calcite vugs in the Palaeozoic limestone of Havre-Mingan island, at Mingan. Although this occurrence is of no commercial importance, it indicates some Ordovician or post-Ordovician mineralization.

Iron

Magnetite and hematite are present in noticeable quantity in some of the pegmatite dykes, particularly in the vicinity of Appititatte bay. None of the observed occurrences are of economic interest.

Molybdenite

Small amounts of molybdenite, associated with pegmatite dykes, were observed at several places. Scattered flakes of the mineral were seen in a dyke on the south side of Victor bay and in a small, white pegmatite dyke a mile southwest of Johan Beetz, on the western side of a long narrow bay.

Small, irregularly-scattered flakes of molybdenite were observed in a narrow dyke of white pegmatite cutting gabbro on the eastern side of the point at Quetachou bay on which the 'Thelminia Mines' feldspar quarry, described later in this report, is located. This is the largest zone mineralized with molybdenite that was observed within the area. The pegmatite mass, which underlies the greater part of the point, includes a narrow band of gabbro. At its southern end, where it passes under the sea, the included band is about 100 feet wide, but it narrows toward the north. It trends about N.55°E. and is probably a part of the gabbro belt occurring immediately to the southeast. An irregular dyke of relatively fine-grained, white pegmatite, striking N.55°E. and dipping 50°S.E., cuts the gabbro band about 30 feet east of its western contact with the main mass of pegmatite. This dyke is somewhat irregular in width, varying from about eighteen inches to three inches. For the greater part of its exposed length of 225 feet, however, it is between six inches and one foot wide.

The dyke is composed chiefly of fine-grained, white plagioclase with a small amount of glassy quartz. Locally, there are schistose pockets of coarse-grained biotite. These are inclusions from the contact-zone rather than constituents of the dyke.

Scattered large grains of molybdenite occur in the dyke, sometimes in incipient fractures within the dyke itself but most

frequently along its marginal or contact parts. The mineralization, however, does not extend into the country rock.

Although, locally, the dyke may contain from 5 to 10 per cent of molybdenite, it probably contains, as a whole, less than one per cent of this mineral, which is not enough to encourage development work.

Pyrite

A small zone of pyrite occurs in the Palaeozoic limestone at the southwestern end of ile à la Chasse (Hunting island). It is exposed along the beach, just at high-water line, in a small bay known as MacLeod harbour. The crust here has the same gentle slope as the bordering nearly flat-lying sedimentary rocks, rising very gradually from the water's edge (Plate XIII).

The pyrite zone trends slightly east of north. It is very irregular, with a maximum width of four feet, and an undetermined length less than 50 feet, as indicated by a barren trench extending across the line of strike north of the exposed zone.

The limestone and pyrite are exposed on the beach at low tide. The pyrite does not seem to be in a true fissure or in a zone of alteration, but occurs in small, scattered pockets. The limestone in the immediate vicinity of the pyrite contains an abundance of small, irregular chert nodules, suggesting that the chert and pyrite may have been formed from the same hydrothermal solutions. As the Precambrian basement at MacLeod harbour likely lies at a depth no greater than 150 feet below the surface, the possibility of any considerable depth to the deposit is eliminated, although the possibility of a bedding plane replacement near the unconformity between Palaeozoic and Precambrian rocks should not be overlooked.

The pyrite is massive, finely granular, somewhat spongy in character, and relatively free of admixed minerals.

This occurrence, like that of the chalcopyrite on Havre-Mingan island, indicates some Ordovician or post-Ordovician mineralization in the area.

Sphalerite and Cassiterite

Some samples of sphalerite, and one of cassiterite, were shown to the writer by two prospectors who claimed they had found them

in some loose transported rock, a few miles north of the head of Quetachou bay.

Non-metallic and Industrial Minerals

Beryl

The writer found three small beryl crystals in a pegmatite dyke on Gull island, just southwest of the feldspar quarry of 'Thelminia Mines'. Two other occurrences were reported by Claveau in 1942 from the mouth of Watshishou river. One of these is on a small island near the tip of the point on the west side of the mouth of the river, where four or five large crystals of beryl were seen in pegmatite near the water's edge on the southeast side of the island. The largest crystal measured one inch in diameter and had a length of six inches. The other occurrence is at the tip of the long point on the east side of the mouth of the river, where a few crystals of beryl, averaging half an inch in diameter, were observed along a muscovite-rich band in pegmatite.

In view of the genetic relationship of beryl to pegmatite, and the abundance of pegmatite within the area, prospectors should be on the look out for occurrences of beryl. It should be pointed out that, even in pegmatites from which there has been commercial recovery of beryl, the mineral has a tendency to occur in pockets rather than uniformly through the rock. Thus, the failure of the writer to observe any considerable amount of beryl does not necessarily indicate that there are no commercial occurrences of this mineral in the pegmatites of the area.

Calcite

De Puyjalon[1] reported the occurrence within the area, and particularly on the southern shore of ile à la Chasse (Hunting island), of calcite suitable for optical use. The present writer made a traverse of the southern shore of this island in search of clear calcite. Many pockets of milky calcite were seen, but no truly transparent calcite. One transparent pebble of calcite, about three-quarters of an inch in diameter, was found. No transparent calcite was observed elsewhere in the area.

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[1]de Puyjalon, H., Monograph on the Minerals of the North Shore of the Gulf of St. Lawrence, from Pointe aux Esquimaux to Pointe Giroux; Report of the Commissioner of Colonization and Mines for the year ending June, 1898, pp. 264-276, 1899, p. 265.

Feldspar

As noted earlier in this report, pegmatite dykes are common throughout the area and are most numerous and largest along the section of the coast extending from the west side of Quetachou bay to Watshishou knoll. These large dykes are composed predominantly of microcline and orthoclase.

Attempts to quarry and market the feldspar in the dykes bordering Quetachou bay were made at various times during the period between 1912 and 1927. The largest quarry is near the end of the point which forms the southeast side of the bay. Two others are on the point that forms the western side of the bay. No occurrences of feldspar observed by the writer appeared to be more favourable for development than those at which attempts at quarrying have been made.

A large pegmatite dyke, or sill, about 250 feet wide, extends along the western side of the small point about half a mile northwest of Quetachou bay. Quarrying operations have been carried on along the dyke for a distance of some 200 feet from the end of the point. The main workings are on the end of the point, where a pit about 50 feet long and 25 feet wide has been opened back from the water's edge.

The country rock is schistose quartzite and a well-banded, biotite-rich, dark grey, quartz-biotite-hornblende schist that is most probably a recrystallized sediment. About half of the area of the point is occupied by these rocks. The schistosity has a general northeasterly trend and the dip is vertical, or steeply to the east. These schistose rocks are extensively cut by irregular dykes of pegmatite.

The large dyke mentioned above extends parallel to the schistosity. The rock of the main pit contains about 50 per cent white microcline, a quarter of which has been replaced by graphically intergrown albite. One feldspar crystal having a length of three feet was observed. The chief associated mineral is quartz which occurs as: (1) large masses of glassy quartz scattered through the pegmatite, in general interstitial to the feldspar crystals; (2) small masses of quartz within the feldspar crystals; (3) a graphic intergrowth with feldspar. Considerable amounts of muscovite, some tourmaline, small garnet crystals, and scattered flakes of biotite are also present.

In view of the large amount of quartz disseminated through the feldspar, separation of the two would not be feasible, and any commercial use of the feldspar would necessarily be confined to purposes where considerable amounts of quartz could be tolerated. As the garnet, tourmaline, and mica occur more or less in 'pockets', it should be possible to eliminate these minerals without too much sorting. The amount of material on the dumps suggests that little has been shipped.

The muscovite 'books' in the pegmatite are too small and irregular in occurrence to be of any commercial interest. The maximum diameter of flakes observed was about two inches, the majority being half an inch or less, and they are widely scattered.

The largest feldspar quarry, that known as 'Thelminia Mines', is on the eastern shore of Quetachou bay, about two miles east-southeast of Johan Beetz. Its southern end is about half a mile northeast of the end of the point. Quarrying operations have been carried on over a length of about 1,000 feet. The main work has been done in a small pit along the shore, and in an open quarry (Plate XIV).

The invaded rock of the point on which the quarry was opened is medium- to coarse-grained gabbro, the minerals of which have been considerably altered to hornblende and chlorite. Quartzite is exposed along the eastern shore of Quetachou bay, northeast of the quarry. Several pegmatite bodies cut the gabbro (Plate IX-B). The quarrying has been done along the western side of the point in a pegmatite body about 200 feet wide, trending N.65°E.

The main operation was on a hill at the northern end of the workings. This quarry, which faces south, is about 150 feet long and 25 feet wide, and the working face has a maximum height of 15 feet. A pit at the southern end of the workings is about 100 feet long, 25 feet wide, and 10 feet deep. The size of the dumps indicates that little material was shipped.

The feldspar here is a flesh-coloured orthoclase. To some extent it is graphically intergrown with a feldspar of higher refractive index which, although it shows no twinning laminae, is probably albite. Muscovite and tourmaline are absent, but scattered flakes of biotite were observed. Quartz is scattered through the feldspar to such an extent that areas of quartz-free feldspar as much as two inches square are very rare. Although some feldspar relatively free from quartz could be obtained from this quarry, the writer considers that the cost of sorting would be too high for a large-scale operation to be profitable.

Fluorite

An occurrence of fluorite, in small fissure veins cutting gneiss, a mile and a quarter southwest of Johan Beetz, is described above under the section on copper. The mineral occurs in a zone of gash veins which is some 30 feet wide and is exposed for a length of about 100 feet. The veins themselves, which are generally about ten feet apart, do not exceed a length of twenty feet and a width of four inches. In most of these gash veins, the vein material is calcite, with clear quartz crystals lining the walls. The veins are drusy in character, indicating deposition at shallow depth. Although this showing of fluorite is not of commercial interest, exploration along the trend of the zone might be warranted.

Limestone

Much of the massive limestone in the area is of good quality for use as building stone. Some of it is somewhat crystalline, buff-grey in colour, and should take a good polish.

Mica

As already noted, the pegmatites of the area contain both muscovite and biotite. Some of the crystals are more than a foot across. Unfortunately, dynamic stresses have shattered them to such an extent that it is impossible to get an intact sheet of mica more than two or three inches across, and only very rarely as large as that. In no place where it was observed was the mica sufficiently abundant to be profitably mined even as low-grade mica.

It appears probable that any mica that may once have been present in the area in crystals of large size is now worthless, because of the severity of the dynamic stresses that have been active in the region.

Quartz Crystals

Many pockets of small quartz crystals were observed in the area. Some of these occur in veins of comb quartz, but many are in vugs in pegmatite. Such quartz-lined vugs are particularly abundant in a pegmatite that forms a long, narrow point about midway between Quetachou bay and Watshishou river. They are generally small, although a few up to a foot across were observed.

A doubly-terminated quartz crystal, about two inches long and an inch in diameter, was found lying in the bottom of one of these

vugs. All of the larger crystals, half an inch or so in diameter, in these vugs are clouded and appear to be impure. Thus, they are not of value for optical or electrical purposes.

Many areas of clear quartz, as much as a foot or so across, were observed in the pegmatite on Gull island. It appears that originally these may have been large single crystals of quartz, but if so they have been fractured to such an extent that their value has been destroyed.

Silica

Trending northeastward from the shore through Watshishou knoll to Watshishou hill is a discontinuous ridge of pegmatite about three miles long. The southwestern part is thoroughly brecciated and re-cemented by an opaque, milky-white quartz, which, in places, constitutes over half the volume of the rock. The quartz here carries too much brecciated pegmatite to be of economic value. The percentage of quartz increases rapidly toward the northeast, however. The largest mass of fairly pure quartz is at Watshishou hill. It is a lens-shaped body, more than 2,000 feet long by 200 feet at its widest part, with an outcrop area estimated at 250,000 square feet. The attitude of the lens is difficult to ascertain, because of the nature of its borders.

There is here available a large tonnage of silica, and the occurrence warrants further investigation by parties interested in obtaining this material.

The foregoing description is summarized from a report by Claveau[1].

Summary and Conclusions

No commercially-interesting deposits of quartz crystals, calcite crystals, beryl, fluorite, or mica were observed in the coastal section herein described. The deposits of feldspar, while large, unfortunately contain considerable quartz. It is not intended, however, by these remarks to discourage further search for these minerals elsewhere along the north shore of the St-Lawrence or in the region lying north of the narrow coastal strip that has been described in this report.

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[1]Claveau, J., Quartz Deposit at Watshishou Hill, Lower St. Lawrence River; The Mining Industry of the Province of Quebec in 1944, pp. 43-45, 1945.

The pegmatites of the area are potential host rocks for beryl deposits and quartz crystals.

The large body of silica, in the form of quartz, at Watshishou hill may have commercial possibilities.

The large reserves of limestone in the Mingan Islands area may also be of commercial interest.

Occurrences of iron oxides and of molybdenite, genetically related to pegmatite, are of sufficient interest to warrant further search for commercial deposits of these minerals. Additional search for pyrite on ile à la Chasse (Hunting island) is also suggested.

Copper-bearing minerals have been found in several places and a search for larger deposits is recommended.

Most of the occurrences of minerals of economic interest observed within the area are confined to the sections underlain by the complex of quartzite, schist, and gabbro. The districts in which prospecting can be recommended are the vicinity of the head of Appititatte bay with the extensions of that belt of rocks, and the area from about a mile west of Johan Beetz to Little Watshishou river and the extension of this belt.

The writer would select as the two most favourable zones for prospecting the contact zone between the sedimentary-gabbro complex and the gneiss, which extends northeastward from Watshishou knoll; and the area in the vicinity of the granite porphyry bodies occurring between Quetachou bay and Watshishou river.

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PART II

LIMESTONE DEPOSITS OF THE MINGAN ISLANDS AREA[1]

By G. W. Waddington

INTRODUCTION

During the summer of 1948, the writer spent four weeks examining the limestone deposits on the Mingan islands and on that part of the mainland immediately north of these islands. The area investigated lies along the north shore of the gulf of St-Lawrence, extending for about 25 miles to either side of the village of Havre St-Pierre. It includes all of the Mingan islands and the neighbouring coastline on the mainland. The object of the work was to obtain preliminary information on the size and composition of these limestone deposits for the purpose of appraising their economic possibilities.

The Mingan islands lie just off the north shore of the Gulf of St-Lawrence, forming a chain about fifty miles long (see accompanying map). The group comprises upwards of twenty islands and numerous islets and reefs. On the south side of the islands there is commonly a heavy swell from the gulf, whereas on the north or inland side the water is usually calm. There are many bays in which small craft can anchor. On all of the larger islands there is an abundant growth of timber. Fresh water can be obtained at several places from small lakes and springs. There are no people living on the islands. The principal settlements along this part of the north shore are the villages of Havre St-Pierre and Mingan.

GEOLOGY

The entire area of the Mingan islands and part of the mainland to the north of them is underlain by Ordovician sedimentary rocks[2]. According to Twenhofel[3], "the Mingan Islands sequence is

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[1]This report was prepared for the Mineral Deposits Branch, Department of Mines, Quebec.

[2]Longley, W.W., North Shore of the St. Lawrence, Mingan to Aguanish; Que. Dept. Mines, Pt.I of this report, G.R. 42, 1950.

[3]Twenhofel, W.H., Geology and Paleontology of the Mingan Islands, Quebec; Geol. Soc. Amer., Special Papers, No.11, June, 1938, pp. 14-15.

composed of two formations -- the Romaine below and the Mingan above. The exposed parts of the Romaine formation consist of dolomite and a little shale. There may be a sandstone at the base. Beds are generally thick and more or less rough in appearance, and in some places they appear kneaded together. The thickness is placed at about 260 feet.

"The Mingan formation has a variable thickness at the base, composed of conglomerate, sandstone, and shale. In some exposures the three forms of clastics are present and in others not more then two. These clastic strata are overlain by limestones whose basal 20 to 30 feet were limestone sands at the time of deposition. These strata contain much fragmentary fossil material and locally are poorly cemented. The larger part of the formation consists of fine-grained limestones of which some have semi-lithographic texture. Fossils are locally common and frequently abundant. The exposed thickness is estimated not to exceed 155 feet".

The beds of the Mingan formation appear to be uniform over large areas. They strike east-west and dip very gently to the south. Observed angles of dip range between one and two degrees. In the underlying Romaine formation, the beds are less regular. Some local folding was noted.

SAMPLING

The coastlines along the mainland and around all of the larger islands were examined, usually on foot. Inland outcrops were also inspected wherever a good cross-section of the beds could be seen. On account of the low dip of the beds, sampling had to be confined to the faces of cliffs. Channel samples, or their equivalent, were taken at all places where the exposed beds appeared to offer attractive conditions for quarrying. Localities at which samples were taken are designated by the letters "A" to "P" on the key map on page 12. Analyses are tabulated on pages 10 and 11. No estimates of possible tonnages have been attempted. However, in view of the uniformity of the beds, it is reasonably certain that considerable tonnages could be developed at all of the localities sampled. Detailed descriptions of these localities follow.

Mingan Island

Mingan island lies near the west end of the group. It has no trees, and locally is often called Bald island. A short distance inland from the east shore there is a scarp which extends almost

the entire length of the island. The limestone beds that form this scarp have a total thickness of 40 feet. Individual beds are two to four feet thick. Sample No. 9111 was taken at the point "A" near the south end of the scarp. The stone has a light cream-grey colour. It breaks with a hackly fracture, and contains numerous small crystals of clear calcite. At low tide, flat-lying beds of limestone are exposed on the beach, but between the beach and the base of the scarp they are covered by overburden. The stratigraphic interval is about twenty feet.

Havre-Mingan Island

"The section exposed on Havre-Mingan (Harbour) island belongs entirely to the basal part of the Romaine formation"[1]. The island was not visited by the present writer.

Ile aux Bouleaux

Ile aux Bouleaux, or Inner Birch island, is high in its central part but no cliffs for convenient sampling were seen.

Petite Ile aux Bouleaux

At the northwest end of Petite île aux Bouleaux (Little Birch, or Outer Birch, island) (locality "B") there is a cliff, 75 feet high. From top to bottom, the beds exposed are light cream-grey limestone with a hackly fracture (sample No. 9109), 15 feet; thick beds of brownish-grey limestone which also breaks with a hackly fracture (sample No.9110), 40 feet; and alternating thin beds of shale and limestone, extending down to sea-level, 20 feet.

Grande Ile

Grande île, or Large island, is the largest island of the Mingan group. At locality "C", in the northwestern part of the island, thick beds of limestone (sample No. 9108) are exposed in the upper 40 feet of a cliff that rises 60 feet above the sea. The stone is light cream-grey in colour and breaks with a hackly fracture. At the base of the cliff is a bed of argillaceous limestone, below which the strata are buried beneath a talus slope which extends down to the sea. The high land seen in the cliff extends eastward entirely across the island.

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[1]Twenhofel, W.H., Op. cit., p.19

On the northeast side of the island, at locality "D", the beds exposed are dolomitic limestone, very uniform in appearance. Sample No. 9107, taken at this point, represents a series of thin beds having an aggregate thickness of 20 feet.

At locality "E", on the south shore of a large bay, a cliff rises almost vertically out of the sea to a height of 40 feet. At its top there is a plateau, 100 feet wide, from which rises another scarp 20 feet high. The limestone exposed in the upper 14 feet of the latter is light brown and breaks into angular fragments (sample No. 9105). For the remaining 6 feet, the cliff face is covered by débris that has fallen onto the terrace. In the lower cliff, the uppermost beds for a thickness of 14 feet are dense buff-grey limestone with a conchoidal fracture (sample No. 9106). Beneath these are thin beds of shale which, in turn, are underlain by a bed of sandstone visible only at low tide.

Ile Moutange

Ile Moutange lies a short distance off-shore at the mouth of Romaine river. It is made up entirely of dolomite belonging to the Romaine formation[1]. It was not visited by the present writer.

Ile à la Proie

On the north side of île à la Proie, or Quarry island, at locality "F", there is a scarp about 1,000 feet long and 50 feet high. The beds for a thickness of 30 feet from the top are buff-grey limestone which breaks with a conchoidal fracture (sample No. 9104). Beneath this is a bed of light brown shale. The underlying strata are covered with talus.

Farther to the east, at locality "G" on the west shore of a bay, there is a bed of light brown, fine-grained limestone, 9 feet thick (sample No. 9102). Beneath this there are 17 feet of light brown limestone (sample No.9103) which, in turn, is underlain by alternating thin beds of dark grey shale and limestone. In the southern part of the island, the surface is covered with large quantities of limestone rubble.

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[1]Twenhofel, W.H., Op. cit., p.19.

Niapisca Island

On the west side of Niapisca island, near its northern end, there is a good exposure of limestone in a cliff along the south shore of a small bay (locality "H"). The upper 10 feet (sample No. 9099) is a resistant brown limestone which, in places, forms overhanging projections in the face of the cliff. The next twelve feet is a less resistant grey limestone (sample No. 9100). Underlying this is a bed of dense, grey limestone 8 feet thick (sample No. 9101) which, in turn, is underlain by dark green shale.

On the east side of the island, at locality "I", the limestone has been eroded into fantastic forms (Plate III). The upper seven feet of the rock exposed is a buff-coloured limestone with a fine-grained texture (sample No. 9097). This bed is underlain by 20 feet of brown limestone (sample No. 9098) containing nodules of chert.

Quin Island

At the point "J", near the southeastern corner of Quin island, the cliffs reach a height of 50 feet. The upper 14 feet is a fine-grained, buff-grey limestone (sample No. 9118). This is followed by thin beds of dense, buff-grey limestone aggregating 22 feet (sample No. 9119). Beneath this, there is 12 feet of light grey, thin-bedded limestone (sample No. 9120) which is underlain by dark green shale.

Havre Island

Havre, or Eskimo, island lies about half a mile off-shore, in front of the village of Havre St-Pierre. There are high cliffs at the east and west ends of the island and also along the north side, facing the village. At the west end, on the south side of a large bay, there are two scarps separated by a bench 200 feet wide (locality "K"). The upper 15 feet of the more southerly scarp is light brown, fine-grained limestone (sample No. 9115). Beneath this is a bed of light brown, dense limestone, 20 feet thick (sample No. 9116). For the remaining 15 feet of this scarp, the face is concealed by talus that has fallen onto the bench at its base. In the other, more northerly, scarp, thin beds of dense, grey limestone (sample No. 9117) with an aggregate thickness of 20 feet are followed downward by green shale, which makes up the remaining 20 feet of the scarp face, down to sea-level.

At the northeast corner of the island (locality "L"), the cliffs stand 80 feet high. The upper 35 feet consists of thin beds of grey limestone (sample No. 9112). Next below are a ten-foot bed of buff-coloured, fine-grained limestone (sample No. 9113), and a bed,

twelve feet thick, of dense, grey limestone (sample No. 9114. These are underlain by alternating thin beds of dark green shale and limestone, which extend down into the sea.

Pointe à l'Eau Claire

On the mainland at locality "M", on the west side of pointe à l'Eau Claire, or Clearwater point (Plate IV-A),there is a cliff 70 feet high. The plateau at the top of the cliff is covered with sand. The upper 28 feet of the rock exposed in the face of the cliff is a brownish-grey limestone (sample No. 9093). Beneath this is a bed of light brown, dense limestone, 8 feet thick (sample No. 9094), and following this a bed, five feet thick, of brownish-grey limestone (sample No. 9095). The next seven feet is fine-grained, grey limestone (sample No. 9096), underlying which is a bed of dark green shale at sea level.

Ammonite Point

Locality "N" is on the east side of Ammonite point, on the mainland immediately west of île Fausse Passe. Dense, buff-grey limestone (sample No. 9092) is exposed here on the beach in a series of thin beds having an aggregate thickness of 2 feet. The limestone is underlain by dark grey shale.

Ile Fausse Passe

At the north end of île Fausse Passe a cliff, 25 feet high, rises out of the sea. It is made up of thin beds of dense, light grey limestone. Sample No. 9091, taken at this point (locality "O"), represents a cross-section of the beds from the top of the cliff down to sea-level. Similar beds can be seen under the water.

St-Charles Island

The best outcrops of limestone on St-Charles island (Plate IV-B) are at locality "P", at its west end. In this part of the island, at the top of a cliff 60 feet high, there is a large, treeless area covered with limestone rubble. The face of the cliff exposes, in its uppermost 10 feet, a band of weathered, buff-grey limestone (sample No. 9089). This is followed, down to sea-level, by beds of dense, buff-grey limestone (sample No. 9090). There is a bed of shale not far below sea-level. It can be seen on the beach farther to the east.

Ile à la Chasse

No limestone was found in the rocks occurring on île à la Chasse (Hunting island).

Ile Ste-Geneviève

On île Ste-Geneviève, as on Hunting island, no limestone was found. All of the sedimentary rocks on these two islands, as well as on the mainland to the north, are dolomites and shales belonging to the Romaine formation[1].

CLASSIFICATION OF LIMESTONES

Most classifications for limestone are based on their chemical composition. The following is quoted from Goudge[2]:

"Limestones are rocks of sedimentary origin consisting mainly of calcium carbonate (calcite) or of the double carbonate of calcium and magnesium (dolomite). Based on their content of these constituents, limestones may be divided into three classes:

"1. Calcium limestones, or those in which calcium carbonate greatly predominates and which contain less than 10 per cent magnesium carbonate.

"2. Dolomites, or those composed almost wholly of the mineral dolomite and containing between 40 and 45.65 per cent magnesium carbonate.

"3. Magnesian limestones, or those intermediate in composition between the other two classes.

"The term high-calcium limestones is reserved to denote a calcium limestone containing not more than 3 per cent total impurities and not more than 2 per cent magnesium carbonate.

"The distinction between the classes is purely arbitrary ... By 'purer' limestones is meant those with less than 5 per cent total impurities ... A scientific classification applicable to all varieties of limestone would be based on the ratio between the calcium and magnesium components present and this would be particularly applicable to limestones containing a high percentage of impurities.

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[1]Twenhofel, W.H., op. cit., pp. 24, 25.

[2]Goudge, M.F., Limestones of Canada, Their Occurrence and Characteristics, Part III; Mines Branch, Dept. of Mines, Ottawa, Pub. No. 755, 1935, pp. 1 and 2.

Such a classification, based on the amounts of calcium oxide and magnesium oxide determined by analysis, would be as follows:

"1. Calcium limestones, those in which the ratio of CaO to MgO is greater than 10.5 : 1.

"2. Magnesian limestones, those in which the ratio of CaO to MgO is less than 10.5 : 1 and greater than 1.76 : 1.

"3. Dolomites, those in which the ratio of CaO to MgO is less than 1.76 : 1 and greater than 1.39 : 1 ...

"All limestone deposits contain some sandy or clayey material, and the deposits may grade almost imperceptibly into a shale, sandstone, or other kind of rock. The usual dividing line, arbitrarily made, between a limestone and another type of rock is that, if the rock contains a total of 50 per cent, or more, of the combined carbonates of calcium and magnesium, it is termed a limestone, if it contains less, it is otherwise classified".

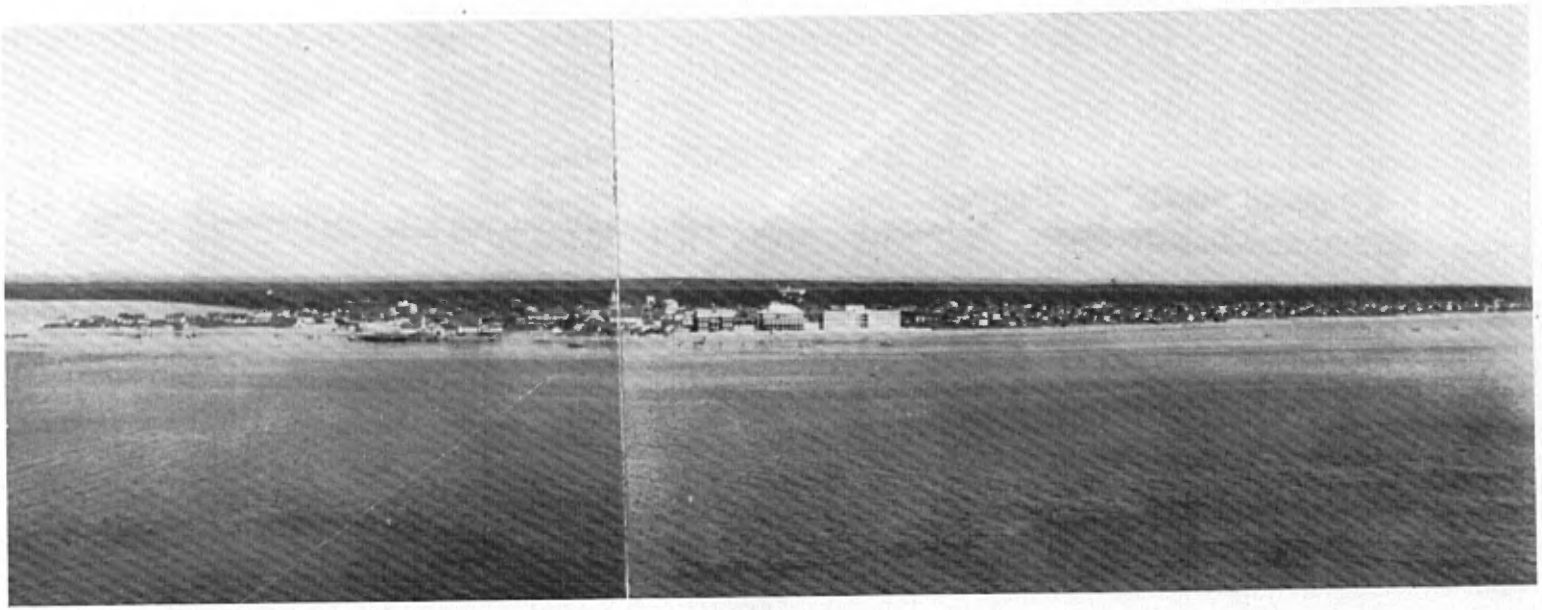
Applying Goudge's classification to the samples from the Mingan Islands area, we note that the rock at locality "D" is dolomite. The rock which occurs at all of the other localities sampled is a calcium limestone. High-calcium limestone occurs at "A", "B" (9110), "C", "E", "F", "I" (9097), and "J" (9119).

UTILIZATION

In 1946, the Province of Quebec produced 4,727,180 tons of limestone, which was used as follows:

Building trade	2,563,900 tons
Cement and builders' lime	1,328,061 tons
Industrial purposes	835,219 tons

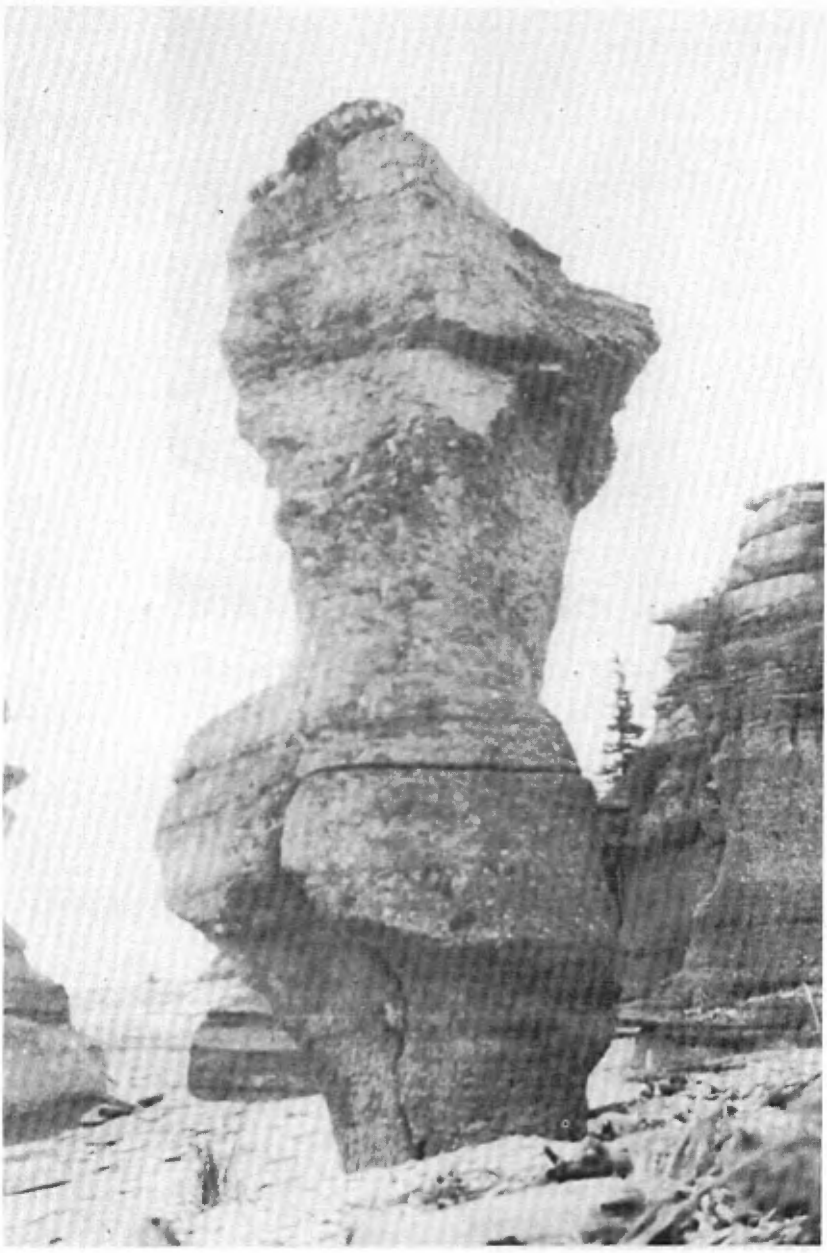
The principal industrial applications, in order of tonnage, were agriculture, pulp and paper milling, manufacture of calcium carbide, flux, tanning, ore concentration, and sugar refining. Other industrial uses include water purification, manufacture of glass, insecticides, fungicides and disinfectants, wood distillation, and petroleum refining. Limestone suitable for most of the uses mentioned above can be found in the Mingan Islands area.



Havre Saint-Pierre, 1948.

Boat-day at the village of Mingan.
(S. S. North Shore)

Plate III



Form produced by erosion of limestone,
Niapisca island

A—Limestone cliffs, Pointe à l'Eau Claire.
(Clearwater point)

B—Limestone outcrop, St. Charles island.

CONCLUSION

Preliminary exploration indicates substantial reserves of limestone in the Mingan Islands area. The deposits are favourably located for economic exploitation. The limestone is suitable for most of the purposes for which limestone is ordinarily employed. High-calcium limestone was found in seven localities. In three of these, "A", "B", and "C", the beds are 40 or more feet thick.

Table I

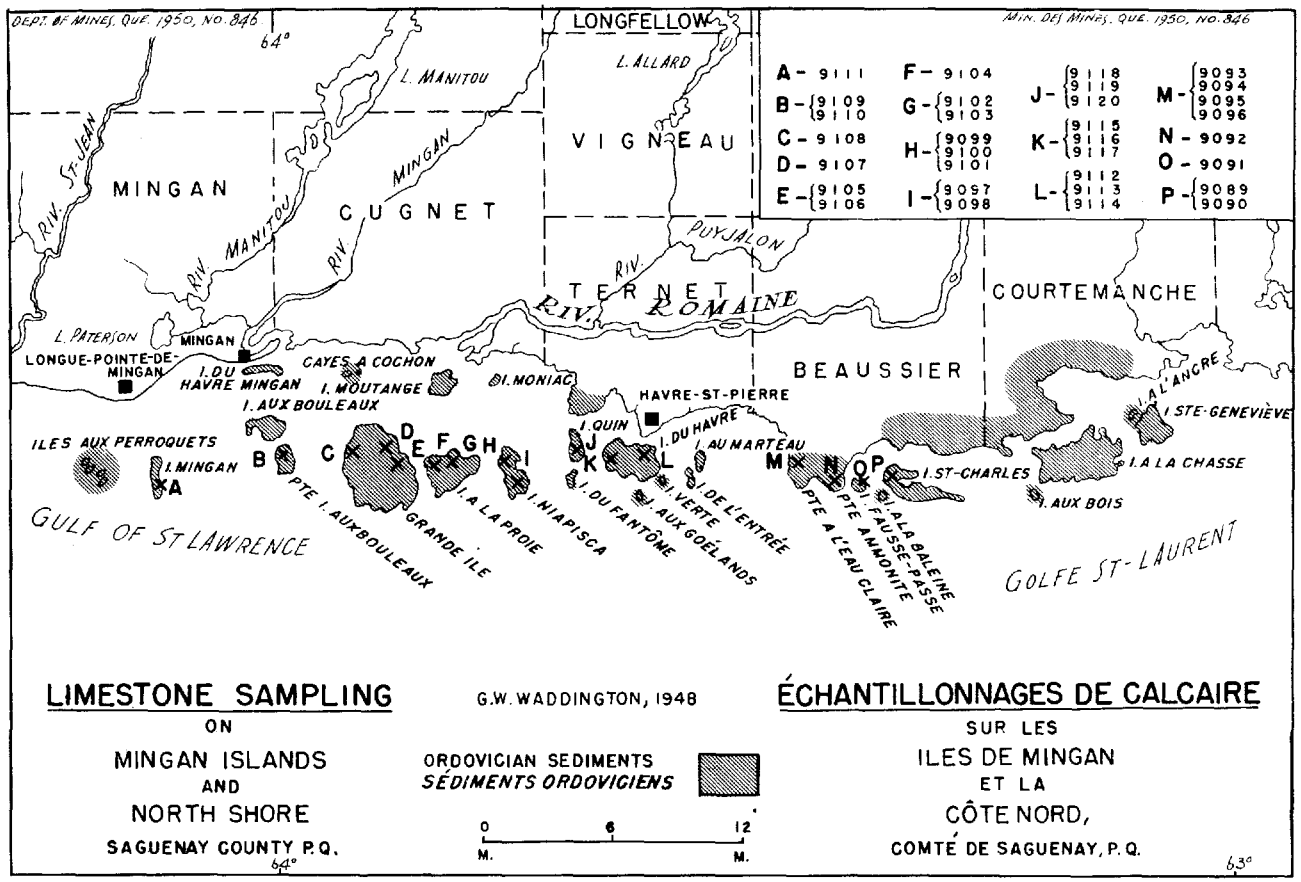
Chemical Analyses

Locality	Sample Number	Width (feet)	SiO_2 %	Fe_2O_3 %	Al_2O_3 %	$Ca_3(PO_4)_2$ %	$CaCO_3$ %	$MgCO_3$ %	Total %	S %	CaO %	MgO %	Ratio of CaO to MgO
A	9111	40	0.67	0.09	0.26	0.02	97.72	1.51	100.27	0.07	54.77	0.72	76:1
B	9109	15	2.70	0.41	0.63	0.02	93.69	2.15	99.65	0.05	52.51	1.03	51:1
	9110	40	1.56	0.25	0.56	0.02	96.31	0.56	99.29	0.03	53.98	0.27	200:1
C	9108	40	1.36	0.20	0.41	0.02	96.47	1.07	99.55	0.02	54.07	0.50	108:1
D	9107	20	2.63	0.69	0.20	0.03	53.42	43.21	100.25	0.07	29.96	20.66	1.45:1
	9105	14	0.44	0.15	0.16	0.02	98.56	0.52	99.88	0.03	55.24	0.25	221:1
E	-	6	-	-	-	-	-	-	-	-	-	-	-
	9106	14	1.10	0.18	0.27	0.02	97.15	0.84	99.63	0.07	54.45	0.40	136:1
F	9104	30	0.78	0.22	0.93	0.04	97.01	1.19	100.17	0.02	54.38	0.57	95:1
G	9102	9	2.42	0.35	1.61	0.05	93.07	2.43	99.93	0.05	52.18	1.16	45:1
	9103	17	9.52	0.83	2.41	0.09	83.66	2.66	99.17	0.13	46.93	1.27	37:1
	9099	10	6.98	0.54	1.96	0.06	87.61	2.74	99.89	0.08	49.12	1.31	37:1
H	9100	12	15.77	0.98	3.35	0.11	75.95	2.95	99.11	0.06	42.62	1.41	30:1
	9101	8	9.72	0.93	2.21	0.08	80.06	6.23	99.23	0.16	44.90	2.98	15:1
I	9097	7	2.23	0.16	0.90	0.06	96.01	0.88	100.24	0.01	53.83	0.42	128:1
	9098	20	21.18	0.68	0.97	0.09	74.72	2.11	99.75	0.01	41.92	1.01	41:1

Table I (Cont'd)

Chemical Analyses

Locality	Sample Number	Width (feet)	SiO_2 %	Fe_2O_3 %	Al_2O_3 %	$Ca_3(PO_4)_2$ %	$CaCO_3$ %	$MgCO_3$ %	Total %	S %	CaO %	MgO %	Ratio of CaO to MgO
	9118	14	8.69	0.55	1.48	0.06	85.84	2.47	99.09	0.20	48.13	1.18	41:1
J	9119	22	0.77	0.17	0.36	0.02	96.76	1.74	99.82	0.11	54.23	0.83	65:1
	9120	12	6.97	0.69	2.24	0.06	86.53	3.01	99.50	0.12	48.52	1.44	34:1
	9115	15	2.90	0.26	0.71	0.03	93.91	1.92	99.73	0.09	52.64	0.92	57:1
	9116	20	0.76	0.14	0.33	0.02	96.67	2.15	100.07	0.08	54.18	1.03	53:1
K	-	15	-	-	-	-	-	-	-	-	-	-	-
	9117	20	10.46	0.83	2.14	0.05	80.52	4.85	98.85	0.11	45.15	2.32	19:1
	9112	35	3.64	0.34	0.93	0.02	92.25	2.74	99.92	0.16	51.70	1.31	39:1
L	9113	10	1.38	0.63	0.40	0.02	93.83	3.70	99.96	0.08	52.59	1.77	30:1
	9114	12	14.69	1.12	2.24	0.11	76.13	4.77	99.06	0.39	42.72	2.28	19:1
	9093	28	5.83	0.46	0.83	0.06	90.00	1.32	98.50	0.13	50.46	0.63	80:1
M	9094	8	2.68	0.29	0.35	0.04	95.49	0.96	99.81	0.06	53.53	0.46	116:1
	9095	5	14.24	1.05	3.79	0.14	76.97	2.22	98.41	0.15	43.21	1.06	41:1
	9096	7	5.31	0.56	1.68	0.08	90.16	1.46	99.25	0.05	50.56	0.70	72:1
N	9092	21	3.44	0.38	0.94	0.04	92.73	1.74	99.27	0.07	51.98	0.83	63:1
O	9091	25	2.04	0.26	0.70	0.04	94.35	1.51	98.90	0.07	52.89	0.72	73:1
	9089	10	6.01	0.25	0.54	0.04	90.16	2.36	99.36	0.05	50.54	1.13	45:1
P	9090	50	4.86	0.37	0.83	0.04	90.76	2.28	99.14	0.12	50.88	1.09	47:1



LIMESTONE SAMPLING

ON

MINGAN ISLANDS

AND

NORTH SHORE

SAGUENAY COUNTY P.Q.

G.W. WADDINGTON, 1948

ORDOVICIAN SEDIMENTS

SÉDIMENTS ORDOVICIENS

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M. M.

ÉCHANTILLONNAGES DE CALCAIRE

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ILES DE MINGAN

ET LA

CÔTE NORD,

COMTÉ DE SAGUENAY, P.Q.

ALPHABETICAL INDEX