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Reports

LATE-QUATERNARY HISTORY OF MAGDALEN ISLANDS, QUEBEC

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INTRODUCTION

The Magdalen Islands in the Gulf of St. Lawrence comprise a group of some 15 islands of varying size, lying between 61° 08' and 62° 13' W and 47° 51' N (Fig. 1). The islands are about 150 km (93 miles) from Newfoundland, 100 km from Prince Edward Island and Cape Breton Island, 220 km from Gaspe Peninsula, and 180 km from Anticosti Island. They form the highest (emerged) part of the Magdalen Shelf, situated to the southwest of the deep Laurentian Channel (Loring and Nota 1973).

Seven of the main islands are joined as tombolos and are now accessible by road; from southwest to northeast these are: Havre-Aubert (Amherst), Cap-aux-Meules (Grindstone), Havre-aux-Maisons (Alright), Loup (Wolf), Grosse Ile, Est (East), and Grande Entree (Coffin) Islands. The small Boudreau Island is joined to the east side of Coffin Island by a sand bar. Entree (Entry) Island is about 10 km east-northeast of Amherst Island, and Brion Island is 21 km north of Gross Ile. The other small, cliffed rock islands, e.g., Ile du Mort lying 15 km west of Amherst Island, and Rocher aux Oiseaux 21 km east-northeast of Brion Island, are erosional bedrock remnants of only marginal interest in this study.

The main islands have a core of volcanic rocks that are interbedded with Windosr-age (Mississippian) sediments, and are flanked by siltstones and sandstones of Permo-Carboniferous age (Figs. 2, 3). There are also intrusive rocks in the volcanic assemblage (Richardson 1881, Brisebois 1972). Dissolution of gypsum in the Windsor sediments has resulted in the development of sinkholes of various sizes that commonly contain small ponds, lake sediments or peat.

On the Magdalen Islands the highest points are 170 m (Entry Island), 136 m (Amherst Island), 162 m (Grindstone Island), and 110 m (Alright Island). The physiography and bedrock geology of Magdalen Islands, including previous studies, have been described by Sanschagrin (1964). Volcanic rocks present are mainly basaltic lavas, with associated tuffs and agglomerates; these are interlayered with varied arenite and argillite beds, limestone (partly fossiliferous), calcareous shale, and some gypsum - all of Lower Windsor age. This assemblage is overlain, on Boudreau Island, by Upper Windsor calcareous and fossiliferous rocks and gypsum. The Windsor-age rocks are overlain unconformably by grey and red sandstone considered to be Permo-Carboniferous in age. Sanschagrin (1964) considers these latter beds to represent two facies of the same formation.

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The objective of the present project is to study the geomorphology and surficial deposits of the Magdalen Islands, to interpret the stratigraphy, chronology and paleoenvironments of the deposits, and to determine the source areas of foreign stones (chiefly cobbles and boulders). These objectives are all pertinent to the glacial and post-glacial history of the Gulf of St. Lawrence. To date, studies other than paleoecological ones, have been made only on the main Magdalen Islands; a reconnaissance has been made on Brion and Entry Islands, and the Bird Rocks have been visited.

HISTORY OF PLEISTOCENE STUDIES

The Pleistocene history of the Magdalen Islands has long been controversial as to whether or not they were glaciated. Richardson (1881) reported the lack of any direct evidence of glaciation though he noted the presence of some boulders that

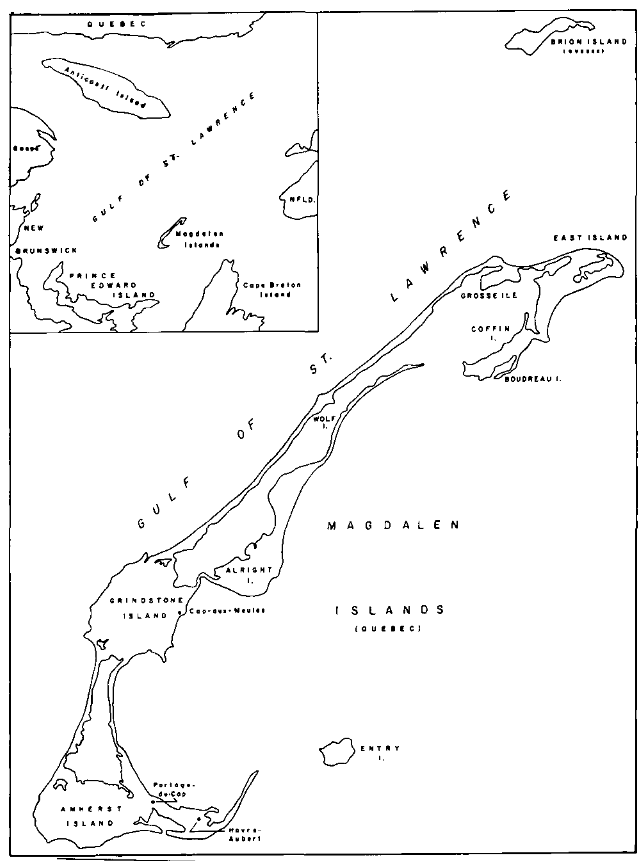

Fig. 1. Location map Magdalen Islands archipelag, Quebec.

Fig. 2. Grindstone Island. View southwest from the hard-rock highlands across the soft-rock lowlands with six-mile long sand bar and Amherst Island in the left distance.

Fig. 3. Alright Island. View southward from central upland.

were foreign to the Islands. Chalmers (1894, p. 48-49M) believed that the islands were unglaciated though he too noted some scattered foreign stones, and he also drew attention to the modification of the islands' weathered rocks and soils below about 110 to 115 feet (35 to 40 m); this he presumed to be due to wave action at a time of higher relative sea level. He stated: "Indeed, the whole examination of the surface of the four largest islands, Amherst, Grindstone, Entry, and Alright, failed to show any evidence of glaciation whatever". In regard to the few foreign boulders noted on Amherst and Grindstone Islands he stated: "It is not improbable that they were borne hither by floating ice when these islands stood at a lower level ...". He emphasized the lack of "boulder clay" on the islands. Clarke (1911) stated: "The islands have never been subjected to glacial action", and he stressed the residual nature of the soils. Regarding the foreign boulders, he concluded: "These boulders are ice borne, dropped where they lie by icebergs and floe ice of no recent date".

Goldthwait (1915) reported on his observations made during ferry stops at four of the islands. He observed that a sea cliff near the Amherst Harbour (Havre-Aubert) pier showed a thick deposit of a "red sand" that had the characteristics of a glacial till. On the basis of the disordered distribution of stones, for the most part of local origin and some of them striated, and the lack of any stratification, he referred to the deposit as "red boulder clay" and thought it might be a "true ground moraine". Though he saw little supporting evidence on Grindstone, Alright and Coffin Islands he emphasized that the foreign stones both seen and reported on the Magdalens, together with striated local stones in the heterogeneous deposits on Amherst Island, required either floating sea ice or glacial ice as the transporting agent. He concluded: "The thickness of the mantle of boulder clay on Amherst Island, together with its physical and lithological heterogeneity, furnish the main ground for the belief that continental ice has covered the Magdalens". The concept of continental ice overriding the entire Gulf of St. Lawrence and indeed even Nova Scotia and Newfoundland was apparently deeply entrenched at this time.

Coleman (1919) spent two days on Amherst Island and confirmed Goldthwait's observation of unstratified sand containing many small striated stones. He saw no foreign stones in the deposit near the pier though he observed several other sites where the unstratified sand (till) carried striated local stones. These deposits were restricted below elevation 100 to 105 feet (31 m). He further noted that parts of the island showed no evidence of glaciation: "If any ice sheet ever crossed the island it must have touched it very lightly, or else have done its work so long ago that weathering has had time to remove completely the evidences of its work." But he further observed scattered foreign stones "... up to 160 to 170 feet (48 to 52 m) above sea on the hillsides." He concluded that they had been ..." transported by floe ice during a higher stage of the sea". He remarked on the lack of striated surfaces in contrast with Prince Edward Island where striated surfaces are evident on equally soft (Permo-Carboniferous) rocks. He thought it possible that the thin edge of continental ice was afloat when the sea was at least 150 feet (45 m) higher than at present and that the sands and pebbles, referred to above, were detached from the sea bottom nearby.

In spite of Coleman's conclusions the concept of overriding Laurentide ice remained in vogue. Alcock (1941), following a field season on the islands, dealt with the matter of glaciation at some length. He felt that the absence of striated surfaces was due to the soft and(or) fragmented nature of the island's bedrock. He was convinced that the islands were glaciated because of (i) the wide dispersion of glacial erratics, (ii) the occurrence of a drift ridge on Grande Entree (Coffin) Island that he believed was an end moraine, (iii) the occurrence of gravels with foreign stones on Grindstone Island, and (iv) the massive sandy deposits with stones on Amherst Island that he considered a till.

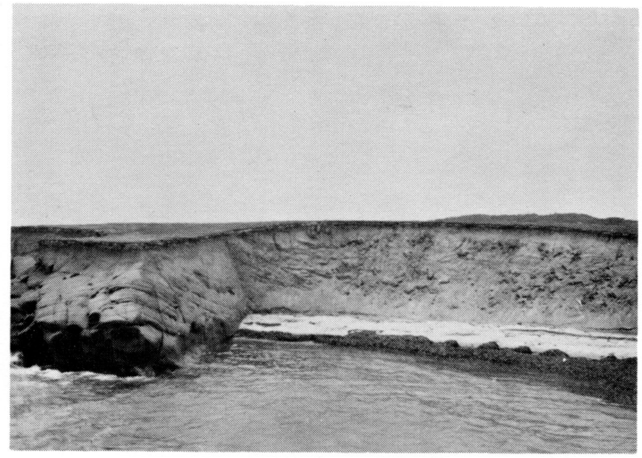

Fig. 4. Seacow Bay, Coffin Island. View to west of south end maj r infilled valley. A late Wisconsinan boulder layer mantles both bedrock and sandy sediments. Sandstone cobbles and rubble interfinger into the sands from the steep rock wall. Two ages of sand filling are indicated by a presistent disconformity, with some foreign pebbles, in the upper part of the section though not visible in the photo.

Prest (1957) reported on a two-day trip to the Islands in 1954. He had been concerned with the conclusions drawn by earlier workers that the islands' soft rocks were responsible for the absence of glacial scour markings, as glacial striations are well preserved on the soft sandstones and siltstones of Prince Edward Island. He reported that the Magdalen Islands showed no evidence below about 120 feet (36 m) on Grindstone Island, that the Coffin Island end moraine was a thick deposit of ice-contact stratified sand overlain by a mantle of ice-rafted boulders (thought to date from a period of marine overlap), and that the reported till on Amherst Island was a glaciomarine deposit because it is commonly striated and is everywhere adjacent to the sea, though no shells were observed. Both before and since publication of these observations several others have written brief but conflicting notes regarding the evidence of glaciation that have added little to what was already recorded in the literature. Prest (1970), following another trip to the Islands, again stated that no drift occurs above the limit of post-glacial marine overlap, and below this limit only stratified to substratified sand and associated till-like material are present, all of which were deposited under water. He concluded: "Marine or lacustrine submergence of at least 120 feet (36 m) is indicative of ice near at hand; this is also indicated by the ice-contrast stratified drift on Coffin Island. Glacier ice evidently reached the islands from the north, but only shelf ice reached the southern shores".

Laverdiere and Guimont (1974), in a colour-illustrated article on the Magdalen Islands, stressed the unglaciated appearance of these islands and drew attention both to the presence of limited foreign stones in the gravel mantle and to the effects of frost action. They concluded that the last ice sheet did not override the Islands but that a periglacial climate prevailed during the Wisconsin and was responsible for some of the geomorphology.

Despite the complete lack of evidence of glacier ice scour at any elevation on the Magdalen Islands, the absence of a lodgement till, the restriction of diverse stratified deposits to elevations below about 170 feet (50 m), the gross geomorphology of the islands, and our current knowledge of local maritime centres of active glaciation (Prest and Grant 1969, Grant 1971, 1974; Brookes 1974), - there is still reluctance to part with the concept of an all pervasive continental ice sheet over the Gulf of St. Lawrence region and beyond.

RECENT WORK

Geological observations and studies by Prest and Terasmae in 1974 and 1975[1] have served to substantiate the older reports pertaining to the essentially unglaciated character of the Magdalen Islands, and to add much new information as to their Pleistocene history. The observations and interpretations of Prest and Terasmae are summarized below:

(i) The gross geomorphology of the Magdalen Islands does not afford evidence of direct glacierization (Figs. 2, 3).

(ii) The Magdalen Islands were definitely not overriden by Laurentide or other ice sheets during the entire Wisconsinan glacial stage though ice was near at hand on the Magdalen Shelf.

(iii) Some sea-coast sections reveal a succession of mainly sandy, stratified sediments, the oldest filling sharp, steep-walled channels or valleys in the bedrock (Fig. 4), and the younger sediments mantling the former, or occupying somewhat broader channels cut in the older sediments. Such deposits have a maximum observed thickness of about 30 m on Coffin Island.

A key stratigraphic section occurs on Wolf Island.[2] In a small cove north of the pier on the west side of the island, the sea cliff reveals about 12 m of Pleistocene sediments of diverse origin. The lowest unit, up to 3 m thick, appears to be a marine (?) shore-line deposit occupying a channelled depression in the red sandstone bedrock. It is a well

[1]The co-operation of I.E. Morrison and W.A. Bryenton of Marine Services, Department of Transport in providing passage to Bird Rocks and Brion Island is gratefully acknowledged in this regard.

[2]This site was drawn to the authors' attention by C. Laverdiere, Department of Geography, University of Montreal.

Fig. 5. West coast, Wolf Island. Cemented marine? gravel (conglomerate) with abundant foreign stones overlies a clean surface of red, silty sandstone. The conglomerate is overlain by a non-cemented marine boulder deposit, fine grained sediments, and an upper boulder layer or mantle.

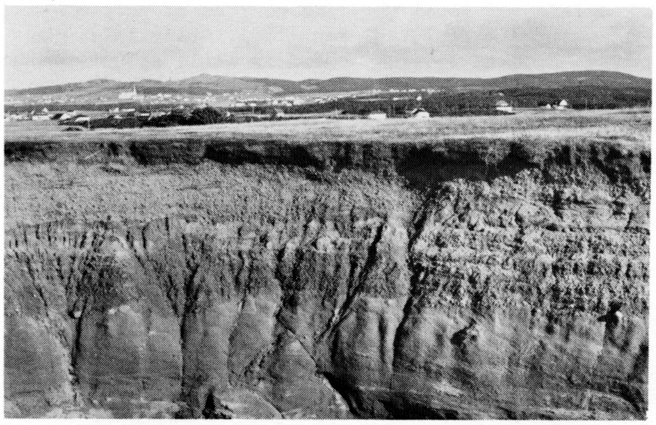

Fig. 6. Grindstone Island; view northwest from Cap Rouge toward central interior hills; sea cliff section shows 3 to 4 m Demoiselle gravels, with few thin diamicton layers, overlying red sandstone.

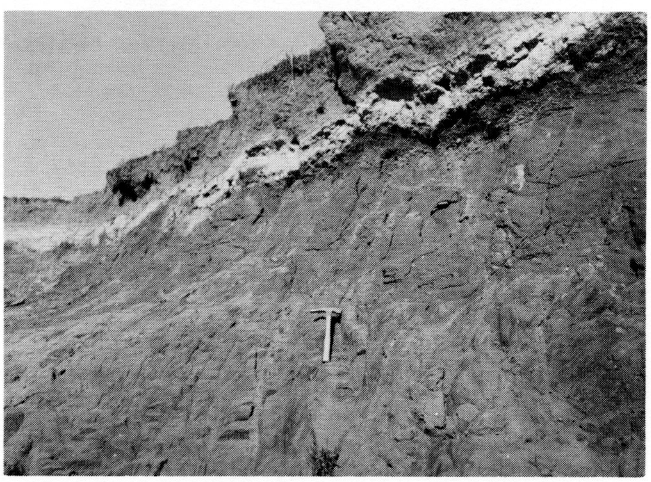

Fig. 7. Ponte Shea, Amherst Island. Roadside section at former p˙er; aeolian san ' with leached basal zone, and trace Demoiselle gravel overlies 1 to 2 m red, sandy diamicton over soft, grey sandstone. Note the very irregular frost.heaved? contact with the bedrock. Though massive here, the diamicton nearby is clearly substratified.

cemented conglomerate of mainly rounded 'gravels' with about 15 % 'foreign' stones (Fig. 5). A coarse, bouldery deposit, up to 4 m thick occupies channels cut in the conglomerate, and overlies it. The boulders are mainly about 0.4 m in diameter but a few are as large as 3 m. They are mainly foreign rocks of greatly diverse types. The upper surface of the bouldery deposit is relatively flat and is overlain by 3 to 4 m of reddish sand with some silty beds, an occasional lens of pebbles, and some widely scattered cobbles. The whole is overlain by a second bouldery deposit which occurs as a cover or mantle on both bedrock and Pleistocene deposits over the whole of Wolf Island from sea level to its maximum altitude of about 25 m. A similar complex stratigraphy is also present in the eastern part of Wolf Island where cemented gravels, two sand units and the boulder mantle have been observed.

On Amherst Island some 10 to 15 m of well stratified sediments are overlain by a diamicton and related substratified sediments. At least two, and probably four discrete periods of sedimentation are inferred from the character of the sediments and their stratigraphical relations on Coffin, Wolf and Amherst Islands. The great sand bars, tombolos, and spits of the Magdalen Islands result from this abundance of sand, reflecting a long and involved history of shifting ice fronts on the Magdalen Shelf and changing water levels.

(iv) Though no true lodgement till is present on the islands, foreign stones are widespread, and these afford evidence of nearby glacier ice and (or) shelf and berg ice. The erratics are sparsely distributed in most places but occur in profuse numbers on Baffin and Wolf Islands and in one small inland 'cove' on the north side of Alright Island. Strangely, there are no foreign stones on Boudreau Island except near sea level at its southern tip. Also erratics are relatively uncommon on Grosse Ile and Brion Islands and differ in character from those on Wolf and Coffin Islands. These latter erratics are of greatly diverse types and are indicative of a northern provenance; K/Ar analyses of two granitoid boulders from Coffin Island indicate a Precambrian source area (GSC-2453, 1032 ± 29 my and 1073 ± 29 my). Scattered foreign stones also occur in some stratified sediments and in the associated diamicton on the southern islands; a grey quartzite is a prevalent type and some granitoid rocks are present but there are none of the basic igenous rocks such as occur farther north. The quartzite and granites may have a southern provenance.

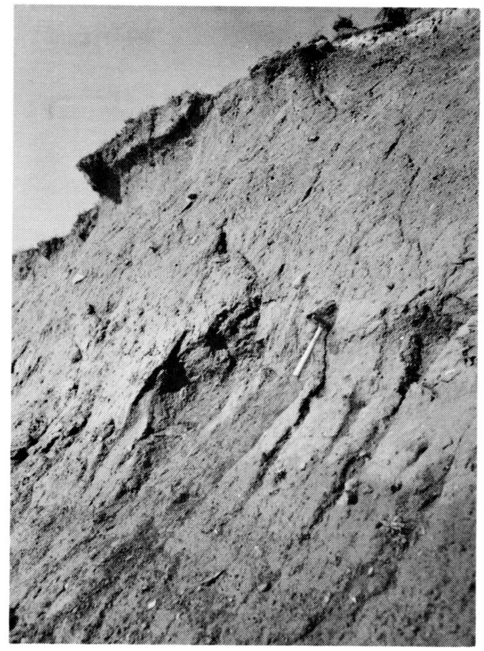

Fig. 8. Southwest coast, Amherst Island. Section shows 1 m of faintly-stratified gravelly sand passing downward into red diamicton over red sandstone. Hammer head at base of diamicton. Bedrock surface is irregular. Foreign stones are rare.

(v) The younger or upper drift mantle, on the southern islands, is here termed the Demoiselle drift[1]. It includes a well bedded gravelly deposit, up to about 3 m thick, comprised mainly of the local sedimentary and Demoiselle igneous rocks, with a sparse scattering of foreign stones; such deposits may be termed Demoiselle gravels (Fig. 6). On southern Amherst and Entry Islands deposit with scattered and non-oriented local stones and the occasional foreign stone. It may be termed a diamicton (Figs. 7, 8), and grades both laterally and vertically into substratified, and even well stratified sediments, and locally rests on a much-weathered and irregular rock surface devoid of ice-scour features. Probably it was deposited from floating ice in quiet offshore waters, and is restricted to lower elevations than those of the Demoiselle gravels. The term Demoiselle drift is hot applicable to the bouldery mantle of mainly foreign stones found on Wolf Island, Grosse Ile, and Coffin Island where no Demoiselle rocks are exposed (Fig. 9).

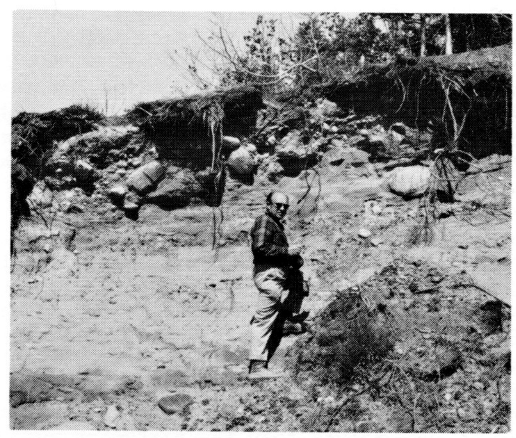

Fig. 9. La Cyr, Coffin Island. Borrow pit exposure showing bouldery mantle deposit resting on 1 metre fine medium sand, with a basal gravelly layer, overlying some 3 to 4 metres fine medium sand.

(vi) Erratic boulders and stratified sediments have been observed at elevations up to about 50 m on southwest Amherst and on northern Alright Island and 48 m on Grindstone Island, but only to about 22.5 m on Grosse Ile (Leslie) and 32 m on Brion Island at the north end of the system. Erratic boulders are, however, present to about elevation 75 m at the southeast end of Entry Island, and inter-layered clayey and sandy diamicton to about 30 m; in both cases this is much higher than on Amherst and Grindstone Islands.

[1] The term Demoiselle refers to nicely rounded conical hills, so characteristic of the higher parts of the Magdalen Islands. The knobby hill immediately west of the Havre Aubert ferry docks is in fact named Les Demoiselles.

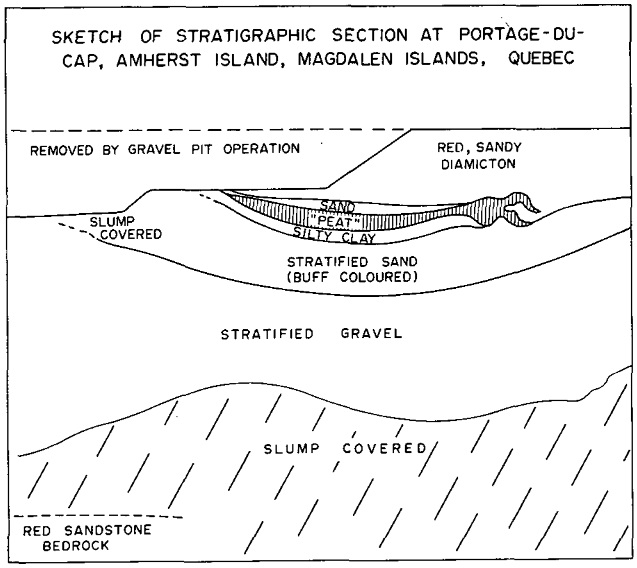

Fig. 10. Sketch of stratigraphic section at Portage-du-Cap, Amherst Island.

(vii) The irregular upper limit of Demoiselle drift on the southern islands of the Magdalen group and of the bouldery mantle or shoreline sediments on the northern islands, the paucity of strandlines below these limits, and the apparent absence of marine shells, suggest that the water body or bodies responsible for the emplacement of most, if not all the erratics and for the stratification of most of the drift may have been one or more glacial lakes rather than the sea. Glacial lakes could form in this region upon the closing of Cabot Strait by combined Newfoundland and Nova Scotian ice with, or without a component from the Laurentian region of Quebec. Certainly there is little evidence of water level still-stands between the upper limit of washing and near present sea level, though low strandlines are evident on the north side of Alright Island, on southern Grindstone Island, and on Brion Island. Rapid changes of water level would ensue as an ice plug gave way in Cabot Strait. To date no shells have been found in any of the stratified deposits nor in the Demoiselle diamicton. Alternatively, if the upper limit of 'washing' is truly a marine limit, then the direction of greatest uplift is toward the southeast and Cape Breton Island, rather than the northwest and the Laurentian Shield.

(viii) There is evidence of a bench on parts of Brion Island that may relate to a Sangamon sea level. The bench surface is about elevation 15 m. More obvious is an old sea cliff up to 15 m high which in places is now protected from the sea by a succession of beach ridges of diverse ages. One set of beach ridges is well forested and stabilized; these abut the abandoned sea cliff at nearly right angles. Two other sets of beach ridges are less vegetated and diverge sharply from each other and the older set. At present, relative sea level appears to be rising and destroying recently formed shoreline and small beach ridges. Two main sets of beach ridges and dunes are clearly evident on East Island. Along the west coast of this island the older forested dunes are truncated by the sea and form cliffs some 7 to 10 m high, in sharp contrast with younger beach ridges and dunes.

(ix) Evidence of one or more former sea-level positions also occurs on Amherst Island. In a gravel pit at Portage du Cap, at 47° 14.5' N, and 61° 54.34' W, soft red sandstone bears numerous shallow, round holes that appear to have been made by a rock-boring pelecypod. From photographs of the holes in the rock surface, the 'clam' belongs to the Family Pholadidae, and possibly the Genus *Zirphea*, and it lived in the intertidal zone (Pers. comm., Dr. J.W. Evans, Memorial University, St. Johns, Nfld.). The bedrock here is at about elevation 8 m, and is overlain by 5 to 10 m of northwest-dipping foreset gravel beds, with abundant well rounded foreign stones that may represent a glaciomarine delta although no shells have been seen by the authors nor the pit operators. The gravels in one part of the pit decrease upward from boulder to pebble-size and then give place to sand and silt. Within the silty beds an organic lens up to 35 cm thick is present. Plant detritus in this layer has been radiocarbon dated at 35,000 years B.P. (BGS-259) and a twig at 38,000 years (GSC-2313). The organic deposit is considered estuarine or intertidal, and Sangamon in age (see below). The indicated sea level is about 13 m above the present sea. The stratigraphy at the organics site (see Fig. 10) is as follows:

Thickness (m)	Description
0.00-2 (1-2 removed)	*Diamicton*; red, sandy; few widely scattered, foreign stones.
2-2.10	*Sand*; stratified, buff-yellow
2.10-2.35	*Peat*; few thin sand and silt partings
2.35-2.50	*Silty clay*; sticky (leached?)
2.50-3.25	*Sand*; stratified, buff-yellow
3.25-9.30 +	*Gravel*; stratified, grey; 15 per cent foreign stones
9.3	*(Bedrock) sandstone*; red

(x) A remnant of a distinct fossil dune of pre-Wisconsinan age was noted on north-central Grindstone Island at an elevation of about 25 m. This dune consists of well compacted and lightly cemented fine sand, and is overlain in part by the red Demoiselle diamicton.

(xi) Well developed permafrost features have been observed on Grindstone Island and evidence of frost-disturbed deposits on some of the other islands. It is evident that cryoturbation was a factor in modifying both the surficial deposits and the exposed bedrock, but it was not a primary factor in development of the diverse surficial deposits, as has been suggested (Hamelin 1959).

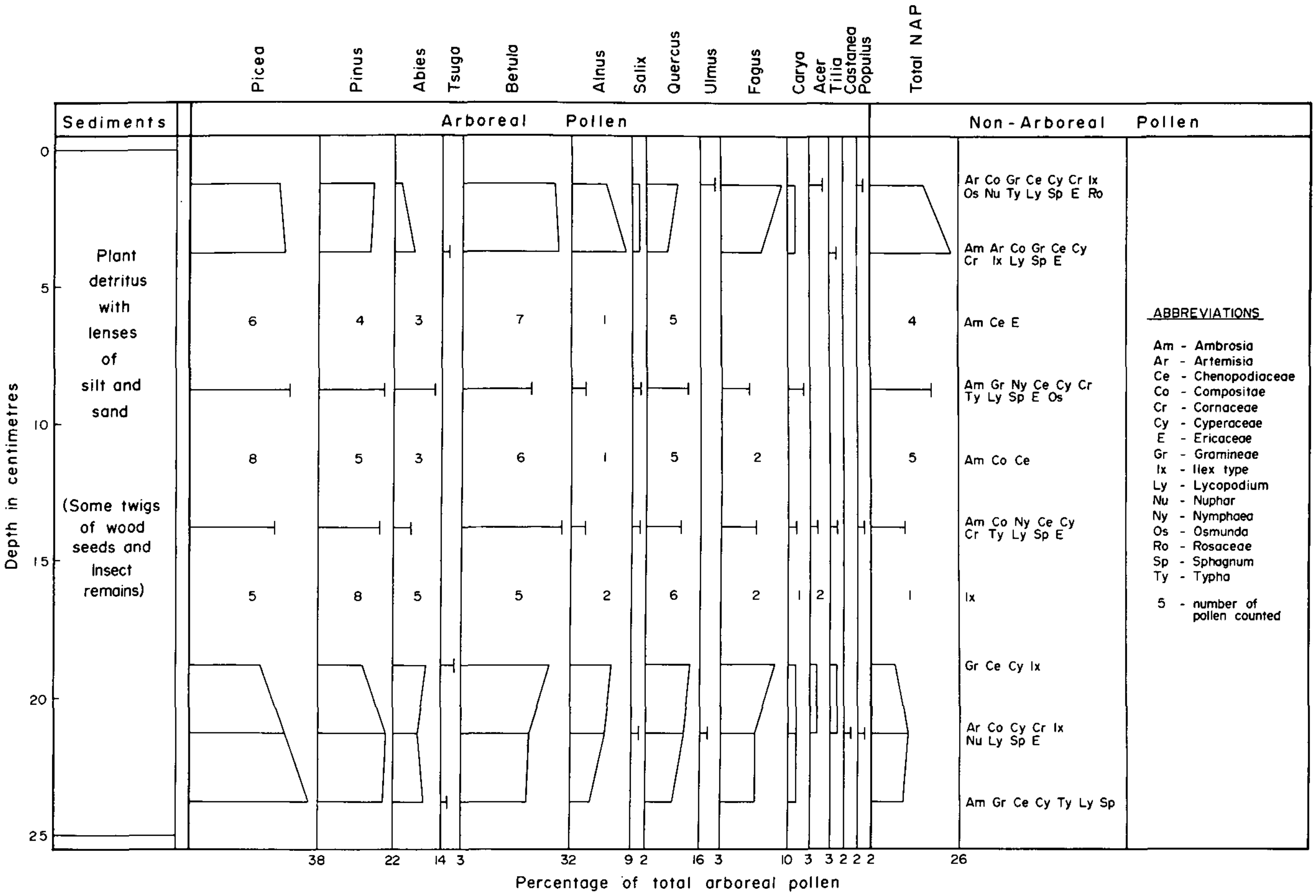

Fig. 11. Pollen diagram of buried peat deposit, Portage-du-Cap, Amherst Island. Age of peat is more than 35,000 radio-carbon years.

ORGANIC DEPOSITS

Organic deposits in sinkholes (formed by dissolution of gypsum) on Amherst, Grindstone, Alright, and Boudreau Islands, and other peat deposits on Entry, Amherst, and Coffin Islands are of Holocene age (the oldest radiocarbon date is 10,000 ± 130 years B.P., BGS-313, from the east end of Baie du Bassin, Amherst Island). Palynostratigraphic records from these deposits (supported by several radiocarbon dates) are generally similar to those from adjacent regions in the Maritime Provinces. It is possible that older organic deposits in some sinkholes may be found. It will be necessary, however, to use standard soil-drilling equipment (from the ice platform in the winter) to reach such deposits because experience from exploration with manually operated coring equipment in the summer has indicated the presence of dense silty-sand layers in the sinkholes that cannot be penetrated with the light weight equipment. These inorganic deposits evidently coincide with episodes of instability of the steep slopes that surround the sinkholes and during these episodes (related to periglacial processes and (or) to clearing of land during European settlement of the islands), soild erosion and down-slope movement were intensified (Terasmae 1974). Similar inorganic deposits have been found in a like context at other sites in the Maritimes. For example, in a sinkhole on Port Hoold Island, Nova Scotia, plant-bearing sandy sediments occur beneath a diamicton interpreted as being a solifluction deposit (Terasmae 1974). Wood identified as *Salix* sp. by R.J. Mott[1] from the lower of two plant-bearing horizons at Port Hoold, has been dated at 11,300 ± 160 years B.P. (GSC-541).

As mentioned above buried organic deposits were found interbedded with sand, silt and clay in a gravel pit on Amherst Island near Portage-du-Cap. These were initially considered to be pond deposits, but as some macrofossils and the diatoms indicate, they represent instead intertidal deposits (see below). They are part of a lenticular body, at least 10 m long by 1.25 m thick, overlain by red, sandy diamicton (Demoiselle drift) and lying on grey, well stratified gravel. The gravels are exposed in several pits at Portage-du-Cap and in the shore bluffs of the lagoon (Le Bassin) to the south. New gravel pits are being excavated in this latter area. The gravels, though somewhat 'dirty', are well stratified and commonly the beds dip steeply toward the northwest. The gravels are composed of subrounded to rounded locally derived stones and about 15 % well rounded foreign stones, including much quartz. The gravels appear to represent a kame delta rather than a valley filling as reported by Sanschagrin (1964). The well rounded stones were probably derived from older beach deposits.

The buried organics are an integral part of the deposit which consists of well bedded sand, silt, clay and peaty material. The organic-rich bed or 'peat' has a maximum thickness of 35 cm and includes some sandy and silty partings and lenses. The peat contains some plant detritus, including twigs, leaves, seeds, and sparse insect remains.

[1] Unpublished GSC Wood Identification Report No. 75-83.

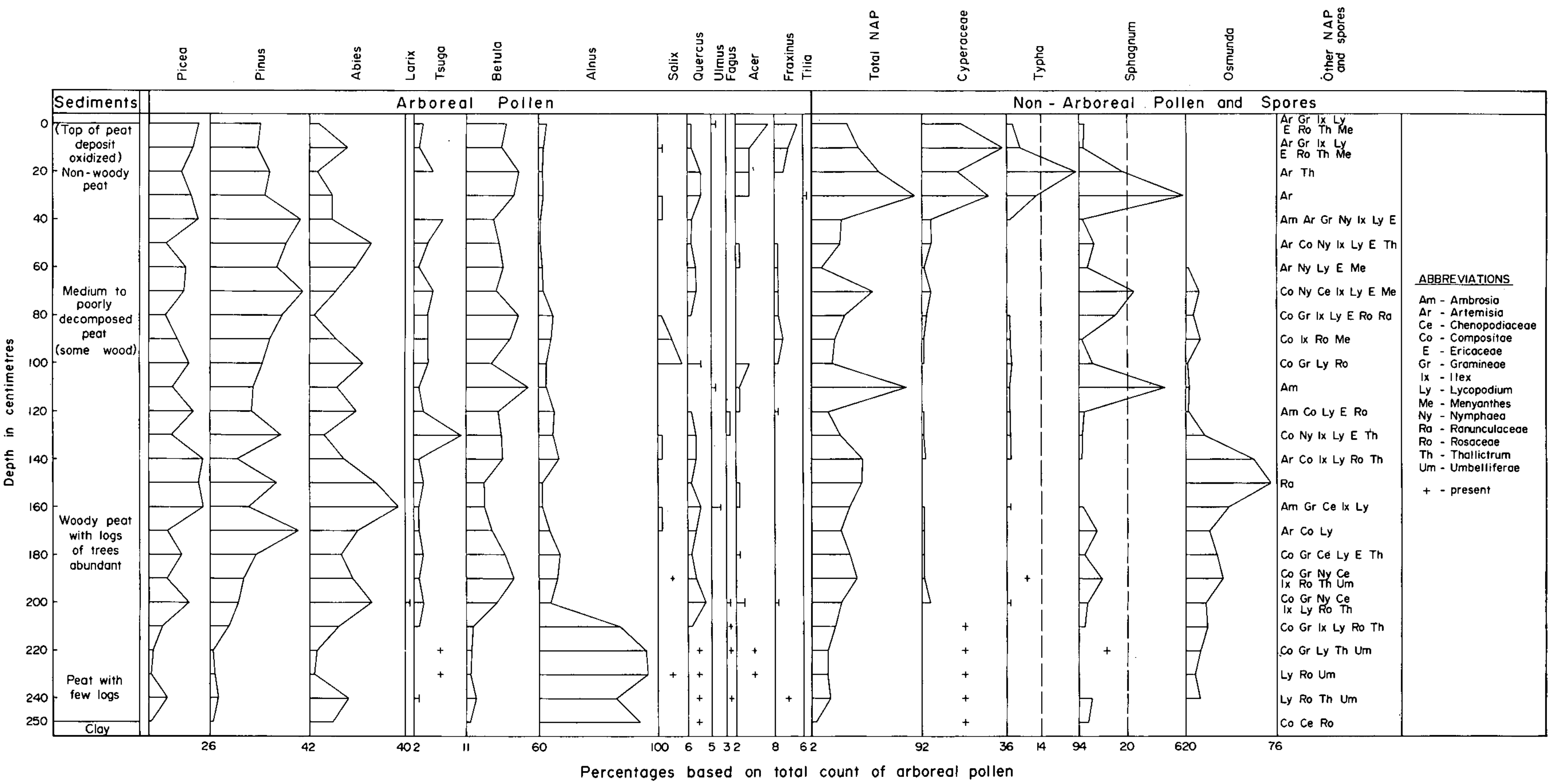

Fig. 12. Pollen diagram of peat exposure in sea cliff, Boudreau Island.

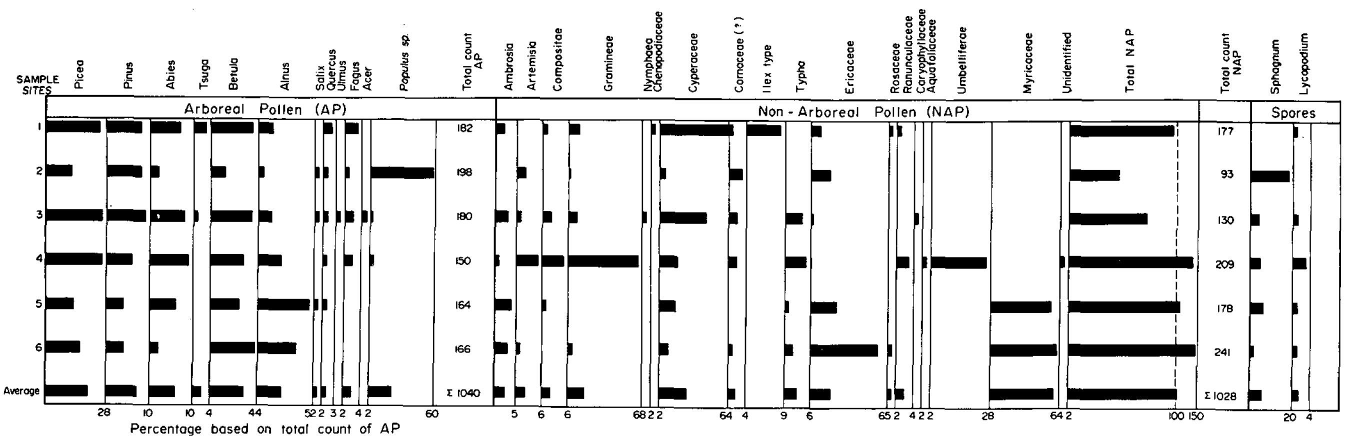

Fig. 13. Pollen diagram, surface sample assemblages, Magdalen Island, Quebec.

PALYNOLOGY

The stratigraphic relationships of the surficial deposits at the Portage-du-Cap gravel pit exposure are shown in Figure 10, and thicknesses of the stratigraphic units and their general description are given above.

A series of 10 samples was collected from the buried peat for palynological analysis, and three bulk samples (top, middle, and bottom) for study of other plant and animal fossils. Results of the preliminary palynological study have been compiled in a pollen diagram (Fig. 11).

The tree-pollen assemblages extracted from the peat samples are generally similar to those of Holocene age in terms of relative percentages of spruce *(Picea)*, pine *(Pinus)*, fir *(Abies)*, and birch *(Betula)* pollen, but contain significantly larger percentages of oak *(Quercus)* and beech *(Fagus)* pollen, and consistently low percentages of hickory *(Carya)*, maple *(Acer)*, and basswood *(Tilia)* pollen. Percentages of alder *(Alnus)* and willow *(Salix)* pollen are lower than in many samples of post-glacial age. The variety and numbers of non-tree pollen do not differ substantially from assemblages (except surface samples) found in post-glacial peat deposits on the same island. Since additional and more detailed palynological studies are in progress, the statements made here must be considered as tentative.

A pollen diagram based on a sea-cliff exposure of peat on Boudreau Island[1] that accumulated in a sinkhole depression (Fig. 12) and a selection of surface-sample pollen assemblages (representing modern pollen deposition) collected from different sites on the islands (Fig. 13), are presented here for the purpose of comparison. One should note that considerable variation exists in the non-tree pollen component of the modern pollen assemblages that reflect clearly the vegetation characteristics of each sampling site. Also to be noted is a corresponding variance in the relative percentages of pollen of tree species that are dominant locally (for example, alder).

[1]The Boudreau Island exposure was drawn to the authors' attention by C. Laverdiere, and is gratefully acknowledged.

The preliminary palynological evidence indicates that environmental conditions during deposition of the Portage-du-Cap buried peat were perhaps more favourable than at any time during the Holocene and hence, an interglacial age for this stratigraphic unit is implied.

Macrofossils

Matthews examined macrofossils, mostly insect and plant fragments, from two series of samples of the buried organics at Portage-du-Cap (see Table Ia) and for purposes of comparison, from two samples (b, c) of a coastal exposure of Holocene peat at the east end of Baie du Bassin, southeast of Portage-du-Cap all collected by J. Terasmae. Fossils identified to date are listed in Table I. The two samples from the Holocene peat are shown separately, as one sample (Table Ic) is stratigraphically above the other and is associated with a woody horizon (site of C^{14} sample BGS-313).

Compared with the Holocene samples, the sediments of the Portage-du-Cap peat contain few macrofossils. Nevertheless several of them are potentially good paleoenvironmental indicators and require comment.

Most of the beetle fossils in the Portage-du-Cap assemblage represent the species *Cercyon litoralis* Gyll. Individuals of this species occur at marine shoreline sites, often beneath seaweed and other debris, between Virginia and Newfoundland. It is ubiquitous at coastal sites in Europe, a fact which has caused it to be considered a recent man-transported introduction to North America (Lindroth 1957). However A. Smetana, who is currently revising the genus, feels that the distributional evidence argues for its being a native species in North America (Pers. comm. with J.V.M., Jr., 1976). The presence of fossils of *C. litoralis* in sediments at least 38,000 years old is ample testimony to the accuracy of his suggestion.

Only a fragment of the pronotum of the ground beetle Oodes *americanus* was found (Plate 1 c, d) but its size, shape and surface sculpture distinguish it from pronata of all other ground beetles including a similar appearing species, *Oodes parallelus* Say. *Oodes* species are primarily southern in distribution. The two species mentioned above are the only ones found in Canada (except some stragglers of two

TABLE I

Macrofossils from Amherst Island Sites
Magdalen Islands, Quebec

	(a)	(b)	(c)[1]
COELENTERATES			
Hydrozoa			
INSECTS	+		
Coleoptera "beetles"			
Carabidae "ground-beetles"			
Calosoma sp.	+		
Patrobus sp.		+	
Trechus cf. *T. crassiscapus* Lth.			+
Bembidion forestriatum Motsch.[2]			+
Pterostichus luctuosus Dej.			+
Agonum sp.	+		
Oodes americanus Dej.[2]	+		
Dytiscidae "predaceous diving beetles"			
Hydroporus spp.		+	
Agabus ?		+	
Hydrophilidae "water scavenger beetles"			
Hydrobius?		+	
Cercyon litoralis Gyll.[3]	+		
Staphylinidae "rove beetles"			
Omalinae, several genera	+	+	
Stenus sp.		+	
Tachinus sp.			+
Genus?	+	+	
Pselaphidae "short-winged mould beetles"			
Genus?		+	+
Helodidae "marsh beetles"			
Cyphon sp.		+	
Byrrhidae "pill beetles"			
Byrrhus sp.	+		
Lathridiidae "minute brown scavenger beetles"			
Genus?		+	
Chrysomelidae "leaf beetles"			
Donacia sp.		+	
Curculionidae "weevils"			
Apion sp.	+		
Rhynchaeneus sp.		+	
Genus?	+		
Scolytidae "bark beetles"			
Genus?		+	
Trichoptera "caddis flies"			
larval head fragments		+	
Diptera "two-winged flies"			
puparial fragments	+		
Hymenoptera "wasps and ants"			
Ichneumonoidea "Parasitic wasps"		+	
Chalcidoidea "chalcid wasps"	+		
Formicidae "ants"		+	
PLANTS			
Gynmosperms			
Pinaceae "pine family"			
Abies balsamae (L.) Mill.	+		
Picea mariana (Mill.) BPS.		+	
Picea			
Angiosperms			
Typhaceae "cat tail family"			
Typha sp.	+		
Najadaceae "pondweed family"			
Potamogeton sp.	+		
P. cf. *diversifolius* Raf.[2]	+		
Zannichellia palustris L.[2]	+		
Gramineae "grass family"			
Genus?	+		
Cyperaceae "sedges"			
Dulichium?	+		
Eleocharis cf. *E. pauciflora* (Lightf.) Link.[2]	+		
Carex aquatilis Wahlenb.		+	
Carex sp.	+		
Salicaceae "willow family"			
Populus sp.[4]	+		
Betulaceae "birch family"			
Betula papyrifera Marsh	+		
Betula sp.			+
Alnus rugosa type		+	
Polygonaceae "buckwheat family"			
Rumex maritimus L.	+		
Polygonum lapathifolium type	+		
Chenopodiaceae "goosefoot family"			
Chenopodium sp.	+		
Rosaceae "rose family"			
Potentilla palustris (L.) Scop.		+	
Rubus cf. *R. idaeus* L.	+		
Hypericaceae "St. John's Wort Family"			
Hypericum sp.	+		
Hippuridaceae "mare's tail family"			
Hippuris vulgaris L.	+		
Cornaceae "dogwood family"			
cornus canadensis L.		+	
Ericaceae "heath family"			
Vaccinium sp.	+		

1. Buried organics site, Portage-du-Cap (a); Holocene peat section, Baie du Bassin (b), and (c).
2. Taxa not currently known from the Magdalen Islands (based on Larochelle 1975 and unpublished floral lists kindly supplied by M. Grandtner, University of Laval.
3. Identified by A. Smetana, Biosystematics Research Institute, Agriculture Canada, Ottawa.

	(a)	(b)	(c)
Gentianaceae "gentian family"			
Menyanthes trifoliata L.	+	+	+
Labiatae "mint family"			
Lycopus cf. *L. uniflorus* Michx.	+		
Mentha cf. *M. arvensis* L.	+		
Solanaceae "nightshade family"			
Solanum or *Physalis*	+		
Schrophylariaceae "figwort family"			
Veronica sp.	+		
Caprifoliaceae "honeysuckle family"			
Sambucus sp.	+		
Compositae "composite family"			
Ambrosia sp.	+		

other species at Pt. Pelee, Ontario - Lindroth 1969) and they are restricted to southern sites e.g., southern Ontario, and Manitoba south of Winnipeg. Only *O. parallelus* is found in southern Quebec (Larochelle 1975) and all species of *Oodes* are absent from the Canadian Atlantic provinces. *Oodes americanus* is apparently not found farther north than southern Maine in the New England region (Lindroth 1954, 1956). The Portage-du-Cap record is thus well beyond the present northern limit of the species.

Several of the plant species to which Portage-du-Cap fossils are referred are not recorded as growing on the Magdalen Islands today (Table I). Some of these do occur in Nova Scotia (Roland 1945), Prince Edward Island (Erskine 1960), or at adjacent mainland Quebec sites (Grandtner and Rousseau 1975) and therefore may well grow on the islands today and simply have been overlooked. Furthermore, caution must be exercised in attempting to draw paleoenvironmental conclusions on the basis of fossils that are only tentatively identified as is the case for many of the plant fossils from Portage-du-Cap sediments.

Still, the possible occurrence of *Potamogeton diversifolius*, *Eleocharis pauciflora* and other unexpected species in the Portage-du-Cap assemblage does indicate the type of surprises that could result from further study of the sediments. One puzzling example concerns the fossil nutlet of an elderberry (*Sambucus* sp.). It clearly represents neither of the native species (*S. canadensis* L., or *S. pubens* Michx.) now found in northeastern North America (Gleason 1952), being instead most similar to nutlets of the far western species, *S. coerulea* Raf. (Hitchock *et al* 1959).

Equally interesting is the multitude of small transversely wrinkled tubules referred to as Hydrozoa. Hydrozoans occur in fresh and salt water, but very few of those that live in fresh water form a chitinous periderm (Barnes 1964). Because all the fossils in the Portage-du-Cap sediments consist of chitinous periderm fragments, they probably represent one or more species of marine hydrozoans. No trace of Hydrozoans was found in the two Holocene samples, and Matthews has never encountered fossils like those from Portage-du-Cap sediments in fresh water or terrestrial samples from other sites in Canada. Neither does Frey (1964) mention them in his exhaustive review of the literature on Quaternary animal fossils from lakes and bogs.

In summary the plant and insect fossils from the Holocene sediments of eastern Amherst Island represent the type of environment that occurs near poorly drained sites on the Magdalen Islands today. It is clear from the abundance of spruce needles in one of the samples that spruce trees were growing quite near the site of deposition of the peat.

The Portage-du-Cap assemblage is markedly different. *Abies* needles are abundant and spruce is rare. Missing are fossils of bog inhabiting beetles like *Donacia*, *Stenus* and *Cyphon* and seeds of the marsh cinquefoil *Potentilla palustris*. Dominating are beetles and plants that occur in open sites near shorelines. *Oodes americanus* is a bog inhabitant as is the plant *Menyanthes trifoliata*, but seeds of the latter float and could easily have been transported from elsewhere while the fact that only a single fossil of *Oodes* was found argues for its being allochthonous.

If it is assumed that the *Oodes americanus* fossil comes from an inland site on the island and that it lived at about the time that Portage-du-Cap sediments were being transported, then it signifies a climate warmer than that of the present. Some of the plant fossils tentatively imply a similar conclusion. Those of the water plant *Hippuris vulgaris* show that the climate was probably no warmer than that of southern New England today, for that is the region in which *Hippuris vulgaris* has its southern limit (Fernald 1956, Miller 1973).

Diatom analysis

Preliminary investigation by Lichti-Federovich of sample material from a buried organic deposit near Portage-du-Cap, Amherst Island, yielded 119 diatom forms, a selection of which is illustrated in Plates II and III. A complete list of species with relevant information on the ecology and climatic-geographic affinity is presented in Table II. Publications referred to in the preparation of this list are cited in the reference (Boyer 1926, 1927, Cleve-Euler 1951-55, Hendy 1964, Husdedt 1927-62, 1965, Round 1971, Wornardt 1969).

The floral spectrum is marked by the total absence of fresh-water forms and the near absence of true brackish taxa. It consists of a marine, littoral assemblage with an element of oceanic, planktonic forms. Silicoflagellates, which require an open-sea environment of normal salinity (Hajos 1973) are also present.

Another noteworthy feature of this assemblage is the comparatively large number of warm-water species with a southern distribution such as *Rhabdonema adriaticum*, *Rhizosolenia bergonii*, *Stephanopysix turris*, etc. *Navicula irroratoides* warrants special mention because its present distribution is known only from tropical regions.

TABLE 2.

Table 2 Alphabetical list of diatoms occurring in a buried organic deposit, Magdalen Islands, Québec.

	M	M-B	B-M	B	B-F	littoral zone	neritic zone	oceanic zone	benth.	epiph.	plankt.	cos.	arct.	north.	temp.	subtr.	trop.
Achnanthes brevipes Ag.			●	●						●		●					
" *groenlandica* (Cleve) Grun.	●									●	●		●				
" *longipes* Ag.	●	●				●						●					
" *septata* Cleve	●							●		●			●				
Actinocyclus octonarius Ehr.	●						●				●	●			●		
" " var. *crassa* (W. Sm.) Hust.	●						●				●	●					
" " var. *tenella* (Bréb.) Hajós	●						●				●	●?					
Amphiprora alata var. *pulchella* Bail. fragment	●	●										●					
Amphora cymbifera Greg.	●					●						●					
" *ocellata* Donk.	●											●					
" *ostrearia* Bréb.	●											●					
" *proteus* Greg.	●	●	●	●					●			●					
" *spectabilis* Greg.	●																
" *terroris* Ehr.	●								●			●					
Anorthoneis hyalina Hust.	●					●				●							
Auliscus caelatus Bail.	●					●			●			●?			●?	●	●
" Ehr. spec.	●					●											
Biddulphia aurita (Lyngb.) Bréb. et God.	●					●	●			●	●	●		●			
" *rhombus* (Ehr.) W. Sm.	●					●	●			●	●	●		●	●		
Caloneis brevis (Greg.) Cleve fragment	●	●										●		●			
" *permagna* (Bail.) Cleve				●													
Campylodiscus Ehr. spec.	●																
Cocconeis californica Grun.	●					●								●			
" *costata* Greg.	●					●			●	●		●?			●		
" *decipiens* Cleve	●					●											
" *notata* Petit	●												●	●	●	●	●
" *scutellum* Ehr.	●	●					●			●		●					
" *pseudo-marginata* Greg.	●					●			●	●			●	●	●		
" Ehr. spec.	●																
Coscinodiscus excentricus Ehr.	●	●					●	●			●	●					
" *Kützingii* A.S.	●						●		●			●					
" *lineatus* Ehr.	●					●	●	●			●	●					●
" *marginatus* Ehr.	●						●	●	●						●		
" *nitidus* Greg.	●					●	●		●		●	●					
" *oculus-iridis* Ehr.	●							●	●		●	●					
" Ehr. spec.	●																
Cyclotella striata (Kütz.) Grun.	●	●	●	●							●	●					
Dimerogramma minor (Greg.) Ralfs	●					●			●	(●)		●					
" " var. *nana* (Greg.) Van Heurck	●					●			●	(●)							
Diploneis coffaeiformis (A.S.) Cleve	●								●					●			
" *didyma* (Ehr.) Cleve	●	●	●	●					●			●					
" *entomon* (A.S.) Cleve	●												●				
" *incurvata* (Greg.) Cleve	●											●?					

TABLE 2. contd.

	M	M-B	B-M	B	B-F	littoral zone	neritic zone	oceanic zone	benth.	epiph.	plankt.	cos.	arct.	north.	temp.	subtr.	trop.
Diploneis interrupta (Kütz.) Cleve	●	●	●	●					●	(●)		●					
" *obliqua* (Brun) Hust.			●	●											●		
" *Smithi* (Bréb.) Cleve	●	●	●	●					●	●		●	●	●	●		
" *subcincta* (A.S.) Cleve	●								●			●		●			
" *suborbicularis* (Greg.) Cleve	●									●		●			●		
" *splendida* (Greg.) Cleve	●											●					
" Ehr. spec.	●																
Frustulia interposita (Lewis) de Toni	●	●	●	●								●					
Grammatophora angulosa Ehr.	●					●			●	●					●		
" " var. *islandica* (Ehr.) Grun.	●					●				●			●	●	●		
" *arcuata* Ehr.	●					●				●			●	●	●		
" *oceanica* (Ehr.) Grun.	●					●				●		●					
" " var. *macilenta* (W. Sm.) Grun.	●	●				●				●		●					
Gyrosigma balticum (Ehr.) Cleve	●	●	●	●		●			●			●					
Hyalodiscus scoticus (Kütz.) Grun.	●	●	●	●					●	(●)	●	●?					
Isthmia enervis (Ehr.)	●					●							●	●	●	●	●
" *nervosa* Kütz.	●					●							●	●	●	●	●
Melosira sulcata (Ehr.) Kütz.	●					●	●		●		●	●?			●		
" " var. *biseriata* fo. *coronata* Grun.	●					●	●		●		●	●			●		
" " var. " fo. *radiata* Grun.	●					●	●		●		●	●			●		
" " var. *crenulata* fo. " Grun.	●					●	●		●		●	●			●		
" " var. *genuina* fo. *coronata* Grun.	●					●	●		●		●	●			●		
" " var. " fo. *radiata* Grun.	●					●	●		●		●	●			●		
Navicula abrupta (Greg.) Donk.	●	●	●	●		●			●		●	●					
" *approximata* Grev.	●														●	●	●
" *brasiliensis* Grun.	●													●	●		
" *clavata* Greg.	●					●						●					
" " fo. *subconstricta*, nov. f.	●					●											
" *digito-radiata* (Greg.) A.S.	●	●	●	●		●			●			●					
" *ergadensis* (Greg.) Ralfs	●					●											
" *forcipata* Grev.	●	●				●			●	(●)		●					
" *granulata* Bail.	●					●			●								
" *Hennedyi* W.Sm.	●					●			●			●	●				
" *humerosa* Bréb.	●	●	●	●		●			●			●					
" *incurvata* (Greg.) Cleve	●																
" *irroratoides* , nov. spec.	●															●	●
" " var. ?	●															●	●
" *latissima* Greg.	●					●			●			●?					
" *lyra* Ehr.	●					●	●		●						●	●	●
" " var. *atlantica* A.S.	●					●	●		●			●		●			
" " var. *constricta* Perag.	●					●	●										
" " fo. *elliptica* A.S.	●					●	●					●					
" *marina* Ralfs	●	●	●	●		●									●		

TABLE 2. (completed)

	M	M-B	B-M	B	B-F	littoral zone	neritic zone	oceanic zone	benth.	epiph.	plankt.	cos.	arct.	north.	temp.	subtr.	trop.
Navicula sulcifera Hust.	●																
" *yarrensis* var. *americana* Cleve				●									●	●	●		
Nitzschia acuminata (W. Sm.) Grun.	●	●	●	●		●			●			●					
Opephora pacifica (Grun.) Petit	●	●	●	●		●				●		●					
" *Schwartzii* (Grun.) Petit	●					●									●		
Pinnularia cruciformis (Donk.) Cleve	●					●			●			●					
" *quadratarea* (A.S.) Cleve	●								●			●					
" *rectangulata* (Greg.) Rabh. var.?	●					●						●					
Plagiogramma staurophorum (Greg.) Heib.	●					●			●	●		●	●	●	●		
" *pulchellum* var. *pygmaea* (Grun.) Perag.	●														●		
Podosira Ehr. spec.	●					●											
Rhabdonema adriaticum Kütz.	●					●	●		●	●		●			●		
" *arcuatum* (Lyngb.?) Ag.	●	●	●	●		●				●		●					
? " *japonicum* Temp. et Brun	●																
" *minutum* Kütz.	●	●	●	●					●	●			●	●			
Rhaphoneis amphiceros Ehr.	●	●							●	●		●					
Rhizosolenia bergonii Perag.	●							●			●				●	●	●
" *hebetata* fo. *semispina* (Hens.) Gran	●						●	●			●			●	●	●	●
" Ehr. fragment	●							●			●						
Rhoicosphenia curvata (Kütz.) Grun.	●	●	●	●	●					●		●					
Rhopalodia gibberula (Ehr.) O. Müll.	●	●	●	●	●					●		●					
" *musculus* (Kütz.) O. Müll.	●	●	●	●	●					●		●					
Scoliopleura tumida (Bréb.) Rabh.	●	●	●	●					●								
Stephanopyxis turris (Grev. et Arn.) Ralfs	●						●				●	●					
Surirella recedens A.S.	●								●						●	●	●
Synedra tabulata (Ag.) Kütz.	●	●	●			●				●		●					
" *Gaillonii* (Bory) Ehr.	●	●	●	●		●				●		●					
Thalassionema nitzschioides Hust.	●						●		●			●		●	●		
Trachyneis aspera (Ehr.) Cleve	●					●	●		●		●	●					
" " var. *intermedia* Grun.	●					●	●		●		●		●	●	●	●	●
" " var. *pulchella* (W. Sm.) Cleve	●								●		●				●		
Triceratium reticulum Ehr.	●					●			●				●	●			
Trigonium arcticum (Brightw.) Cleve	●					●			●			●					
Silicoflagellates:																	
Distephanus speculum Ehr.	●							●			●						

M = marine
M-B = marine-brackish
B-M = brackish-marine
B = brackish
B-F = brackish-fresh

benthonic = bottom forms
epiphytic = growing on other plants
planktonic = free floating organisms

littoral zone = intertidal zone
neritic zone = low tide to continental shelf
oceanic zone = limit of continental shelf to -

cos. = cosmopolitan
arct. = arctic
north. = northern
temp. = temperate
subtr. = subtropical
trop. = tropical

In summary, the dominant component of marine littoral forms, in this inland deposit, clearly indicates deposition at or near a shoreline at a time when the sea was higher and probably warmer than at present; this was probably during an interglacial interval.

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PLATE I

Fig. 1 Portage-du-Cap macrofossils and modern counterparts, Amherst Island

(a) *Potamogeton* cf. *P. diversifolius* Raf.; GSC-46938; fruit.

(b) *Eleocharis* cf. *E. pauciflora* (Lightf.) Link; GSC-46939; achene fragment.

(c) *Oodes americanus* Dej.; GSC-46949; pronotal fragment.

(d) Magnified view of corner of pronotum in Plate Ic. Note the distribution of punctures (faint white spots) on the surface.

(e) *Oodes americanus* Dej.; modern specimen, Left ptonotal half; Lansing, Michigan, VII - 20 to 24, '73, Coll.: J.V. Matthews, Jr. Compare with Plate Ic.

(f) Magnified view of corner of pronotum in Ie. Note close spacing of surface punctures, one character by which *O. americanus* and *O. parallelus* may be distinguished (punctures more widely spaced in *O. parallelus*). Compare puncture density on the fossil shown in Plate Id with that in If.

Scale bar = 0.5 mm.

All photos are SEM micrographs, taken with the help of Louis Ling, Carleton University, Ottawa.

PLATE I

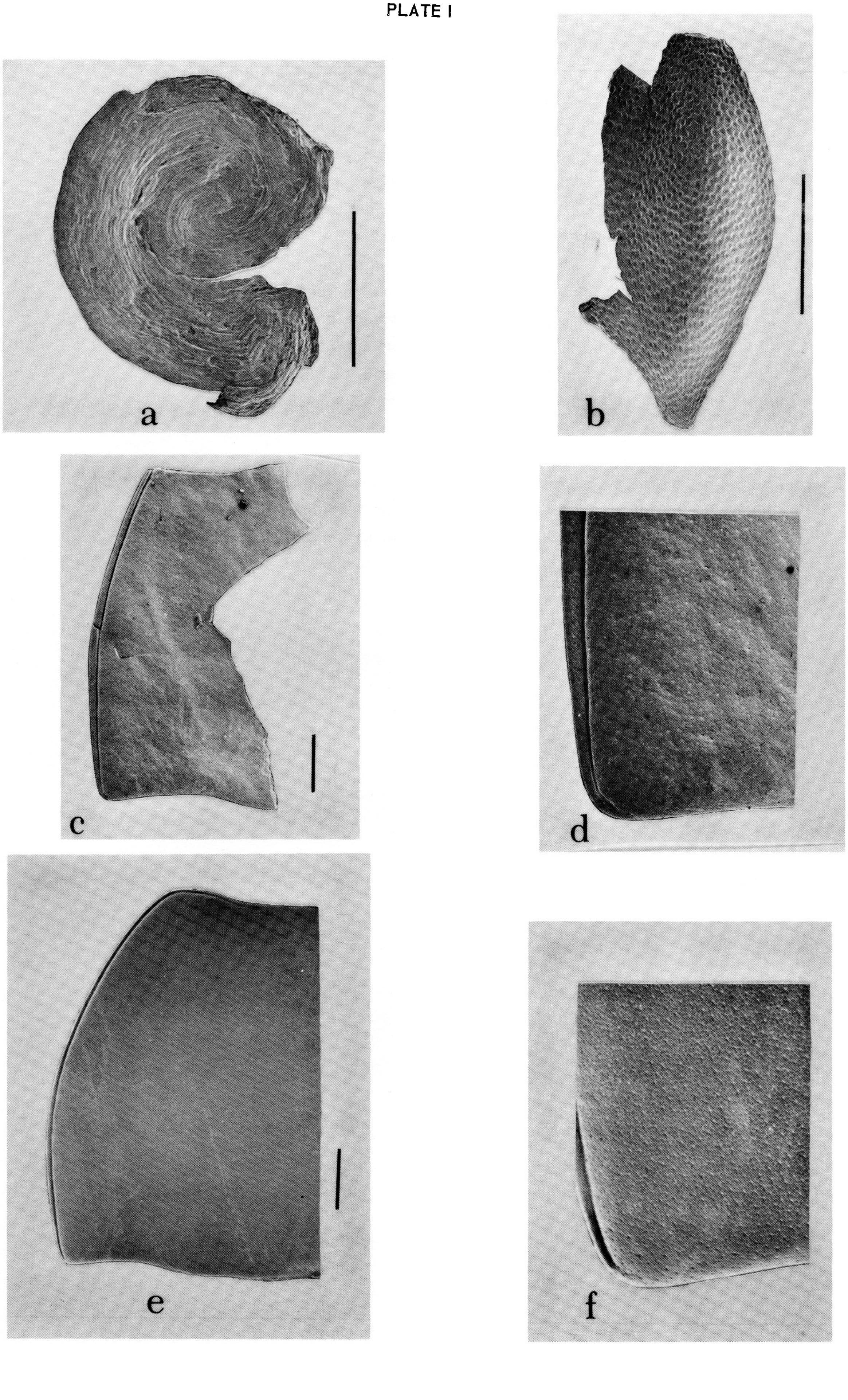

PLATE II

fig. 1 *Cocconeis scutellum* Ehrenberg
fig. 2 *Cocconeis costata* Gregory
fig. 3 *Rhabdonema minutum* Kutzing
fig. 4 *Naviculua Hennedyi* W. Smith
fig. 5 *Auliscus caelatus* Bailey
fig. 6 *Diploneis didyma* Ehrenberg
fig. 7 *Navicula digito-radiata* (Gregory) A. Schmidt
fig. 8 *Coscinodiscus excentricus* Ehrenberg
fig. 9 *Triceratium reticulum* Ehrenberg
fig. 10 *Coscinodiscus Kutzingii* A. Schmidt
fig. 11 *Navicula humerosa* Brebisson
fig. 12 *Plagiogramma staurophorum* (Gregory) Heiberg
fig. 13 *Navicula latissima* Gregory
fig. 14 *Amphora spectabilis* Gregory
fig. 15 *Coscinodiscus lineatus* Ehrenberg
fig. 16 *Rhaphoneis amphiceros* Ehrenberg
fig. 17 *Coscinodiscus nitidus* Ehrenberg

(Magnification 800/1)

PLATE II

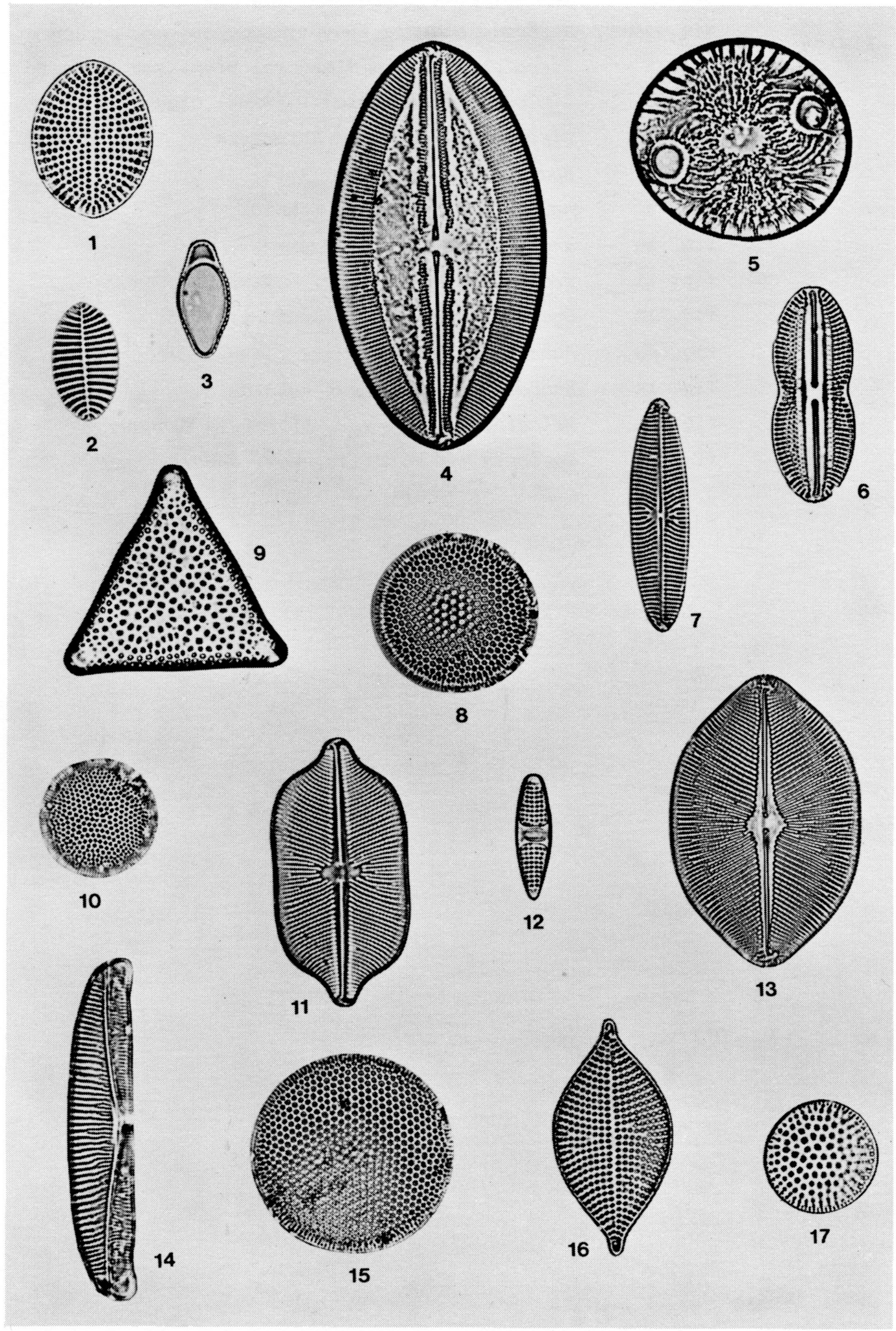

PLATE III

fig. 1	*Diploneis Smithi* (Brebisson) Cleve
fig. 2	*Navicula granulata* Bailey
fig. 3	*Grammatophora angulosa* Ehrenberg
fig. 4	*Navicula clavata* Gregory
fig. 5	*Biddulphia aurita* (Lyngbye) Brebisson et Godey
fig. 6	*Diploneis interrupta* (Kutzing) Cleve
fig. 7	*Distephanus speculum* Ehrenberg
fig. 8	*Hyalodiscus scoticus* (Kutzing) Grunow
fig. 9	*Surirella recedens* A. Schmidt
fig. 10	*Anorthoneis hyalina* Hustedt
fig. 11	*Trachyneis aspera* var. *intermedia* Grunow
fig. 12	*Opephors Schwartzii* (Grunow) Petit
fig. 13	*Achnanthes groenlandica* Cleve
fig. 14	*Rhabdonema adriaticum* Kutzing
fig. 15	*Melosira sulcata* var. *biseriata* Grunow
fig. 16	*Navicula irroratoides,* nov. spec.

PLATE III