# RG 106(A)

MAGDALEN ISLANDS

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GEOLOGICAL EXPLORATION SERVICE
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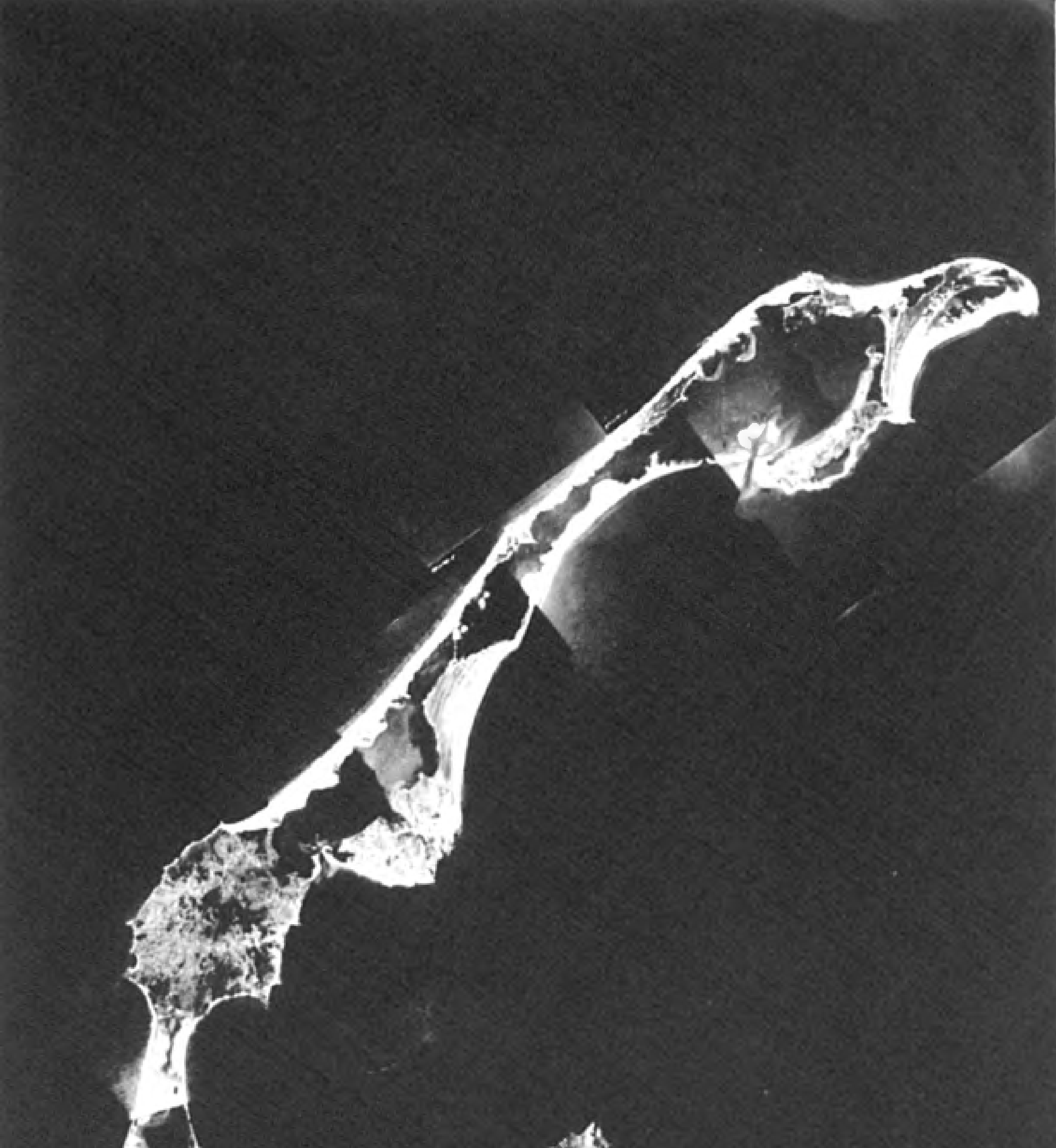
## GEOLOGICAL REPORT 106

# MAGDALEN ISLANDS

by

Roland Sanschagrin

QUEBEC
1964




Mosaic of the Magdalen Islands

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# MAGDALEN ISLANDS*

by

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## INTRODUCTION

The archipelago of the Magdalen Islands, which lies in the centre of the Gulf of St. Lawrence and extends for about sixty miles in a northeasterly direction, is made up of about fifteen islands of varying size. According to the maps of the Canadian Hydrographic Service, these islands are located between longitudes 61°08' and 62°13' West, and latitudes 47°12' and 47°51' North. Although the total surface area of the islands is barely 150 square miles, the shoal on which they are based is much more extensive.

Cap-aux-Meules, the archipelago's principal port, is about 90 miles from Newfoundland, 65 miles from both Cape Breton and the northeast extremity of Prince Edward Island, 135 miles from Gaspé Peninsula and 115 miles from the easternmost tip of Anticosti Island.

### History

The Magdalen Islands were discovered by Jacques Cartier when, on June 25, 1534, during his first voyage, he sighted steep cliffs on which nested innumerable birds. The cliffs are now known as part of the Rocher aux Oiseaux, the first of the islands to come into view when approaching from the direction of the Strait of Belle-Isle. Jacques Cartier next landed on Brion island, which he named after the Grand Admiral of France, Philippe Chabot, Sieur de Brion.

On his second voyage, Jacques Cartier went from Brion island to the sandy shores of Grosse-Ile, Cap de l'Est, Entrée island and Plaisance bay. He named all of these "The Araynes". Until 1663, the archipelago was known as the Araynes, the Brion Islands or the Ramée-Brion. In that year, however, the Company of One Hundred Associates granted the islands to François Doublet de Honfleur, who named them after his wife,

*Translated from the French edition.

Madeleine Fontaine. Since then, they have been known as either the Madeleine Islands or, as in some English reports and maps, the Magdalen Islands.

The initial attempts at colonization were short-lived. The first people actually to settle on the Islands were Acadians from the Grand-Pré region, who came over after the fall of Louisbourg. The people of the Islands are still quite proud of their Acadian ancestry. When, in 1763, New France came under English rule, the Magdalen Islands were annexed to Newfoundland. Soon after, however, the passing of the Quebec Act transferred them to the jurisdiction of the Province of Quebec, where they were, for administrative purposes, attached to Gaspé county. In 1798, King George III, as a reward for service during the American War of Independence, granted the Islands to Admiral Isaac Coffin. They were under the control of Coffin's agents, and those of his successors, for more than a century. It was only in 1895 that the Quebec Parliament passed a law allowing the Acadians to become landowners. In that year, as well, the Islands formed a part of the diocese of Charlottetown, Prince Edward Island. They remained a part of this diocese until 1946, when they were again joined with the Gaspé diocese. As far as Federal jurisdiction was concerned, the Islands had to wait until 1948 before being considered an autonomous county.

## Nomenclature

Owing to the succession of French and English influences, it is not surprising that each of the islands has several names. They are, in some cases, direct translations of each other; in others, completely different. The following is a list of the names used on different maps.

| National Topographic Series Canada, 1956, 11N/4, 11N/5, etc. | Hydrographic Map No. 4451 1956 | Magdalen Islands county maps-1941- and local usage |
|---|---|---|
| North Bird | North Bird | Rocher aux Oiseaux |
| Bird Rocks | | Rocher Fou-de-Bassan |
| South Bird | South Bird | Rocher aux Margaux |
| Brion | Brion | Ile Brion |
| East Island | East Island | Ile de l'Est |
| Coffin Island | Coffin Island | Coffin<br>Ile-de-la-Grande-Entrée<br>Ile Royale |
| Ile Boudreau | Oyster Island | Ile Boudreau |
| Grosse Ile | Grosse Ile | Grosse Ile Nord<br>Grosse Ile Sud |

| | | |
|---|---|---|
| Wolf Island | Wolf Island | Ile au Loup<br>Ile de la Pointe-au-Loup |
| Alright Island | Alright Island | Ile Alright<br>Ile du Havre-aux-Maisons |
| Ile aux Cochons | | Ile aux Porcs |
| Grindstone Island | Grindstone Island | Ile Grindstone<br>Ile du Cap-aux-Meules |
| Gull Island | Gull Island | Ile aux Goélands |
| Ile aux Oeufs | Egg Island | Ile aux Oeufs |
| Amherst Island | Amherst Island | Ile Amherst<br>Ile du Havre-Aubert |
| Entry | Entry | Ile d'Entrée |
| | Deadman | Ile Le-Corps-Mort<br>Ile Elézaz |

The names used by the Acadians of the archipelago, who make up 90 per cent of the population, are as follows: Grande-Entrée island (Coffin), Boudreau island, Cap de l'Est island, Grosse-Île, Pointe-au-Loup island (Wolf), Havre-aux-Maisons island (Alright or House Harbour), Cap-aux-Meules island (Grindstone), Havre-Aubert island (Amherst), Corps-Mort island (Deadman), and Entrée island. In the present study, the writer has used the locally employed names, following the example of L.-E. Hamelin (1959).

## Access

Clarke Steamship Company operates between the archipelago, the Maritimes and Quebec City from mid-April to the end of December. In addition, a ship of the Madeleine Islands Cooperative Sea and Air Transport Company serves the Islands from mid-March to mid-January. As to air service, Maritime Central Airways Ltd. operates a daily run between the Magdalen Islands and Moncton, New Brunswick, and Trans-Gaspésien Aérien, Ltée., has flights between the Islands and Gaspé.

## Previous Work

The Magdalen Islands have been extensively studied, especially in recent years. For a complete bibliography, the reader is referred to the report by Louis-Edmond Hamelin (1959).

The work done by P. Hubert (1926), Noël Falaise (1954), and F.P. Shepard (1931) should also be mentioned, as well as the articles written by L. Lauzier (1956-1957).

Since 1880, the geology of the Islands has been studied by J. Richardson (1881), J.M. Clarke (1910), F.J. Alcock (1941), W.A. Bell (1946) and C. Le Gallo (1952). R. Chalmers (1895), J.W. Goldthwait (1915), A.P. Coleman (1919), L.-E. Hamelin and B. Dumont (1958) wrote on the problems of glaciation. J. Obalski (1903), W.F. Jennison (1911), L.J. Weeks (1940) and F.J. Alcock (1940) studied the deposits of manganese and gypsum on the Islands, and G.W. Waddington (1947 and 1948) concerned himself with the utilization of both the gypsum and the extensive sand deposits. The soil was the object of studies by J.-E. Thériault and A. Scott (1938). Fossils from the rocks of the Islands, brought back by J. Richardson, were studied by Sir William Dawson (1878). He gave them a lower Carboniferous age. This age determination was corroborated by J.W. Beede (1910), who examined fossils brought back by J.M. Clarke.

## Field Work

The geology of the Magdalen Islands was studied by the writer during the summer of 1960. R. C. A. F. aerial photographs, at a scale of 1/4 mile to the inch, were used, in conjunction with maps of both the Quebec Department of Natural Resources (1:50,000) and the Federal Department of Mines and Technical Surveys. The latter were enlarged to the same scale as the aerial photographs.

The outcrops of each of the islands of the archipelago were examined, particularly those sections bordering the sea. In the interior of the islands, where outcrops are scarce, wells were examined or information was gathered from the people who had dug them. Such information was of great value, particularly if the wells concerned were located in the contact zone between the argillites of the Havre-aux-Maisons formation and the overlying red sandstones of the Cap-aux-Meules formation. These studies indicated that much of the richer soil of the Islands is underlain by argillite.

## ACKNOWLEDGMENTS

Many thanks are due to Dr. W.A. Bell, who mapped the islands geologically in a private capacity, and who generously made his manuscript report available to the writer and aided in stratigraphic interpretations and in identifying fossils.

Michel Moreau, Guy Asselin and André Lafrance acted as field assistants during the summer's work. Without their aid, and that of several fishermen who guided the geological party with great efficiency along the shore-lines, the work could not have been carried out.

## PHYSIOGRAPHY

L.J. Weeks (1957, p.126) placed the Magdalen Islands within the physiographic boundaries of the New Brunswick Lowlands. "This lowland together with the Prince Edward Island Lowland and the Magdalen Islands comprise a single physiographic unit.... The lowland areas are underlain by soft, Carboniferous rocks, through which, particularly in the Magdalen Islands, small bodies of intrusive rocks cause prominent eminences."

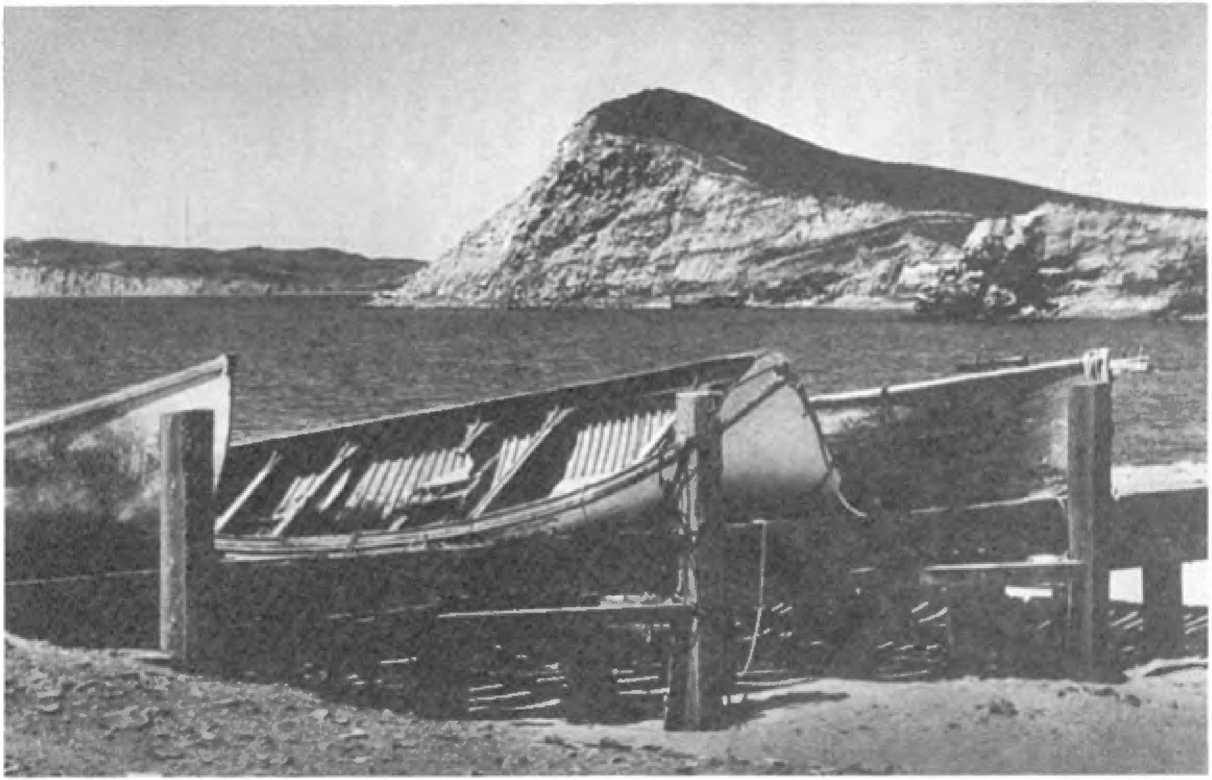
The Magdalen Islands archipelago is made up of seven main islands, joined by sand-bars or tombolos. It is hook shaped and extends about 40 miles in a N.45$^{o}$E. direction. From southwest to northeast, the principal islands are Havre-Aubert (Amherst) island, Cap-aux-Meules island, Havre-aux-Maisons (Alright) island, Loup island, Grosse-Ile, Est island and Grande-Entrée (Coffin) island.

In addition to these seven principal islands, which actually form a single unit, there are several isolated islands. In the southern region, these include Corps Mort island, located 10 miles west of Havre-Aubert (Amherst) island, and Entrée island, 6 miles to the northeast of Havre-Aubert. In the north, Brion island and the Rocher aux Oiseaux are situated, respectively, 13 miles to the north and 20 miles to the northeast of Grosse-Ile. There are also numerous cliffed rock-islands, representing the remnants of marine erosion, either bordering the main islands or in the lagoons separating them. Examples of these rock-islands include Goélands island, and the neighbouring islets, near Etang-du-Nord on the southwest side of Cap-aux-Meules island, Rouge island and Cochons island, at the entrance of the Havre-aux-Maisons lagoon, and Shag island, east of the South dune. The water surrounding the islands is less than 20 fathoms deep and is dotted with shoals and reefs. Although a permanent danger to navigation, these shoals abound with sea life.

## TOPOGRAPHY

The four principal islands of the southern part of the archipelago, Havre-Aubert (Amherst), Entrée, Cap-aux-Meules and Havre-aux-Maisons (Alright), are quite similar in topography. The central core of each island, consisting of numerous rounded hills, is partly made up of

Plate I



Topography of the buttes.
Taken from Damase inlet, Havre-aux-Maisons (Alright) island, and looking toward the southwest.

Plate II

Plainal topography.
Looking toward the southeast, at Cabane inlet, Havre-Aubert (Amherst) island

volcanic rocks. These volcanic rocks, which are more resistant to erosion than the accompanying argillites and the surrounding sandstones, are generally covered with a few feet of regolith and agriculturally-poor soil. The highest point on the Magdalen Islands, with an elevation of 559 feet above sea-level, is on Entrée island. The hills of Havre-Aubert and Cap-aux-Meules islands reach elevations of 447 and 532 feet, respectively, and the area of the "chemin des buttes", on Havre-aux-Maisons island, is at an elevation of about 362 feet.

The fact that the hills and buttes are seldom farther than one mile from the sea gives the Islands a mountainous aspect when viewed from the water. Some of the more prominent buttes have been given specific names. For instance, an elevated area in the southwest portion of Havre-Aubert island has been called "La Montagne," and the twin buttes near Havre-Aubert village go under the name of "Les Demoiselles". J.M. Clarke (1910) suggested that the term "Demoiselles" be applied to all the prominent hills of the Islands. The inhabitants, however, simply call them "buttes".

The sides of the buttes display a generally undulating topography, marked with several funnel-shaped sink-holes 10 to 100 feet deep; these, though generally dry, may contain small lakes or ponds. The local bedrock is made up of argillite and siltstone, with some limestone and gypsum. The solubility of the gypsum, which commonly outcrops in the sink-holes, is believed to be responsible for their development.

Bordering the butte and sink-hole topography, the Islands are featured by a gently rolling plain that lies a few tens of feet above sea-level. This plain is covered with a sandy soil that is quite amenable to agriculture, and is underlain by a poorly consolidated, friable, red sandstone. The sandstone is exposed along the beach escarpments and along the road-cuts. In places, a few rounded hills rise above the plain. Several prominent headlands made up of fairly well consolidated greyish green sandstone overlook the sea. Examples of such cliffed headlands include Meules, Pointe Basse, Dauphin and Est capes. The differential attack of the sea on the sandstone is also evidenced in the cliffed forms located at Vert cape, Richard point, Mounette cape and Alice mountain, bordering the Havre-aux-Maisons lagoon, as well as at Rockhill point and the southwest side of Grosse-Ile, bordering the harbour at Grande-Entrée. In the gulf north of the archipelago, cliffs of the reddish and greyish green sandstone, a few hundred feet high and relatively unmarked by sea erosion, give a fortress-like appearance to Brion island and the Rochers aux Oiseaux.

Another topographic feature of the Islands is the presence of large amounts of unconsolidated sands. These sands, which, essentially, are products of marine erosion, have formed a series of tombolos (and double tombolos) which link together the seven principal islands of the archipelago.

## DEVELOPMENT OF THE DUNES

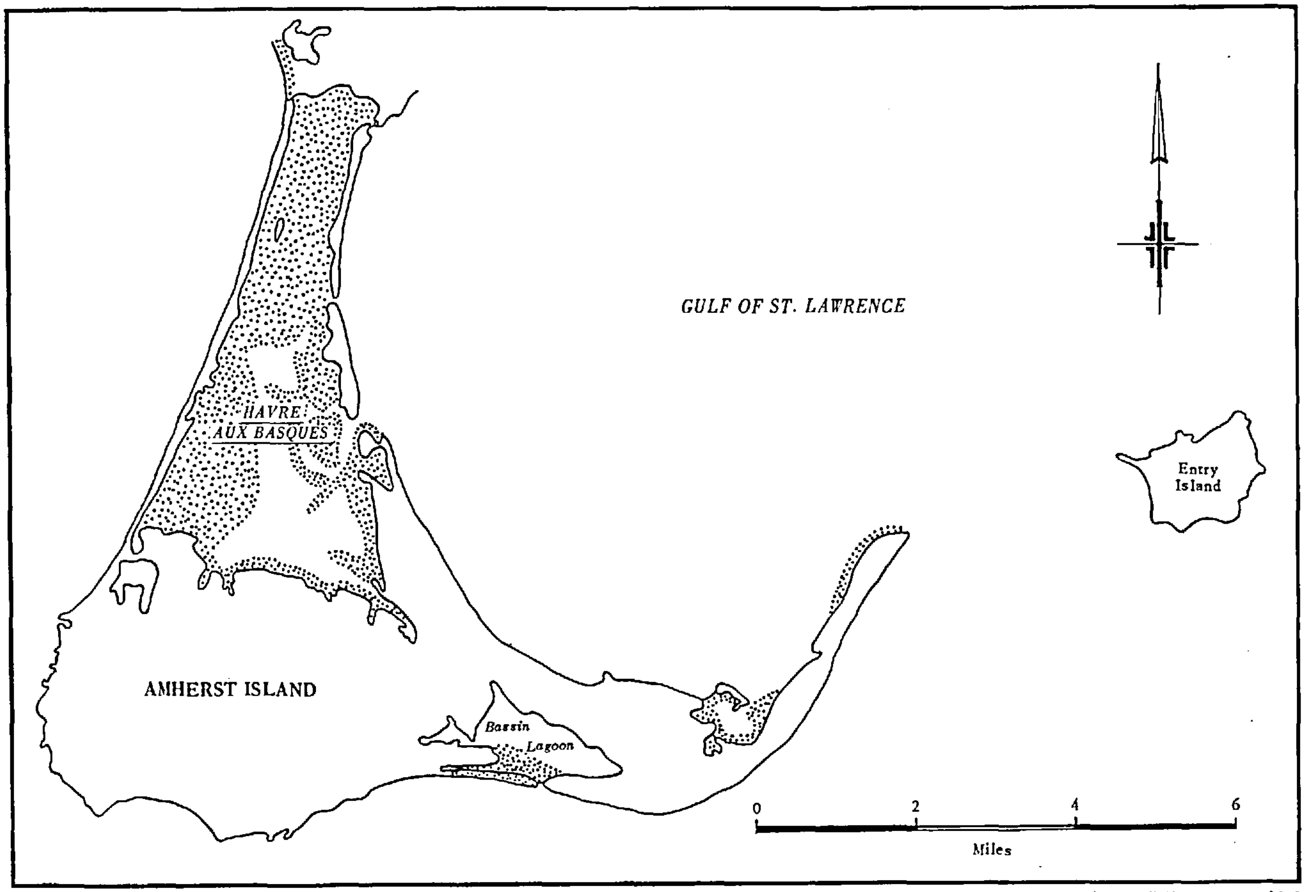
The Havre-Aubert dune extends easterly from the south side of Havre-Aubert island toward Entrée island. It has developed on a sea bottom that is 20 to 25 feet deep. For more than 3 miles, this dune is a few feet to a few tens of feet above sea-level. Farther on, for another 1 1/4 miles, it is covered by not much more than a fathom of water. This dune is a product of littoral currents set in motion by waves moving northeast toward the south shore of Havre-Aubert island. A stronger current, emanating from Plaisance bay, and moving southeast, has prevented the sands from joining Entrée island to the other islands. In fact, the natural channel on the west side of Entrée island, which is 25 feet deep and a mile wide, still gives easy access to Plaisance bay.

In comparing different maps, it appears that the tombolo being built between Havre-Aubert and Entrée islands has changed considerably in form over the years. The distance between Entrée island and that part of the dune that is above water has been reported as: 17,980 feet, in 1765; 17,221 feet, in 1833; 17,950 feet, in 1916; 16,720 feet, in 1917; 16,720 feet, in 1935; 17,420 feet, in 1956; and 16,620 feet, in 1959.

At times, a storm has proved sufficient to change the aspect of the tombolos. Richardson (1881) gives an example of such a rapid transformation. Some time before his visit, during a violent storm, the sea opened up a passage in the North dune, west of Hospital cape, which was large enough to allow fishing boats to enter the Havre-aux-Maisons lagoon. This passage did not exist for long, however, because, at the time of Richardson's visit, the action of the sea had again sealed it off.

The lagoons that have been closed off by a double tombolo display a strong tendency to become filled up. In this connection, Richardson (1881, p.2g) describes Havre-aux-Basques:

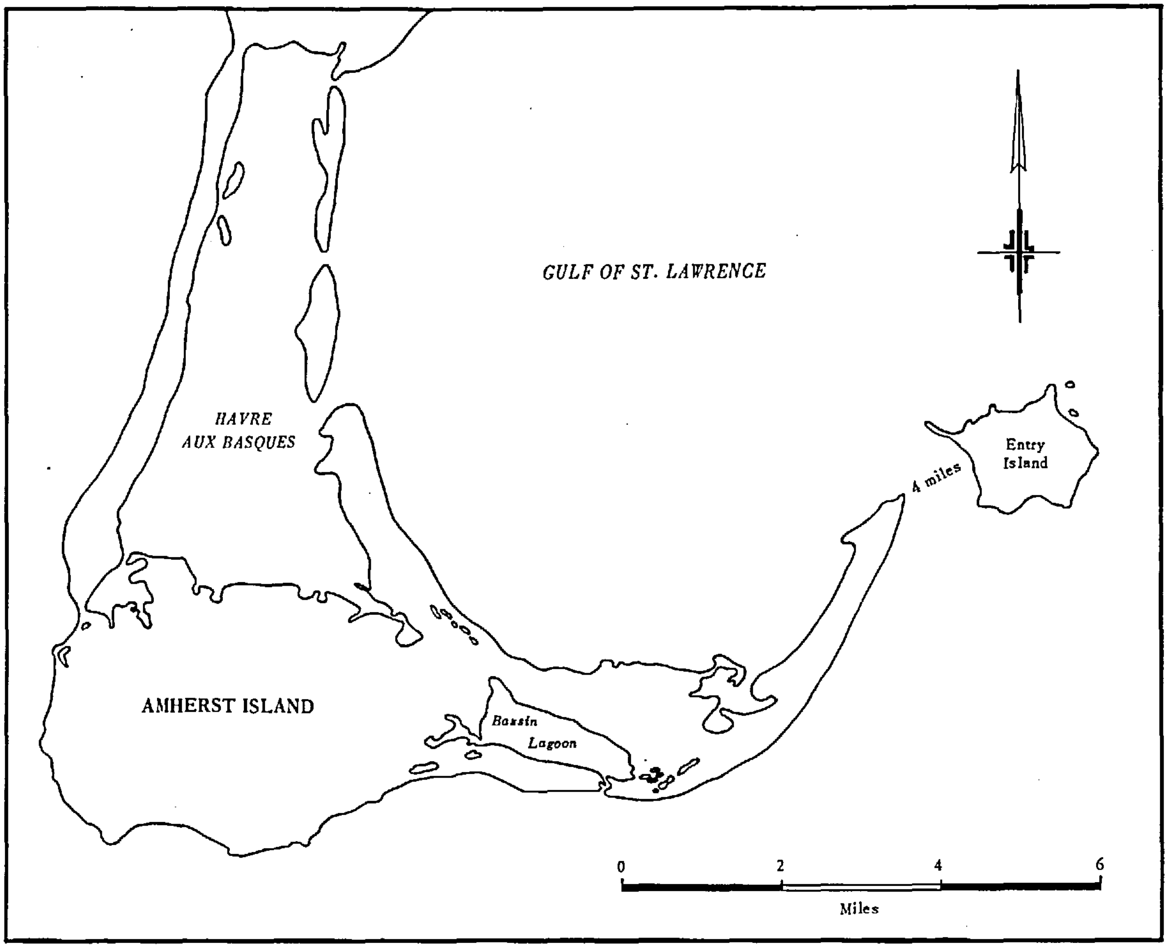
> "From the east and west ends, respectively, of Amherst (island), narrow sand-banks extend north to Grindstone, the space between them being occupied by a stretch of shallow water from three to four miles wide, which, though called Basque Harbor (Havre-aux-Basques), is really a salt lake or lagoon, without any permanent opening to the sea."




D.N.R.Q. NO. 1483

FIGURE 1.

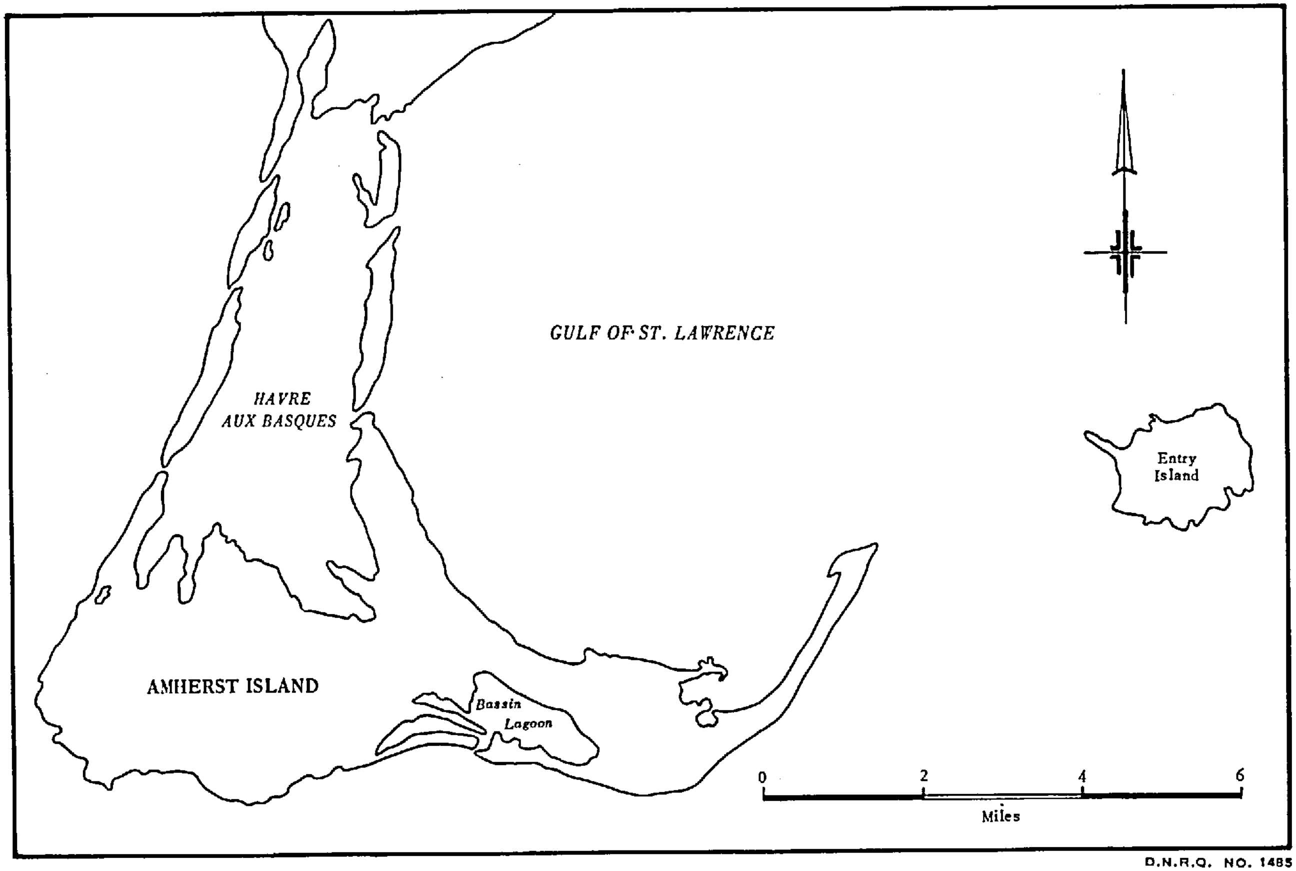
SKETCH DRAWN FROM TOPOGRAPHICAL MAP, 11 N/5, 11 N/4, 1955,
MINES AND TECHNICAL SURVEYS, OTTAWA,.




D.N.R.Q. NO. 1484

FIGURE 2.

SKETCH DRAWN FROM CADASTRAL COMPILATION MAP,
ILES-DE-LA-MADELEINE COUNTY, 1941




D.N.R.Q. NO. 1485

FIGURE 3.

SKETCH DRAWN FROM MAP NO. 66 ACCOMPANYING MINES BRANCH REPORT NO. 84, 1911,
MINES AND TECHNICAL SURVEYS, OTTAWA.

Nevertheless, in 1917, Havre-aux-Basques was open to the sea at three different places on the west side and at three places on the east side. However, since the new roadway was built, which, for 2,000 feet, closes off the principal water-gap in the eastern sand-spit, the lagoon has again become totally enclosed. More than half of the lagoon is now dry, having been gradually, starting from the north side, filled in with sand.

The wharves that have been built out into the sea have had an effect on the littoral currents and have changed the appearance of the shore-lines. Examples from two localities on the south side of Havre-aux-Maisons island illustrate this.

For the use of local fishermen, a wharf, or breakwater, was constructed in 1931 at Pointe-Basse, which is a headland of solid sandstone and quite vulnerable to waves and littoral currents. As it was too short, and could not be used when even a light south wind was blowing, it was lengthened in 1956. At the same time, a slip was built 120 feet to the west of the wharf so that the fishermen could easily beach their boats, even at low tide and with a wind blowing. Four years later, by the summer of 1960, the shifting sands had left the slip "high-and-dry", it being 90 feet from water at high tide and 150 feet from water at low tide. It has therefore not been used for several years. Another wharf was built 3 miles north of Pointe-Basse, on the east shore of Havre-aux-Maisons island where the South dune begins. This structure, 550 feet long, is now sanded in for a distance of 220 feet at high tide and for 380 feet at low tide, despite frequent dredging operations carried out in the vicinity of the wharf. The nearby slip is presently 260 feet from water at high tide.

The tombolos, or "dunes", as they are called on the Islands, vary in width from a few feet to 8,500 feet. Although their average height is less than 30 feet, they may rise to as much as 125 feet in places. Owing to the winds blowing in off the sea, they are generally covered with small hills of sand, thus displaying an undulating surface. This is illustrated in Plate III and in the aerial photographs taken by the R. C. A. F. L.-E. Hamelin (1959) estimated that the dunes extended over 12,428 acres, thus making up 30% of the total area of the archipelago.

Plate III

Topography of the dunes.
View looking toward the north, from north of Loup island.

Plate IV

Volcanic breccia.
Havre-aux-Maisons formation; Diable cape, Entrée island.

## GENERAL GEOLOGY

The Magdalen Islands belong to the Appalachian system and form a part of the Gulf of St. Lawrence Lowlands. These Lowlands extend as far as New Brunswick and Prince Edward Island. The Magdalen Islands are underlain both by volcanic and sedimentary rocks. The oldest rocks, referred to here as the Havre-aux-Maisons formation, belong to the Windsor group and are subdivided into two characteristic members. The first is the Cap Adèle member, which consists of interstratified volcanic and sedimentary rocks and contains a Lower Windsor fauna. The second, made up solely of sedimentary rocks, is the Bassin-aux-Huîtres member, of Upper Windsor age. Lying discordantly on the Windsor is a series of non-fossiliferous red and greyish green sandstones. These rocks have been compared to the Canso group (W.A. Bell, 1946), to the Bonaventure formation of the Bay of Chaleurs (F.J. Alcock, 1941) and to the red sandstones of Prince Edward Island (J.M. Clark, 1910). J. Richardson (1881) classed them as Permian or Triassic in age. The present writer has placed these sandstones, as found on the Magdalen Islands, in the Cap-aux-Meules formation, believed to be Permo-Carboniferous in age.

### Table of Formations

| Age | Group | Formation (Approximate thickness, in feet) | Member | Lithology |
|---|---|---|---|---|
| Pleistocene and Recent | | | | Sand and gravel |
| Permo-Carboniferous | Canso? | Cap-aux-Meules 1250 + | | Red and greyish green sandstone |
| | | Unconformity | | |
| Mississippian | Windsor | Havre -aux-Maisons 2500 ± | Bassin-aux-Huîtres (Upper Windsor) | Fossiliferous limestone and calcareous shale; red and grey argillite; gypsum. |
| | | | Cap Adèle (Lower Windsor) | Brecciated basalt, tuff and agglomerate interstratified with conglomerate, sandstone, siltstone, fossiliferous limestone and calcareous shale, argillite and gypsum. |

Until recently, owing to the fact that the fossil content of the rocks of the Magdalen Islands was not too well known, the local formations were included with the Windsor, or some other such group common to the Maritime Provinces. However, with the accelerated mapping program which has been carried out on the Islands, several new fossil localities have been discovered. This has led to the introduction of formation names, such as Havre-aux-Maisons, for Windsor, and Cap-aux-Meules for the sandstones which lie above the Windsor. These names derive from the localities where each formation is best exposed. The same applies to the two members of the Havre-aux-Maisons formation.

## Havre-aux-Maisons Formation

The two members of the Havre-aux-Maisons formation are different in age. The Cap Adèle member, which is Lower Windsor, includes basaltic lava flows, with some andesitic and rhyolitic types, as well as tuffs and agglomerates. The latter rocks are interbedded with conglomerates, sandstones, siltstones, partly fossiliferous limestones and calcareous shales, and non-fossiliferous red and greyish green argillites. In places, this assemblage contains fairly regular beds of gypsum. The Bassin-aux-Huîtres member, which is Upper Windsor in age, is made up of fossiliferous limestone and calcareous shale, red and grey argillites and gypsum.

## Cap Adèle Member

### Volcanic Rocks

In January, 1961, C.L. Lewis, of Falconbridge Nickel Mines Limited, made a semi-quantitative spectrographic analysis of nine samples of volcanic rock taken at random from the following localities:

Havre-aux-Maisons Island 188-8, 188-25, 184;

Cap-aux-Meules Island 214-51, 214-74, 119;

Havre-Aubert Island 262, 361, 89.

Table I gives the calculated chemical analyses of the nine specimens. The low silica and relatively high alumina content leads to the classification of the volcanics as under-saturated basalts. The methods of analysis, however, make definite conclusions very difficult to reach.

Table 1.- Spectrographic Analyses of Volcanic Rocks from the Havre-aux-Maisons Formation

| | 188-8 | 188-25 | 184 | 214-51 | 214-74 | 119 | 262 | 361 | 89 |
|---|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | 40.2% | 44.1% | 44.9% | 39.0% | 42.0% | 36.4% | 43.9% | 43.2% | 43.9% |
| $Al_2O_3$ | 23.6 | 24.2 | 23.4 | 21.5 | 26.5 | 23.4 | 22.3 | 20.8 | 23.4 |
| CaO | 6.9 | 2.4 | 1.0 | 2.5 | 2.7 | 2.0 | 2.1 | 3.4 | 2.9 |
| MgO | 5.0 | 7.8 | 7.5 | 9.1 | 5.8 | 6.0 | 6.1 | 5.6 | 5.6 |
| FeO | | | | | | | | | |
| $Fe_2O_3$ | 12.3 | 10.3 | 12.3 | 13.7 | 11.7 | 17.2 | 12.4 | 16.2 | 15.0 |
| $TiO_2$ | 2.7 | 2.5 | 3.2 | 2.5 | 3.0 | 4.3 | 2.5 | 4.7 | 2.7 |
| $Na_2O$ | 3.1 | 1.3 | 0.6 | $<$0.6 | 2.2 | $<$0.6 | 3.2 | 2.4 | 3.4 |
| $K_2O$ | 2.5 | 1.1 | 3.7 | 2.7 | 1.3 | 2.7 | 2.3 | 1.6 | 2.9 |
| MnO | 0.37 | 0.15 | 0.22 | 0.14 | 0.32 | 0.27 | 0.54 | 0.65 | 0.65 |

Thin beds of the volcanic rocks display considerable alteration. Nevertheless, relic intergranular, porphyritic and pilotaxitic (felted) textures can still be observed. The original ferromagnesian minerals have been replaced by chlorite and by hematite. The feldspars, which occur as phenocrysts and as thin oriented laths, and which, in places, display zonal and twinned structures, have also been altered.

As seen in outcrop, the lava flows are generally characterized by a brecciated structure (Plate IV) which has given rise to deep, surface alteration. The extent of this alteration is demonstrated by the fact that power shovels, working in this brecciated material, can dig to depths of nearly 100 feet on the sides of the buttes. The material consists of angular fragments and is used in local roadwork.

The lava flows are generally dark green to black, although some grey or light green types have been observed. The latter are believed to be andesitic or rhyolitic in composition. Almost all of the lavas are fine grained to aphanitic, and some display a porphyritic texture. In two or three places, as at the coastal escarpment on the southeast side of Entrée island, the flows exhibit a columnar structure. Amygdules, including carbonates, iron oxide and quartz, are common in the volcanics. J.M. Clarke (1910) mentions the presence of analcite and chabazite amygdules, amongst others. The joints and fractures in the volcanics are commonly filled with crystals of calcite, pyrite, specularite, acicular quartz, amethyst and dolomite.

Tuffs, which are greyish white on the weathered surface, are associated with the volcanics. Several hundred feet of these well-layered tuffs outcrop on the south side of Entrée island, 1/2 mile east of the lighthouse. The tuff horizon has also been observed on Havre-aux-Maisons island, where it is exposed in the "chemins des buttes" quarry and on the shore alongside Buttes Pelées.

In addition to the lavas and tuffs, agglomerates or volcanic breccias, intermediate to basic in composition, have also been observed. The fragments of these rocks are angular to sub-angular, and range from a few millimeters (tuffaceous) to more than a meter across. Some of the breccias may possibly have a tectonic origin.

In places, as well, there are rocks which appear to be volcanic conglomerates. The matrix comprises a black sandy material, of volcanic origin, which is considerably altered and friable. These conglomerates are interbedded with the lava flows and may possibly represent short periods of marine erosion.

The volcanic rocks, and their relationships with the accompanying sedimentary rocks, are best observed on the south shore of Havre-aux-Maisons island, between the Catholic church and Damase inlet, and on the east shore, alongside Buttes Pelées. At these localities, which are easily accessible at low tide, near-vertical sections, more than 100 feet in height, are exposed. Alongside Buttes Pelées, the rocks outcrop for more than a mile.

Other vertical sections, displaying various types of volcanic rocks, are present at intervals along the shore to the east of the Cap-aux-Meules wharf, as well as alongside the "Demoiselles" on Havre-Aubert island. The interstratification of the volcanic and sedimentary rocks, as well as their subsequent deformation, is well illustrated in vertical sections on the southeast and east shores of Entrée island. Most of these sections are accessible only at low tide.

F.J. Alcock (1941) mentions the presence of a 4-foot-thick bed of lava in the Bassin-aux-Huîtres section. A detailed study was made of this locality, at low tide, and a thin section of the rock was examined in the laboratory. This has led to the conclusion that the rock in question represents a bed of limestone, containing numerous organic remains.

This complex of volcanic rocks makes up the central core of Havre-aux-Maisons, Cap-aux-Meules, Havre-Aubert and Entrée islands. It also forms the nucleus of both Goélands island, southeast of Etang-du-Nord, and the east point (Noir cape) of Corps-Morts island, located 10 miles to the east of Havre-Aubert island.

Sedimentary Rocks

The sedimentary rocks included with the Cap Adèle member comprise conglomerates, fine-grained sandstone, siltstones, several argillites, gypsum and shale. These rocks are, in part, interbedded with the volcanic rocks.

A vertical section of conglomerate is exposed on the shoreline of Entrée island, about 500 feet east of the lighthouse. This rock is made up of poorly rounded cobbles and boulders of fossiliferous shale (F23)*, from a few inches to two feet in diameter, contained in an argillaceous matrix. The conglomerate is included within an assemblage of shale and grey argillite, cut by veins of gypsum a few feet thick. This conglomerate has not been noted in other sections, and its limited extent indicates that it is probably intraformational. Other conglomerates and breccias, containing numerous volcanic fragments, have been observed at several places within the shale exposed in the section on Corps-Mort island.

The fine-grained sandstone is reddish, calcareous and quite fossiliferous. It outcrops (location F18) on Cap-aux-Meules island, a mile and a quarter east of the Hérissée point lighthouse and about 100 feet south of an abandoned road. The same stratigraphic horizon apparently reappears on the south side of the Butte Ronde on Havre-aux-Maisons island (location F4).

The siltstones in this sedimentary series are red to grey and almost uniformly fossiliferous. They commonly accompany the limestones and are slightly calcareous. They are well exposed near the gypsum cliffs on Cap-aux-Meules island, about 6,500 feet south of Trou cape (J.W. Beede, 1910, and W.A. Bell, 1946), and fossil collections F14 to F19 were taken from this locality. Although outcrops of siltstone are not very extensive here, in many places being represented only by frost-heaved blocks, this is where the best exposures of gypsum in all the Islands occur.

The limestones associated with the siltstones are also fossiliferous and are reddish to fairly dark grey. Other fossiliferous limestones outcrop on Havre-aux-Maisons island. These rocks are grey, thin bedded, and accompany calcareous shales that are locally fossiliferous. They are observed only in the vicinity of gypsum masses (localities F2, F3 and F6) or near conspicuous depressions (localities F5, F7, F8, F9 and F10).

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*(F23) is the reference number for a collection of fossils taken from this locality. They are described in the section of this report which deals with paleontology.

A bed of grey, black weathering shelly limestone occurs on the southwest side of Buttes Pelées. This bed, which is near the shore-line and about 50 feet above sea-level, contains such fossils as Dielasma latum Bell and Linoproductus lyelli (Verneuil) (F1). The limestone is surrounded with green and red argillite and a small amount of gypsum, the whole assemblage being included within a body of agglomerate and tuff which forms the buttes. This quite distinctive shell limestone bed does not outcrop at any other locality.

Greyish green and red, non-fossiliferous argillite (mudstone) makes up about 60% of the sedimentary rocks of the Havre-aux-Maisons formation. Bedding is generally not visible, except in places where the red and green bands alternate and where the rock has not been too severely deformed. The argillite is cut by veins 1-8 inches thick of white, pink or black fibrous gypsum.

In addition to veins, large masses of gypsum are present in the argillite and volcanics, making up from 5 to 10% of the rock. This gypsum is generally greyish, but pink, red, white, and black types are present. It outcrops at several places, such as the sides and bottoms of the funnel-shaped sink-holes, but reaches its maximum exposure in the vertical sections along the shore. Here, the gypsum is in masses up to 250 feet thick that are so irregular in shape and discontinuous that they cannot be used to determine the strike and dip of the enclosing rocks. It appears that, during the folding of the whole assemblage, the gypsum, which was quite plastic, accumulated as irregular masses in zones of low pressure.

Finely bedded shales, in places grading into argillaceous limestones, accompany the poorly bedded to completely massive argillite. Well preserved fossils are common in these rocks as at localities F6 and F10 on Havre-aux-Maisons island.

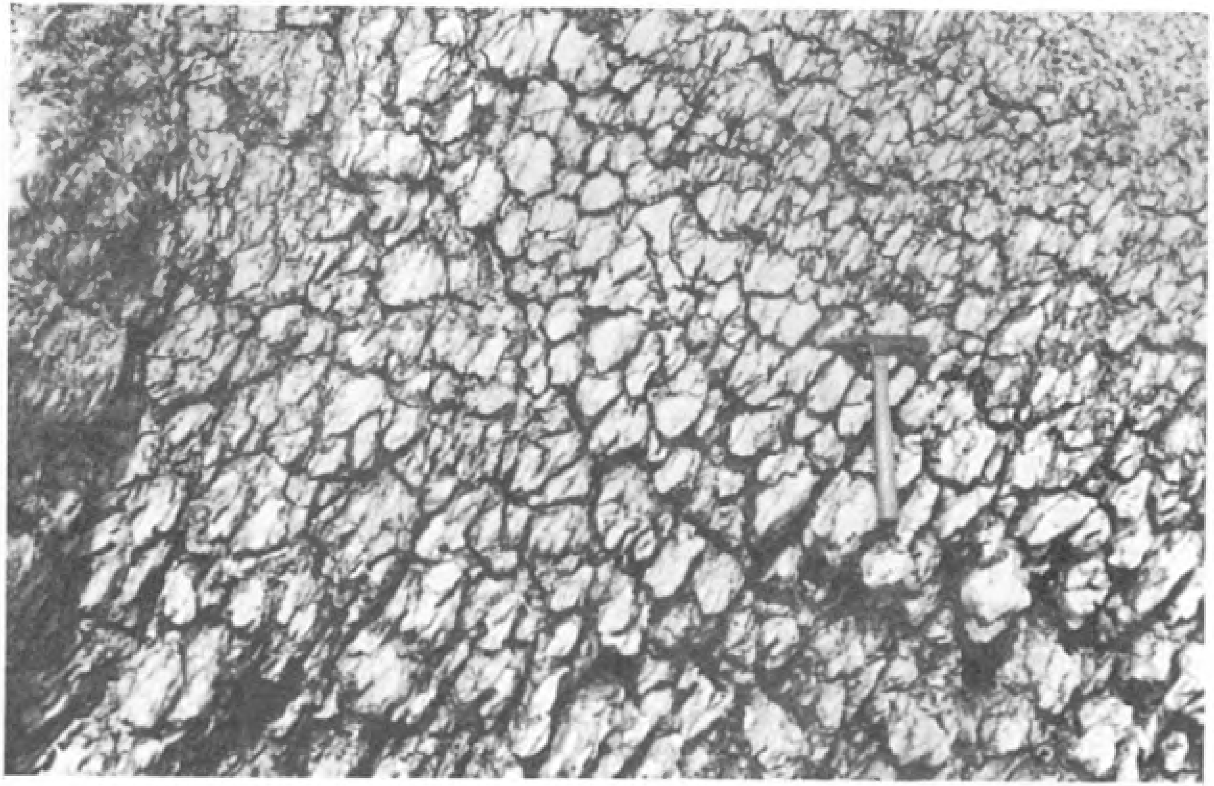
The sedimentary portion of the Cap Adèle member is best exposed in the vertical section along the shore at the foot of Butte Ronde. This section extends 2,800 feet northeast from a point 600 feet north of the lighthouse at Alright cape. Beginning with a fault which brings the Havre-aux-Maisons formation into contact with the red sandstone of the Cap-aux-Meules formation, it displays a very complex structure. Six irregular bodies of gypsum, which could have originally belonged to two or three different beds, were observed in the section, as well as two masses of volcanic rock that are enclosed in an argillite veined with gypsum.

Another vertical section, located in Damase inlet on the south shore of the same island, includes four bodies of gypsum enclosed in

Plate V

Two bodies of gypsum (left) and another of volcanic rock (right) in relief on argillite of the Havre-aux-Maisons formation; island east of Ronde butte, Havre-aux-Maisons (Alright) island.

Plate VI



Gypsum washed by the sea.
Shore east of Ronde butte, Havre-aux-Maisons (Alright) island.

argillites and bedded limestones. A similar section is exposed on Cap-aux-Meules island. Starting at a point 4,000 feet northeast of the main wharf, it extends intermittently for 2,300 feet. The same rocks are exposed in places along the shore of the Havre-aux-Maisons lagoon, as far as Richard point.

Two sections on Havre-Aubert island also contain bodies of gypsum. These bodies, along with some masses of volcanic rocks, are enclosed in gypsum-veined argillites that have been overturned. One of the sections is located on the southwest shore of La Cabane inlet. The other, on the south and north sides of Noir cape, is 2,000 feet long. Argillite and gypsum are also exposed in a similar section located west of the "Demoiselles" at Plâtre inlet.

Another section, on Entrée island, starts 350 feet from the southwest point and extends 3,300 feet to the east. The western part of this section displays an angular uncomformity with the overlying sandstone of the Cap-aux-Meules formation. A large mass of gypsum also occurs in this section, and, on the point where the lighthouse has been built, there is a good-sized mass of volcanic rock. From the west shore of Rouge cape, in the south, to La Cormorandière, in the north, several irregular masses of gypsum, as well as numerous masses of crushed volcanic rock, lie within the argillite.

## Thickness

The exact thickness of the Cap Adèle member cannot be ascertained in any of the vertical sections owing to the lack of stratification and to the complexity of the structure. J. Richardson (1881) assigned a stratigraphic thickness of 2,000 feet to the section exposed at Plâtre inlet, west of the "Demoiselles" on Havre-Aubert island. According to W.A. Bell (1946), the shore section on Havre-aux-Maisons island, between Alright cape and Adèle cape, is approximately 2,500 feet thick. Although these are only approximations, they are believed to be quite reasonable.

## Paleontology

W.A. Bell, of the Geological Survey of Canada, kindly examined the fossils gathered during the course of the summer's work. These came from 23 different localities, distributed across Havre-aux-Maisons island (F1 to F10), Cap-aux-Meules island (F11 to F19), Havre-

Aubert island (F20 and F21) and Entrée island (F22 and F23). According to Dr. Bell, the fauna of the Cap Adèle member belongs to sub-zone B of the Lower Windsor.

## Havre-aux-Maisons (Alright) Island

F1. Grey, black-weathering shell limestone.

Dielasma latum Bell (common)
Pugnax dawsonianus (Davidson) (rare)
Linoproductus lyelli (Verneuil) (common)

F2. Grey, non-calcareous siltstone.

Linoproductus lyelli (Verneuil) (rare)
Tracks and borings of worms (common)

F3. Grey silty limestone.

Diaphragmus tenuicostiformis (Beede) (rare)

F4. Fine-grained red sandstone, quite silty and only slightly calcareous.

Linoproductus lyelli (Verneuil) (common)
Productella baddeckensis Bell (very rare)
Composita windsorensis Bell (very rare)
Dielasma latum Bell (common)
Pugnax dawsonianus (Davidson) (rare)
Aviculopecten lyelli Dawson (common)

F5. Grey calcareous shale, rich in silty material and finely bedded limestone.

Pseudamusium simplex (Dawson) (common)
Stegocoelia abrupta Bell (very rare)
Unidentified cephalopod
Worm tracks (rare)

F6. Grey calcareous shale.

Leptodesma dawsoni (Beede) (rare)
Pseudamusium simplex (Dawson) (common)
Beyrichiopsis? sp. and unidentified ostracod
Mourlania? sp. (very rare)
Stegocoelia? compactoidea? Bell (very rare)

F7. Grey calcareous shale, rich in silty material and finely bedded limestone (same as F5).

Pseudamusium simplex (Dawson) (very common)
Leptodesma?
Stegocoelia abrupta Bell (very rare)

*Paraparchites*? (very rare)
Worm tracks (fairly rare)

F8. Grey calcareous shale, rich in silty material and finely bedded limestone.

*Linoproductus lyelli* (Verneuil) (common)
*Leptodesma dawsoni* (Beede) (rare)
*Leptodesma borealis* (Beede) (rare)
*Pseudamusium simplex* (Dawson) (rare)
*Aviculopecten* (very rare)
Worm tracks (common)

F9. Grey calcareous siltstone or silty calcareous shale.

*Linoproductus lyelli* (Verneuil) (common)
*Leptodesma dawsoni* (Beede) (common)
*Leptodesma acadica* (Beede) (rare)
*Pseudamusium simplex* (Dawson) (rare)
*Murchisonia*? *gypsaea*? Dawson (very rare)
Worm tracks (common)

F10. Grey calcareous siltstone or silty calcareous shale.

*Linoproductus lyelli* (Verneuil) (fairly rare)
*Leptodesma dawsoni* (Beede) (very rare)
Worm tracks (common)

## Cap-aux-Meules Island

F11. Grey, non-calcareous siltstone.

Worm tracks (common)
Stringy algae (?)

F12. Dark grey siltstone, with very little calcareous material.

*Diaphragmus tenuicostiformis* (rare)
Stringy algae (?)

F13. Grey calcareous siltstone.

*Linoproductus lyelli* (Verneuil) (common)
*Leptodesma dawsoni* (Beede) (common)
*Leptodesma borealis* (Beede) (rare)
*Aviculopecten lyelli* Dawson (rare)
*Pseudamusium simplex* (Dawson) (rather common)
*Bulimorpha maxneri* Bell (a single specimen)
Worm tracks

F14. Fine-grained red sandstone, with little or no limestone; reddish calcareous siltstone and thin-bedded limestone.

Linoproductus lyelli (Verneuil) (common)
Diaphragmus tenuicostiformis (Beede) (common)
Dielasma latus Bell (common)
Aviculopecten lyelli Dawson (common)
Pugnax dawsonianus (Davidson) (rare)
Leptodesma dawsoni (Beede) (rare)
Edmondia rudis McCoy (rare)
Diodoceras avonensis (Dawson) (rare)
Conularia planicostata Dawson (rare)
Unidentified tubular cephalopod
Crinoid stems (rare)

F15. Grey calcareous siltstone.

Linoproductus lyelli (Verneuil) (common)
Diaphragmus tenuicostiformis (Beede) (common)
Dielasma latum Bell (rather rare)
Dielasma davidsoni (Hall and Clarke) (rare)
Composita windsorensis Bell (rare)
Leptodesma dawsoni (Beede) (rather rare)
Parallelidon dawsoni Beede (rare, a single specimen)
Schizodus fundiensis Bell (very rare)
Stegocoelia? compactoidea? Bell (very rare)
Stroboceras hartli (Dawson) (rare)

F16. Fine-grained, slightly calcareous reddish siltstone or sandstone.

Linoproductus lyelli (Verneuil) (common)
Diaphragmus tenuicostiformis (Beede) (rare)
Composita windsorensis Bell (a single specimen)

F17. Brownish red siltstone, with very little calcareous material.

Linoproductus lyelli (Verneuil) (common)
Diaphragmus tenuicostiformis (Beede) (common)
Composita windsorensis Bell (rare)
Pugnax dawsonianus (Davidson) (very rare)
Aviculopecten lyelli (Dawson) (common)
Schizodus fundiensis (Bell) (rare)

F18. Fine-grained red sandstone, with very little calcareous material.

Linoproductus lyelli (Verneuil) (common)
Dielasma latum (Bell) (rare)
Diaphragmus tenuicostiformis (Beede) (common)
Pugnax dawsonianus (Davidson) (rare)

Leptodesma dawsoni (Beede) (rare)
Aviculopecten lyelli Dawson (common)
Unidentified tubular cephalopod

F19. Red siltstone, slightly calcareous siltstone or limestone, and reddish to grey limestone.

Linoproductus lyelli (Verneuil) (common)
Diaphragmus tenuicostiformis (Beede) (rare)
Dielasma latum Bell (common)
Composita windsorensis Bell (very rare)
Pugnax dawsonianus (Davidson) (rare)
Leptodesma dawsoni (Beede) (rare)
Pseudamusium simplex (Dawson) (rare)
Aviculopecten lyelli Dawson (common)
Naticopsis howi Dawson (very rare)
Stegocoelia compactoidea ? Bell (very rare)
Diodoceras avonensis (Dawson) (very rare)
Batostomella abrupta Ulrich (very rare)
Serpula annulate Dawson (rare)

## Havre-Aubert (Amherst) Island

F20. Brown calcareous siltstone.

Linoproductus lyelli
Diaphragmus tenuicostiformis
Leptodesma dawsoni
Schizodus sp.
Pseudamusium simplex
Cypricardella ? acadica
Worm tracks

F21. Grey calcareous siltstone.

Unidentified fucoids

## Entrée Island

F22. Dark grey dolomite.

Linoproductus lyelli (Verneuil)
Diaphragmus tenuicostiformis (Beede)
Ptatyschisma? dubium Dawson
Bellerophon? (or one of the Bellerophontids)

F23. Grey non-calcareous siltstone.
Pseudamusium? simplex? (Dawson)
Unidentified cylindrical form - possibly an alga?

The following is a summary of Dr. Bell's comments concerning the age of the local formations:

1- With the exception of those from localities F6, F11 and F12, the types of fossils listed above are typical of the B sub-zone of the Lower Windsor, which is Mississippian in age.

2- The associations, however, are not sufficient to determine the actual horizon in the B sub-zone to which the fossils belong.

3- Several of these species have also been noted in the C sub-zone of the Windsor in Nova Scotia.

4- Nevertheless, the most typical species of the C sub-zone are entirely lacking in the rocks of the Islands. Such species include: Martinia galataea, Nodosinella priscilla, Lophophyllum avonensis, Dibunophyllum lambii, Productus subfasciculatus, Spirifer adonis, Modiola hartii and Flemingia dispersa.

5- The fauna observed at localities F11 and F12 is totally inadequate for determining an exact age for the rocks.

6- The ostracod, Beyrichiopsis?, from F6 could be a co-species with a fossil from the Windsor formation's sub-zone C at Amherst, Nova Scotia, and provisionally identified as Glyptopleura sp. However, the study of ostracods from the Windsor formation has not progressed sufficiently for their stratigraphic extent or exact age to be determined.

J.W. Beede (1910) studied the fossils brought back by J.M. Clarke from two localities on Cap-aux-Meules island and from three on Grande-Entrée island. He noted that, although Productus was quite abundant on Cap-aux-Meules island, it was represented by only two groups. These groups are similar in many respects, but show sufficient distinguishing characteristics to be separated. Beede also noted the absence of the spirifers Chonetes, Derbya, and Orthothetes. He therefore concluded that this poorly differentiated fauna must have developed in a closed basin of limited extent — a basin even more limited than that of the Nova Scotia fauna. The discovery of several other fossil occurrences does not invalidate this conclusion in any way, despite the fact that localities F4, F15, F16, F17 and F19 contain a spirifer, Composita windsorensis Bell. The distribution of this fauna is still believed to have been quite restricted.

## Structure

J. Richardson (1881) recognized two major anticlinal structures in these rocks. One, on Havre-Aubert island, trends east; the other, on Cap-aux-Meules and Havre-aux-Maisons islands, trends N.80°E. Alcock (1941) mentions a synclinal structure in the shore-line section north of Cap-aux-Meules. Our own field studies have indicated that the rocks of the Cap Adèle member of the Havre-aux-Maisons formation have been folded into two main anticlines. One of these, in the south, is the Havre-Aubert anticline, named after the island on which it occurs. The other, farther to the north, is the Cap-aux-Meules anticline, located on Cap-aux-Meules and Havre-aux-Maisons islands.

The Havre-Aubert anticline extends east from Noir cape,to the "Demoiselles". The axial zone is occupied by the volcanic and sedimentary assemblage described earlier in this report. The sandstone of the overlying Cap-aux-Meules formation outcrops on the north and south limbs of the anticline. Cross-folding of the axial zone, in the Bassin area, has given rise to two domal structures: one at "La Montagne", to the west; the other at the "Demoiselles", to the east.

The second major anticline extends N.80°E. from Hérissée point, on the west shore of Cap-aux-Meules island, as far as Buttes Pelées on Havre-aux-Maisons island.

These two major anticlinal structures are separated by a broad syncline, the axis of which is located close to the Havre-aux-Basques lagoon. Outcrops of red sandstone of the Cap-aux-Meules are exposed on the limbs of this fold.

On Entrée island, the rocks of the Cap Adèle member outcrop on the east side of the central core, as well as on the south shore-line. The west side of the island, on the other hand, displays exposures of the more recent Cap-aux-Meules formation. The general structural trend of the rocks is approximately north.

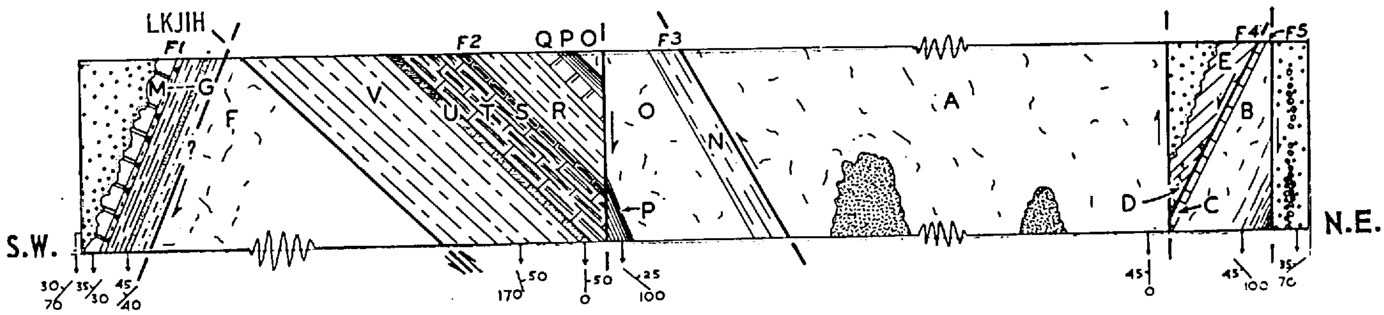
Folding has had very little effect on the Windsor rocks on Corps-Mort island. The beds generally strike N.60°E., with a dip of about 55° north. Where deformation has been more severe, several inclusions of volcanic rocks, commonly angular in shape and veined with gypsum, have been observed in the sedimentary rocks. F.J. Alcock (1941) has interpreted these volcanic masses as "bombs", that fell into the sediments during the accumulation of the gypsum. On the other hand, W.A. Bell (1946), noting the angular shape of the inclusions, believes that they represent the remnants of very thin lava flows that were broken up during tectonic movements. He also observed inclusions of sedimentary rocks in the volcanics at such places as the shore-line section of Buttes Pelées, on Havre-aux-Maisons island, and the east and southeast shore of Entrée island. Here, irregular masses of argillite and gypsum, up to several hundreds of feet across, are completely enclosed in the volcanic rocks.

In summary, it appears that thin flows of lava were originally intercalated within the sedimentary rocks. During deformation, these flows were broken into various-sized blocks, whereas the sedimentary rocks, being considerably more plastic, tended to flow around and envelop the lava fragments and to infiltrate the cracks and fissures in these fragments. In places where the sedimentary beds made up only a minor proportion of the assemblage, deformation caused them to form irregular masses enclosed by crushed volcanic rock.

## Bassin-aux-Huîtres Member

This upper member of the Havre-aux-Maisons formation, made up entirely of sedimentary rocks, is apparently confined to Grande-Entrée (Coffin) island, in the northern part of the archipelago. It outcrops in the scarp that follows the south shore of Boudreau island, bordering Bassin-aux-Huîtres. This section, which is more than a mile long, is fully accessible only at low tide. The Bassin-aux-Huîtres member is lithologically similar to the sedimentary portion of the Cap Adèle member, except that more than 50% of the exposed portion of the former is made up of limestones and schists. In places, these rocks are quite fossiliferous. The remaining portion of the Bassin-aux-Huîtres member is composed of non-fossiliferous green and red siltstone and argillite. These rocks are unstratified and are intersected in varying directions by narrow veins of white, pink, red or black gypsum. In addition, fairly large masses of gypsum have been observed at two places within the siltstones and argillites. The Bassin-aux-Huîtres member, in contrast to the Cap Adèle member, does not contain any volcanic rocks.

The structures observed in this section of the Bassin-aux-Huîtres member are quite complex. There are apparently six or seven faults, including one thrust fault. According to the observations of W.A. Bell (1946), as well as our own, the section, from southwest to northeast is as follows:




F1, F2, F3, F4, F5: FOSSILIFEROUS DEPOSITS

FIGURE 4.

CROSS-SECTION SHOWING THE STRUCTURE OF BASSIN-AUX-HUÎTRES MEMBER OF HAVRE-AUX-MAISONS FORMATION,

SOUTH SHORE OF BOUDREAU ISLAND (OYSTER ISLAND)

AGE: **A** IS OLDER AND **V** IS YOUNGER

D.N.R.Q. NO 1486

| | | Thickness, in feet |
|---|---|---|
| | Red sandstone of the Cap-aux-Meules formation (Strike, 70°; dip, 30°N.) | |
| | Unconformity | |
| M- | Grey limestone with thin shale interbeds. (Strike, 30°; dip, 35°N.) Collection F1 | |
| L- | Calcareous grey or red intraformational breccia with red shale fragments | 1 |
| K- | Grey calcareous shale with some argillaceous bands | 4 |
| J- | Grey and red shale, calcareous shale and limestone | 6 |
| I- | Grey shale with brick-red lamellae and thin bands of limestone | 27 |
| H- | Thinly bedded red sandstone, with limestone concretions (Strike, N.40°E.; dip, 45°N.) | 5 |
| G- | Grey shale and red calcareous siltstone with limestone concretions. | 28+ |
| | Fault? | |
| F- | Red siltstone and argillite with greenish bands, criss-crossed by narrow gypsum veins | 130? |
| | Thrust fault toward the northwest | |

The following beds, from V to A, were overturned in a northwest direction by the thrust fault. The beds designated as R to V are younger than those designated as Q to A.

| | | |
|---|---|---|
| V- | Shale and grey shaly limestone with red bands. Some grey beds contain pseudomorphic crystals of rock-salt. (Strike, S.80°E.; dip, 50°E.) | 200? |
| U- | Thin-bedded dark grey limestone. (Strike, 0°; dip, 50°E.) | 15± |
| T- | Thin-bedded limestone with grey calcareous shale. (Collection F2) | 75± |
| S- | Thin-bedded dark grey limestone. (Collection F2) (Strike, S.80°E.; dip, 45°E.) | 3 |
| R- | Light grey calcareous shale. (Collection F2) | 125± |
| Q- | Thin-bedded dark grey limestone. (Strike, 0°; dip, 45°E.) | 25± |
| P- | Grey calcareous shale. (Strike, 0°; dip, 45°E.) | 25± |
| O- | Red and grey siltstone and argillite | 15± |
| | Fault | |
| P- | Grey calcareous shale. (Strike, S.80°E.; dip, 25°N.) | 25± |
| O- | Red and grey siltstone and argillite, veined with gypsum | 130± |
| N- | Light grey shale and dark grey calcareous shale. (Collection F3) | 35± |

| | Fault | Thickness, in feet |
|---|---|---|
| A- | Red, grey and green siltstone and argillite, overturned and veined with gypsum. Mass of gypsum more than 100 feet across. | ? |
| | Fault | |
| Basal beds of calcareous red sandstone of the Cap-aux-Meules formation | | |
| E- | Reddish grey calcareous shale. (Collection F4) | 20± |
| D- | Wavy-bedded reddish grey limestone. (Strike, 0°; dip, 45°W.) | 7 |
| | Fault | |
| C- | Thin-bedded dark grey limestone; reddish calcareous shale, including a 4-foot-thick bed of limestone which displays a columnar structure. This latter bed was interpreted by Alcock (1941) as a lava flow. | 10 |
| B- | Red and green siltstone and argillite, with reddish grey, fossiliferous, calcareous shale (Strike, S.80°E.; dip, 45°S.) (Collection F5) | 50± |
| | Fault | |
| Red sandstone with several beds of conglomeratic (intraformational) limestone of the Cap-aux-Meules formation. (Strike, N.70°E.; dip, 35°N.) | | |

## Paleontology

J.W. Beede (1910) was the first to study the fossils of the Bassin-aux-Huîtres section. On the basis of the similarity of the fauna with that of Nova Scotia, he concluded that the rocks are Carboniferous in age. The fossils of this section, which are listed below (p. 185 of Beede's report), were contained in a calcareous shale.

| | |
|---|---|
| Nodosinella clarkei | Aviculopecten debertianus |
| Cornulites ? annulatus | Aviculopecten egena |
| Serpula ? infinitesima | Edmondia sp. A |
| Stenopora ? sp. | Nucula iowensis magdalenensis |
| Composita dawsoni | Nucula sp. |
| Hemiptychina ? waageni | Paralleledon ? sp. |
| Lingula eboria | Schizodus cuneus |
| Martinia glabra | Schizodus denysi |
| Orbiculoidea limata | Bucanopsis perelegans minima |
| Productus dawsoni | Euphemus ? sp. |
| Productus dawsoni acadicus | Conularia sorrocula |
| Strophalosia nebraskensiformis | Ostracods |

W.A. Bell (1946) noted four fossil beds within the Bassin-aux-Huîtres section. A fifth was observed during the summer of 1960. The fossils from these five beds are listed below. Dr. Bell believes them to be Upper Windsor in age, and has also suggested a correlation with the sub-zones of the Upper Windsor. This correlation is given in the right-hand column of the list below.

| | | Fauna | Correlation |
|---|---|---|---|
| F.1 | M Beds | FORAMINIFERS | |
| | | *Nodosinella* sp. | Upper Windsor |
| | | BRACHIOPODS | Upper part of the C sub-zone |
| | | *Productus* (*Linoproductus*) sp. | |
| | | *Productus avonensis* Bell | |
| | | *Leptodesma acadica* (Beede) | |
| | | Productid fragments | |
| | | OSTRACODS | |
| | | *Paraparchites*? | |
| | | Small crinoid stems | |
| | | Small gastropods | |
| F2. | Beds T to R | BRACHIOPODS | |
| | | *Linoproductus lyelli* (Verneuil) | Upper Windsor, E sub-zone |
| | | *Diaphragmus tenuicostiformis* (Beede) | |
| | | *Martinia galataea* Bell | |
| | | *Composita windsorensis* Bell | |
| | | *Composita obligata* Bell | |
| | | *Camarotoechia atlantica* Bell | |
| | | *Schuchertella pictoense* Bell | |
| | | PELECYPODS | |
| | | *Aviculopecten subquadratus*? Bell | |
| | | *Leptodesma borealis* Beede | |
| | | *Leptodesma dawsoni* (Beede) | |
| | | *Leptodesma acadica* (Beede) | |
| | | *Lithophagus poolii* (Dawson) | |
| | | *Pteronites gavensis* Dawson | |
| | | *Sanguinolites niobe* Bell | |
| | | *Sanguinolites parvus* Bell | |
| | | *Spathella insecta* (Dawson) | |
| | | *Schizodus* sp. | |
| | | *Cypricardella*? *acadica*? Bell | |
| | | GASTROPODS | |
| | | *Buchanopsis* sp. | |
| | | *Bellerophon*? sp. | |
| | | *Flemingia*? sp. | |
| | | *Cyclonema*? *sublangulatum* Hall | |
| | | *Worthenia*? *longi* Bell | |
| | | *Poterioceras* sp. Bell | |

TRILOBITE

*Phillipsia eichwaldi* Fischer

OSTRACOD

*Paraparchites*? sp. cf. *gibbus* Bell

Algae

F.3- N Beds

BRACHIOPODS — Upper Windsor, C sub-zone

*Linoproductus lyelli* (Verneuil)

*Composita windsorensis* Bell

*Camarotoechia acadiensis* (Davidson)

PELECYPODS

*Aviculopecten lyelli* Dawson

*Leptodesma borealis* (Beede)

*Leptodesma dawsoni* (Beede)

*Leptodesma acadica* (Beede)

*Lithophagus poolii* (Dawson)

*Pseudamusium simplex* (Dawson)

*Sanguinolites parvus* Bell

*Sanguinolites striatogranulatus* Hind

*Modiola hartii* Bell

GASTROPODS

*Mourlonia*? sp. Bell

*Murchisonia gypsaea* Dawson

F.4- E Beds

CORAL

*Dibunophyllum* sp. — Upper Windsor

BRACHIOPODS — Lower portion of the C sub-zone

*Linoproductus lyelli* (Verneuil)

*Productus subfasciculatus* Bell

*Diaphragmus tenuicostiformis* (Beede)

*Dielasma davidsoni* (Hall and Clarke)

*Martinia galataea* Bell

*Martinia* sp.

*Composita windsorensis* Bell

*Spirifer adonis* Bell

*Pugnoides* sp.

PELECYPODS

*Aviculopecten subquadratum*? Bell

*Pseudamusium simplex* (Dawson)

*Schizodus fundiensis* Bell

GASTROPODS

*Worthenia longi* Bell

CEPHALOPOD
*Orthoceras vindobonense*? Dawson

TRILOBITES
*Phillipsia eichwaldi* Fisher
*Phillipsia* sp.

Crinoid stems

| | | | |
|---|---|---|---|
| F.5- | B Beds | BRACHIOPODS<br>*Linoproductus lyelli* (Verneuil)<br>*Productus avonensis* Bell<br>*Diaphragmus tenuicostiformis* (Beede) | Upper Windsor sub-zone? |

## Cap-aux-Meules Formation

The Cap-aux-Meules formation is made up of grey and red sandstone. The red is much more abundant than the grey and is fine grained, cross bedded, poorly consolidated and quite deeply weathered. The reddish colour is due to a thin coating of hematite on the quartz grains. In places, the rock contains a small amount of calcium carbonate. Generally, however, this material has disappeared, leaving the rock with a porosity that may be as much as 45%. This red sandstone outcrops on a slightly undulating plateau ranging from 10 to 100 feet above sea-level. The plateau, located on the periphery of the Islands, is commonly bordered with a scarp which has been cut into many unusual shapes by marine erosion.

The grey to greenish grey sandstone is well stratified. Although it also has a calcareous cement, it is better consolidated, less altered and more resistant to erosion than the red sandstone. Being more resistant, it is responsible for the formation of the many capes and headlands which border the sea. Examples include Meules (Grindstone) cape, where this sandstone was formerly quarried to make grindstones, the two headlands of Pointe Basse on Havre-aux-Maisons island, Nord-Est cape of Est island, and Shea point, located east of the Havre-Aubert wharf. The grey sandstone also underlies five well rounded hills, trending in a general N.75°E. direction, on Cap-aux-Meules and Havre-aux-Maisons islands.

## Relationship between the Grey and Red Sandstones

The age relationships between the dense, erosion-resistant, grey-green sandstone and the poorly consolidated, friable red sandstone are difficult to assess. J. Richardson (1881) observed that at Meules cape, as well as at Butte Portage on the north shore of Havre-Aubert island, the red sandstone appears to overlie the grey. J.M. Clarke (1910,

Marine erosion in the red sandstone, Cap-aux-Meules formation, west of the Old Harry wharf, Old Harry point, Grande-Entrée (Coffin) island.

Plate VII

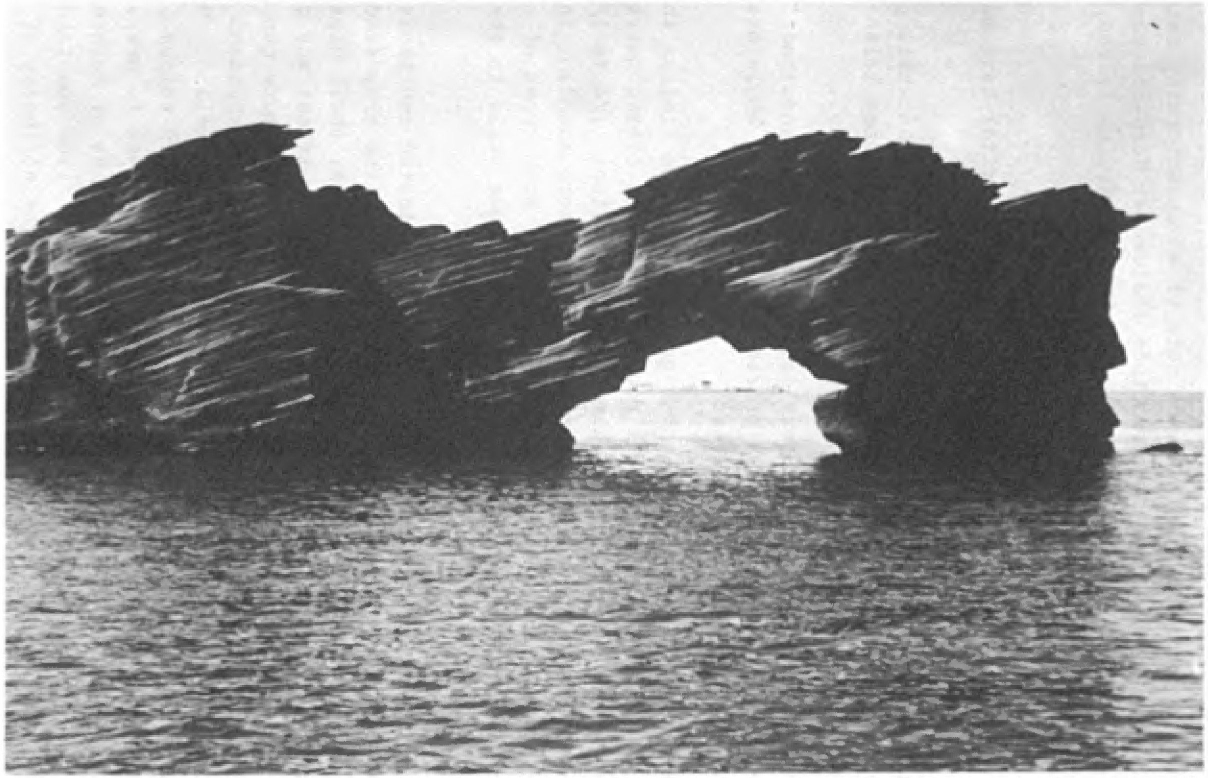
Plate VIII

Marine erosion along joints in red sandstone, Cap-aux-Meules formation. View from Belle-Anse, west side of Cap-aux-Meules island.

Plate IX

Marine erosion in red sandstone, Cap-aux-Meules formation. View from Rouge cape, Cap-aux-Meules island.

Plate X



Marine erosion in red sandstone, Cap-aux-Meules formation.
View from Belle-Anse, Cap-aux-Meules island.

p. 146), in describing the latter locality, writes that this 856-foot section displays a hard, grey, spotted sandstone lying beneath a dark red friable type, with the change in dip between the two indicating the presence of an unconformity. The present author, however, could not find any evidence of this change in dip at the locality mentioned. F.J. Alcock (1941), on the other hand, also makes note of an unconformity between the grey and red sandstone. He observed this feature at Nord-Est cape on Havre-aux-Maisons island, at two places on Cap-aux-Meules island, and around Demoiselle on Havre-Aubert island.

Dr. W.A. Bell (1946) and the present writer have made the following observations:

1. At Brion island, Oiseaux rock, Dauphin cape, and at Rockhill point on Grosse-Île, as well as at Portage butte on Havre-Aubert island, the red and grey sandstones are interbedded and gradational.

2. At Sud-Ouest cape on Havre-Aubert island, the grey sandstone lies conformably on more than 600 feet of red sandstone, the whole assemblage dipping $15^{o}$-$40^{o}$ to the southwest.

3. The red sandstone and the greenish grey variety are similar in many respects. Both consist of well rounded, frosted, pitted quartz grains of approximately equal size. Limestone concretions, 1/4 to 1/2 inch across, are found in both sandstones, but are more abundant in the grey variety. Crossbedding is also typical of both types of sandstone, although it is more common and occurs on a larger scale in the red sandstone.

4. The grey sandstone grades into a poorly consolidated red sandstone at Leslie cove, on Cap-aux-Meules island. Here, as the grey sandstones, striking S.$75^{o}$E., are traced south along the shore, their dips become more gentle and take on a brownish hue and then, without any change in stratification, abruptly become red. The same feature can be observed in a cliff-face on the shore-line about one thousand feet west of the Pointe Basse wharf on Havre-aux-Maisons island. Here, in the same sequence of beds, there are abrupt changes in colour – from brownish grey to red, to greenish grey, red, and back to grey. Such transitions are also in evidence on the eastern side of Pointe Basse. A similar situation exists on the west slope of Alice mountain on Havre-aux-Maisons island, and on the hill to the northeast of Hérissée point. The poorly consolidated red sandstone along the shore-line has the same attitude as the well consolidated grey sandstone exposed at a higher elevation. W.A. Bell (1946) also observed such a colour transition on Havre-aux-Maisons island. Here, although the sandstone beds of the western limb of the Pointe Basse syncline are grey, the beds of the east limb, apparently belonging to the same stratigraphic horizon, are red.

5. Either the red or the grey sandstone may appear at the base of the Cap-aux-Meules formation, lying uncomformably above, or in fault-contact with, the underlying rocks. The only place where the actual contact between the grey sandstone and the older rocks can be observed is at the east point of Damase inlet, on the south shore of Havre-aux-Maisons island. Here, the discordant contact between the grey sandstone and the siltstones of the Cap Adèle member of the Havre-aux-Maisons formation is clearly visible. The red sandstones, for their part, display a well marked contact with these same siltstones, and the accompanying volcanics on Goélands island and the neighbouring islets, as well as at Sud-Ouest point on Entrée island. F.J. Alcock (1941), on the other hand, recorded the presence of a fault contact at the latter place.

The writer believes that the red and grey sandstones represent two facies of the Cap-aux-Meules formation.

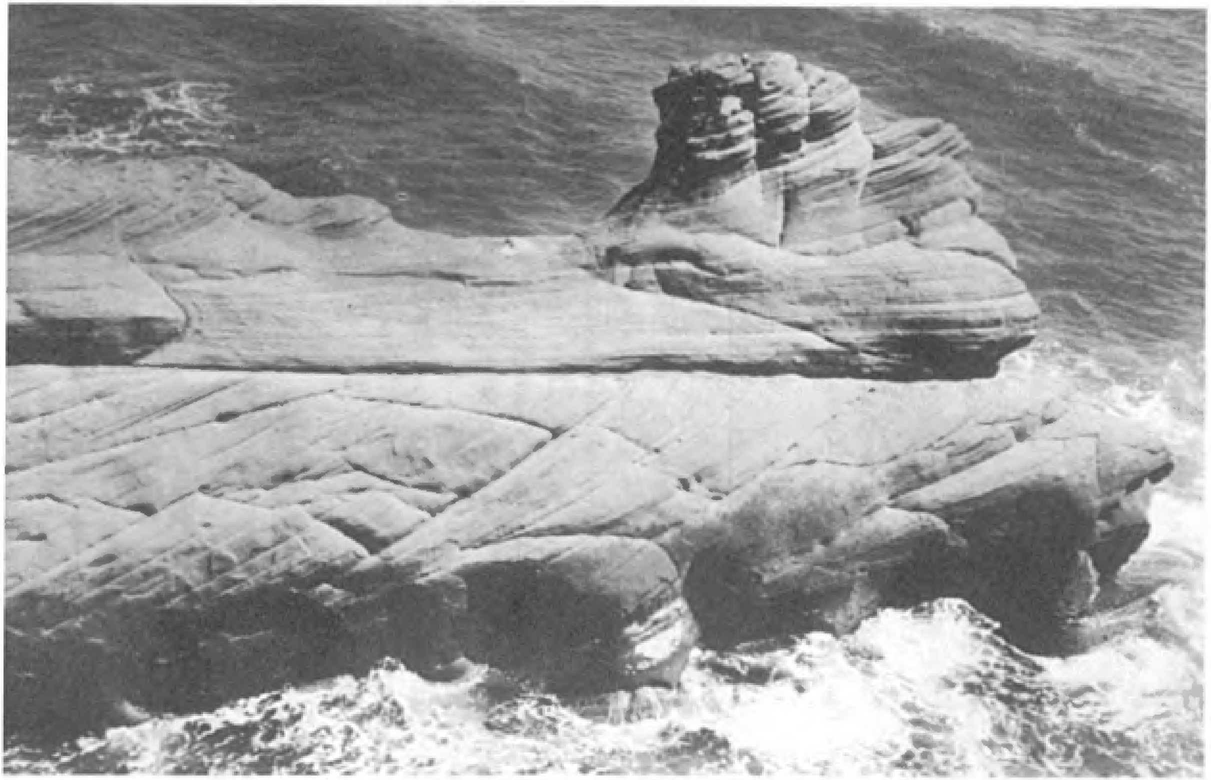
## Typical Sections

An excellent section of the red and grey sandstones can be seen on the south shore of Havre-aux-Maisons island, near the east point of Damase inlet. Here, a ferruginous brown sandstone, which is distinguished by nodules of altered pyrite, lies unconformably on grey-green siltstone of the Havre-aux-Maisons formation. Near the contact, the sandstone beds strike N.60$^{o}$E. and dip 40$^{o}$ southeast. A fault intersects the beds about 200 feet to the east, and, farther to the east, a small syncline and anticline can be seen. W.A. Bell (1946), after an examination of this section, estimated the thickness of these sandstones to be greater than 1,250 feet.

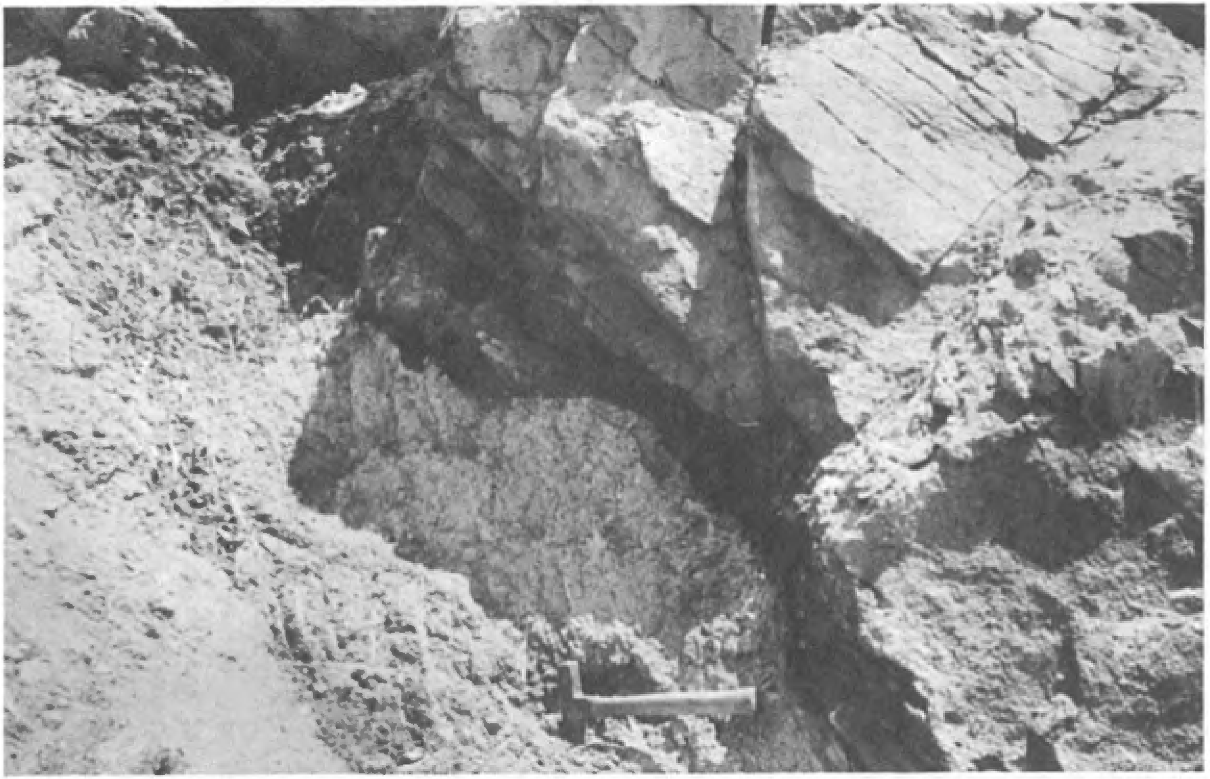
At Firman cove, 550 feet north of the Alright Cape lighthouse, as well as at Noir cape on northern Entrée island, the red sandstone is in fault-contact with the underlying volcanic rocks. The fault exposed at Firman cove is the normal type, with a dip of 75$^{o}$S.

In the quarries opened on the side of the butte between Grand-Ruisseau and Fatima, well stratified, green, shaly beds 3 to 6 inches thick, are intercalated with the sandstone. Geodes and joints filled with "dog-toothed" calcite were also observed, as well as interbedded reddish and greyish sandstone, a few conglomeratic beds and beds of siltstone.

Plate XI



Cross-bedding in red sandstone, Cap-aux-Meules formation.
"The Praying Monk", Alright cape, Havre-aux-Maisons (Alright) island.



Unconformity between argillite of Havre-aux-Maisons formation and grey sandstone (right) of the Cap-aux-Meules formation.

Plate XII

## The Red and Grey-green Colour of the Sandstone

As mentioned above, the red sandstone derives its colour from a thin coating of hematite around the quartz grains. The grey sandstone, on the other hand, does not generally contain any of this material, although, in a few places, some fairly regularly distributed red stains have been observed. J.M. Clarke (1910) attributes the colour of the grey-green sandstones to igneous action, wherein the sulphur and other gases emanating from rising intrusions are postulated to have further solidified these sandstones and, by dissolving the iron oxides, caused them to change from red to grey-green. This theory, however, does not seem valid in view of the fact that the sandstones were deposited after the lava flows had been extruded. In a few places, in fact, the basal conglomerate of the Cap-aux-Meules sandstone lies unconformably above the Havre-aux-Maisons formation and contains numerous pebbles of the underlying volcanic rocks.

Large-scale crossbedding is common within the red sandstones, and ripple marks are a feature of the grey variety. This leads to the belief that the red sandstones represent terrestrial deposits laid down in an oxidizing atmosphere, whereas the grey or green sandstones are marine deposits laid down in a reducing environment.

J. Richardson (1881) mentions that, in southwestern Grosse-île, he observed beds of gypsum that were characterized by funnel-shaped depressions, similar to those which, elsewhere, accompany the volcanic rocks. The present author, however, after an examination of both the shore-line and the interior of the island, could not find any trace of these gypsum deposits.

## Geological Age and Correlation

J. Richardson (1881) first mentioned the probable existence of an unconformity between the red sandstone, to which he assigned a Permian or Triassic age, and the underlying Windsor rocks. This unconformity is visible in several sections exposed along the shore-lines. On Goélands island and the neighbouring islets, for example, 25 to 30 feet of red sandstone lies in angular unconformity on the volcanic and sedimentary rocks of the Cap Adèle member.

The fact that the sandstone deposits seem to have moulded themselves around certain topographic shapes in the folded and faulted basement rocks indicates that there was a fairly long interval of time between the deposition of the Havre-aux-Maisons formation and the Cap-aux-Meules. It is quite possible that the sandstones are Pennsylvanian, or even Permian, in age. However, as they do not contain any recognizable fossils, their age cannot be definitely established.

J.M. Clarke (1910), in comparing these rocks with other formations of the Maritime Provinces, correlated the red sandstone with similar rocks on Prince Edward Island. These latter rocks were at first regarded as Triassic, but, upon the discovery in them of the jawbone of a pelycosaur, identified by Drs. Lull and Von Huene, Clarke referred them to the Permian. L.J. Weeks (1957), on the other hand, while maintaining that the exact age of the 10,000-foot-thick red sandstones of Prince Edward Island is still uncertain, assigns a Permo-Carboniferous age to them. Lithologically, the red sandstones of the Magdalen Islands are very much the same as those of Prince Edward Island.

F.J. Alcock, who made a study of the Chaleur Bay region Alcock, 1935), and later of the Magdalen Islands (Alcock, 1941), describes the red sandstone of the Islands in this way.

> "The writer was impressed with the similarity of the formation to certain beds of the Bonaventure formation of the Chaleur Bay region. It is true that the Bonaventure is made up to a large extent of conglomerate, but it also contains a great deal of red sandstone, much of which is as fresh as the red beds of the Magdalens (Madeleine Islands). Furthermore, there are more firmly cemented layers of a lighter reddish shade in the Bonaventure which have an exact counterpart in certain strata of the red sandstone on Grosse isle and on Bryon (Brion) Island. Such lithological similarities do not form very reliable evidence for correlation, but when it is considered that, geographically, the Magdalens lie in front of the mouth of Chaleur bay, a depression which occupies much the same site as that in which the Bonaventure formation accumulated, and that stratigraphically these two sets of red beds occupy similar positions, i.e., they are the oldest undeformed beds of their respective regions, each resting on an eroded complex of folded rocks, it does not seem unreasonable that they should be regarded as of the same age. The age of the Bonaventure has not been definitely proved, but what evidence there is points to an early Pennsylvania age."

W.A. Bell (1946), on the other hand, compares the sandstones of the Islands with the Canso group of Nova Scotia, which is Upper Mississippian in age.

Although the exact age of the red and grey-green sandstones of the Cap-aux-Meules formation is still uncertain, the present writer considers this formation to be Permo-Carboniferous.

## PLEISTOCENE

The problem of the glaciation of the Magdalen Islands has been studied by many geologists and geographers. J. Richardson (1881) and R. Chalmers (1895) were of the opinion that the Islands had not been subjected to continental glaciation at all. They believed that any erratic boulders and pebbles which were present had been dropped by floating ice. J.W. Goldthwait (1915), however, through his discovery of morainic debris, became the first writer to present evidence of glaciation on the Islands. Later, other definite evidence came to light. F.J. Alcock (1941, p. 632-635), for instance, gives an excellent description of the work done by himself and others in this regard. The present writer adds the following observations:

1) On Havre-Aubert island, 1,000 feet west of Portage-du-Cap post office, there is a deposit of pebbles and well bedded gravel which seems to represent the course of a former (preglacial?) river valley. The deposit is 20 to 30 feet thick, and is made up of well sorted and well rounded material, consisting mainly of grey and red sandstone. A few granite pebbles, probably originating from a source outside the Islands, were also noted. In places, the beds dip at an angle of $25^{\circ}$. This material, in all likelihood, represents a fluvioglacial deposit which completely filled the valley. This valley was located between Portage bay, to the southeast of Havre-aux-Basques, and "le Bassin," to the northwest. An abandoned gravel pit, excavated in this material, borders the road leading to Portage bay.

2) Ground moraine covers the red sandstone of the Cap-aux-Meules formation near the shore-line at Caps cove, on the west side of Havre-Aubert island. Several pebbles of iron formation (goethite), including one with a diameter of 6 inches, were observed in this material. Other pebbles include quartzite, gneiss and granite; all in a clayey matrix. The record of these pebbles suggests that they originated north of the gulf of St. Lawrence.

3) Numerous erratic pebbles and boulders, generally showing faceted surfaces and ranging from a few inches to about 7 feet in diameter, were seen on Loup and Grande-Entrée islands. Several of these erratics are made up of white quartzite, granite, gneiss and amphibolites. These deposits also might have originated north of the gulf of St. Lawrence.

4) At Rouge cape, on northern Havre-aux-Maisons island, well rounded, faceted pebbles of white quartzite and granite are very common.

N. Falaise (1954), in examining the bathymetric maps of the Magdalen Islands (Canadian Hydrographic Service), believed that it was possible to discern several shallow preglacial valleys that apparently extended at least 10 to 15 miles from the present shore-line. Beyond such distances, the absence of reliable depth soundings made them impossible to trace. These valleys, if, in reality, they exist, would provide evidence of a considerable subsidence of the Islands during the Pleistocene.

Falaise estimates that the amount of post-glacial uplift was about 15 feet. He bases this on the presence of an old beach deposit, ending with a small scarp that is approximately parallel to the present shore-line near Cap-Vert bay on Cap-aux-Meules island.

## ECONOMIC GEOLOGY

The economy of the Magdalen Islands has been, thus far, based primarily on the fishing industry. Mining, however, presents possibilities, with manganese, gypsum, sand and oil being of special interest.

### Manganese

Manganese was first noted on the Islands by J. Richardson (1881) who mentioned its presence at two localities: the shore-line of Havre-Aubert (Amherst) island, immediately under the "Demoiselle"; and one mile nearly due west of Cap-aux-Meules, close to the English mission church. His assay of a manganite nodule returned 45.61% $MnO_2$. J. Obalski (1903) lists several places where manganese minerals (pyrolusite, manganite, bog manganese and manganiferous limonite) were observed. He states that a well-planned development program is needed in order to establish the value of any workable deposits which may be present.

F.J. Alcock (1940 and 1941) gives a detailed account of the Islands' manganese deposits. He believed that the mineralization originated from the volcanic rocks of the Lower Windsor. According to this hypothesis, the present deposits, which are of the replacement or residual type, formed in depressions at the foot of the hills of volcanic rock during the erosional period between the deposition of the Havre-aux-Maisons and Cap-aux-Meules formations.

Our own observations seem to substantiate Alcock's interpretations. Spectrographic analyses of nine specimens of volcanic rock give an average MnO content of 0.37%. At several places, as well, manganese minerals, such as manganite, pyrolusite and ramsdellite, were seen in samples of the volcanic rocks.

The first exploitation of the manganese deposits, according local sources, took place on Cap-aux-Meules island in 1920. This operation, however, was unsuccessful. In 1939, two companies were formed for exploiting manganese. They were represented by J.W. Storer and W.G. Porter, both of Toronto. Some work was done on Grosse-Île, Havre-Aubert, Havre-aux-Maisons and Cap-aux-Meules islands. Most of the work, however, was concentrated on Cap-aux-Meules island, where, between 1939 and 1948, Quebec Mnaganese Mines, Limited, dug four main pits. Despite their efforts, the operation proved to be unsuccessful.

Gypsum

The first mention of gypsum on the Islands also stems from the report by J. Richardson (1881). He describes the relationship of these deposits to the volcanic rocks. J. Obalski (1903), in commenting on the large size and general accessibility of the deposits, remarks that they could be easily exploited. W.F. Jennison (1911) was the first to make a detailed study of the gypsum deposits. He presented chemical analyses of eleven samples taken at random; they averaged 45.45% $SO_3$, 32.35% CaO and 20.27% $H_2O$, thus indicating that the gypsum contains 97.97% $CaSO_4.2H_2O$.

Later, G.W. Waddington (1947) described the five principal areas where gypsum is found. These include lot 184 and the neighbouring lots (sample No. 9073), of the municipality of Havre-aux-Maisons; lot 327 (sample No. 9074), lot 184 and the neighbouring lots (sample No. 9072), of the municipality of Etang-du-Nord; lot 262 (sample No. 9071) and lot 341 (sample No. 9070) of the municipality of Havre-Aubert.

Table 2.- Chemical Analyses of Gypsum Samples from the Magdalen Islands (Waddington, 1947)

| | Sample No.9070 | Sample No.9071 | Sample No.9072 | Sample No.9073 | Sample No. 9074 |
|---|---|---|---|---|---|
| Water (free) ........... | 0.21 | 0.14 | 0.12 | 0.23 | 0.10 |
| Water (combined) ........ | 18.25 | 19.55 | 20.18 | 18.76 | 19.82 |
| Carbon dioxide ($CO_2$) .... | 0.61 | 1.00 | 0.36 | 0.64 | 0.85 |
| Silica and insolubles ($SiO_2$) ................ | 2.37 | 0.80 | 0.38 | 0.34 | 0.67 |
| *Sesquioxides ($R_2O_3$) .... | 0.50 | 0.29 | 0.23 | 0.23 | 0.36 |
| Lime (CaO) .............. | 32.44 | 33.16 | 32.63 | 33.02 | 32.69 |
| Magnesia (MgO) .......... | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Sulphur trioxide ($SO_3$) .. | 45.63 | 45.05 | 45.86 | 46.62 | 45.62 |
| Sodium chloride (NaCl) .. | 0.11 | 0.01 | 0.03 | 0.02 | 0.03 |

*Ammonia - precipitated ferric oxide, alumina, titania phosphoric pentoxide, manganic oxide, etc...........

Table 3.-Hypothetical Compositions -- Recalculated from the Chemical Analyses (Waddington, 1947)

| | Sample No. 9070 | Sample No. 9071 | Sample No.9072 | Sample No. 9073 | Sample No. 9074 |
|---|---|---|---|---|---|
| Gypsum, $CaSO_4.2H_2O$ ....... | 83.79% | 92.29% | 95.72% | 86.49% | 93.87% |
| Calcined gypsum $CaSO_4.1/2H_2O$ ............. | 11.41% | 3.80% | 2.38% | 10.53% | 2.78% |
| Anhydrite, $CaSO_4$ ......... | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Excess, $SO_3$ .............. | 0.34% | - | - | 0.56% | 0.40% |
| Excess, CaO .............. | - | 0.40% | 0.11% | - | - |
| Sodium chloride, NaCl .... | 0.11% | 0.01% | 0.03% | 0.02% | 0.03% |
| Insolubles, $R_2O_3$, $MgCO_3$, $CaCO_3$, (free $H_2O$) ........ | 4.47% | 3.50% | 1.55% | 2.26% | 3.06% |
| TOTAL | 100.12% | 100.00% | 99.76% | 99.84% | 100.14% |

Waddington concluded that the grade of the gypsum represented by these samples was considerably higher than the minimum required grade (64.5% $CaSO_4.2H_2O$) set by the American Society for Testing Materials. The problem is one of quantity of gypsum present on the Islands, not of its quality or means of transport. To date, the amount of gypsum available for open-pit mining has not been evaluated.

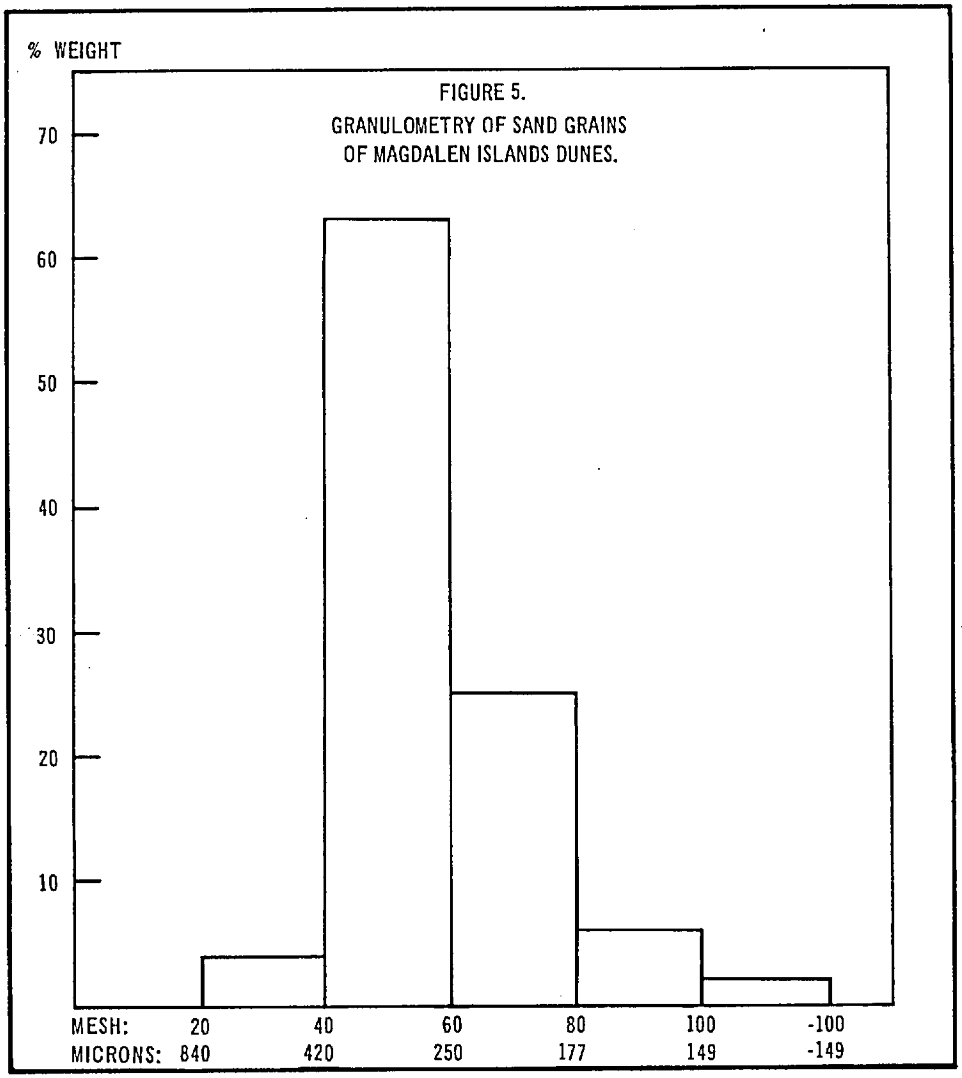
## Sand

The tombolos linking the principal islands of the archipelago are formed of grey sand made up almost entirely of quartz. About 75% of the quartz grains are clear, the remainder being coated with a thin film of hematite. This sand seems, in large part, to have been derived from the red sandstone of the Cap-aux-Meules formation.

Granulometric analyses, as shown in Figure 5, were made on five samples, taken from the following locations: 1) the Cap de l'Est dune; 2) 1 1/2 miles west of Pointe-au-Loup; 3) the Est dune; 4) at Caps cove; and 5) the Havre-Aubert dune.

The exploitation of this type of sand, however, does not appear to be economically feasible.

Some of the sand of the Islands may be used as moulding sand. According to tests carried out in Federal laboratories, this sand lends itself to the moulding of bronze, brass, and light cast-iron.




D.N.R.Q. NO. 1487

It is not, however, refractory enough for the moulding of malleable cast-iron or of heavy grey cast-iron. The sand is also too coarse to be used for the moulding of aluminum. Waddington (1948), who studied the principal deposits, believes that moulding sand is present in large enough quantities to permit a fair-sized operation for several years.

Petroleum and Natural Gas

In July, 1959, the Federal Department of Public Works carried out preliminary drilling on lot 1 of the municipality of Havre-Aubert. This project, which was of the nature of test-work prior to the construction of a wharf, was intended to determine the depth to bedrock and the nature of the sub-soil. One of the many holes drilled, all of which averaged between 30 and 50 feet in length, gave natural gas that flowed intermittently, under varying pressure, for nearly two months before the source was exhausted.

Michel Houde, geologist with the Quebec Department of Natural Resources, attributed this gas to the decomposition of organic and vegetal matter in the overburden rather than to a bedrock source.

However, such shallow borings have little bearing on the possibilities of finding oil or gas on the Magdalen Islands. The oldest rocks appearing at the surface belong to the Lower Windsor. It is thus not known if the Islands are connected with the basin in which the sediments of the Horton group accumulated at the beginning of the Mississippian. If such sedimentary rocks exist below the Lower Windsor of the Islands, they may contain deposits of fresh water, as do those found in the formations on the north point of Cape Breton; or, in common with similar rocks of the Albert formation of New Brunswick, they may contain oil. It is also possible that the sedimentary basin in which the Horton group accumulated does not extend as far as the Magdalen Islands and that the Windsor rocks of the Islands are lying on formations of Devonian or Silurian age. Such formations are found in the Chaleurs Bay area and are considered to be possible sources of oil. A few well-placed drill holes would be of interest in view of these possibilities.

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