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Relative Sea-Level Change and Coastal Response, Northeast Newfoundland[1]

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ABSTRACT

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Sand beaches and coastal dunes are prominent features on the northeast coast of Newfoundland, between Bonavista Bay and Hamilton Sound. This is in contrast to most other parts of the island, where coastal progradation typically takes the form of gravel beach ridges. At Man Point, near Musgrave Harbour, an extensive beach- and dune-ridge foreland is mantled by freshwater peat up to 2.9 m thick. Radiocarbon dates on basal peat are 3,150 ± 90 BP, 3,060 ± 90 BP and 2,740 ± 60 BP (unadjusted). The base of salt-marsh peat landward of the barrier is dated at 2,980 ± 90 BP. At Deadman's Bay, where moribund flood tidal deltas, flood channels and washover fans at the north end of the barrier system provide evidence of an arrested transgressive phase, organic deposits at two sites are dated at 1,780 ± 80 BP and 1,260 ± 70 BP. An extensive, partly buried, peat unit overlying old dune ridges at Cape Freels is dated at 1,630 ± 50 BP. We also report on a core from a backbarrier marsh at Eastport, in western Bonavista Bay, where freshwater organic material at −3.3 m is dated at 5,490 ± 120 BP.

The evidence from these and other locations suggests that, between 12 and 10 ka BP, relative sea level fell below present datum to an undetermined minimum. During the subsequent transgression it was still below −4 m at 5.5 ka BP, but had reached approximately −0.7 m by 3 ka BP. With relatively early termination of the Holocene transgression, some coastal deposits in the area were stabilized, becoming mantled by woodland, marsh and bog. We note the apparent absence of major glacigenic sources, such as those which supply material to prograded coastal systems elsewhere on the island, and suggest a likely course for the episodic postglacial evolution of coastal sediment bodies in the region.

ADDITIONAL INDEX WORDS: *Dune ridges, relative sea level, beaches, palynology, peat.*

INTRODUCTION

Although it is intuitively apparent that relative sea-level change is a major driving force for coastal evolution, an understanding of how the two are related remains elusive where the pattern of relative sea-level change is either unknown, or poorly understood. Parts of the formerly-glaciated island of Newfoundland (Figure 1, inset) fall into these categories. Relative sea-level curves have been published for only two regions. GRANT (1980) and QUINLAN and BEAUMONT (1981) indicated patterns of falling relative sea level during postglacial time in the Great Northern Peninsula. A different pattern was demonstrated for the St. George's Bay area of southwest Newfoundland, where relative sea level dropped from a Late-Wisconsinan highstand to a postglacial minimum, before rising once more (BROOKES *et al.*, 1985; GRANT, 1987). Evidence emerging from recent nearshore seismic surveys (FORBES and SHAW, 1989; FORBES and SHAW, *in prep.*) suggests that the postglacial minimum was at least 25 m below present sea level.

The nature of Late-Quaternary relative sea level elsewhere on the island remains enigmatic, and in most areas the Late-Wisconsinan marine limit is the only published information available (for example see JENNESS, 1960; TUCKER, 1974; GRANT, 1980; TUCKER, LECKIE and McCANN, 1982; BROOKES, 1989). While numerical models were used to derive sea-level zones (QUINLAN and BEAUMONT, 1981, 1982) for Atlantic Canada, including Newfoundland, some of the subsequent evidence (LEWIS and MACPHERSON, 1987; SCOTT, BOYD and MEDIOLI, 1987) has shown they do not correctly predict the course

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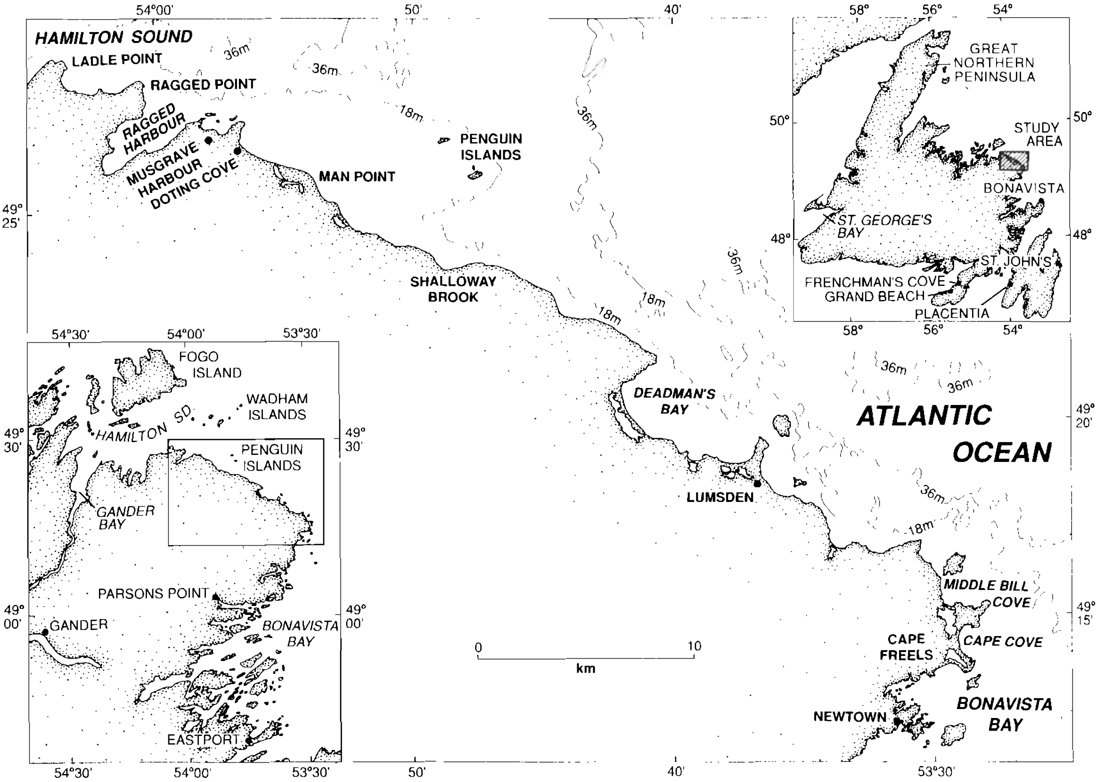


Figure 1. Location of the study area, and place names referred to in the text.

of relative sea level across the island. Consequently, a major objective of this paper is to present evidence of relative sea-level change from a region where it has hitherto been largely unreported, namely the northeast coast, between Hamilton Sound and Cape Freels (Figure 1).

Our second objective, closely related to the first, is to describe the organic deposits associated with coastal sediment systems in the study area, and to account for their formation. It became apparent from early field reconnaissance that the organic deposits overlying prograded forelands, barriers and dunes along the coast are, in places, thicker and hence (we speculated) older than those observed elsewhere on the island. Peat, both freshwater and saltmarsh, is commonly found overlying gravel beach-ridge plains scattered along the otherwise rocky coast in many parts of Newfoundland (SHAW and FORBES, 1987, 1988; SHAW, 1989). Thicknesses vary, but the maximum observed by the authors is a little over 1 m. The oldest radiocarbon dates which we have obtained from this type of environment include 2,100 ± 110 BP (Beta-19570) at Placentia (Figure 1), 1,210 ± 70 BP (Beta-19581) at Frenchman's Cove (Figure 1), and 1,350 ± 70 BP (Beta-19583) at Flat Island, in St. George's Bay (Figure 1).

We have reiterated in several papers (FORBES and TAYLOR, 1987; SHAW and FORBES, 1987, 1988; SHAW, 1989; FORBES, TAYLOR and SHAW, 1989) the strong links between sediment supply and coastal sedimentation in Newfoundland. Gravel beach-ridge complexes, in a variety of configurations controlled by local physiographic setting, are located downdrift of eroding glacigenic deposits. By contrast, preliminary reconnaissance work along the northeast coast revealed that there were extensive areas of coastal progradation not obviously linked to major sources of sediment. In addition, whereas many beaches elsewhere on the island are composed of gravel (FORBES, 1984, 1985; FORBES and TAYLOR, 1987; FORBES, TAYLOR and SHAW, 1989), the northeast coast appeared to be sand-dominated, with extensive beach and coastal-dune development. The third objective of this paper is to describe these distinctive depositional features and to comment upon their evolution, in relation to both changing sea levels and to the apparent absence of glacigenic sediment sources.

STUDY AREA

Coastal Setting

We focus primarily on three locations on the coast between Hamilton Sound and Cape Freels (Figure 1). These are the peat-covered beach and dune-ridge foreland at Man Point, the barrier at Deadman's Bay, and the coastal dunes at Cape Freels. We also present evidence from a coastal site at Eastport, in western Bonavista Bay, 70 km south of Cape Freels (Figure 1), and from several other sites in the area.

Relief in the study area is subdued, with low hills rising to a maximum elevation of 70 m within 5 km of the coast. Bedrock is predominantly Paleozoic granite (JAYASINGHE, 1978). During the Wisconsinan glaciation ice moved radially outward from central Newfoundland to cross the present coast (JENNESS, 1960), leaving a thin veneer of till over much of the study area. The coastal fringe is part of the "eastern hyper-oceanic barrens" ecoregion (DAMMAN, 1983). With a present climate that is cool and wet (BANFIELD, 1981), blanket bog development is extensive and forest cover is sparse and discontinuous.

Salt marshes are largely absent from this coast today. However, they occur widely on the island (THANNHEISER, 1984) although they are typically small in extent. A variety of associations exists. Species of the Chenopodiaceae family are typical components of these associations, and occur in both low and high marshes. Seashore plantain (*Plantago maritima*) is common, and is mainly a high marsh species, sometimes forming pure swards.

At Cape Freels (Figure 1), several rocky islands are linked to the mainland by sandy tombolos which enclose shallow brackish lagoons. Between Cape Freels and Hamilton Sound a number of predominantly sandy coastal sediment systems are present in a range of settings. These include the large tombolo at Lumsden and the bayhead barrier at Deadman's Bay, which together form a major sediment sink, bounded to the west by a prominent headland. Between there and Man Point the coast is relatively straight, with a fringe of thin gravel beaches. The small coastal compartment at Shalloway Brook contains a sand beach and well-developed dunes. The large depositional foreland at Man Point, southwest of the Penguin Islands, constitutes a second major sediment sink, with some leakage of sediment westward to Ragged Harbour.

The inner shelf in the study area is characterized by relatively subdued relief. There is, however, a marked break in slope at about 70 m water depth, 15 km offshore from Cape Freels. Of particular note is the shallow area between the Man Point foreland and the Penguin Islands. Most of this area is shallower than 9 m, much of it shallower than 4 m. We return to this feature later in the paper.

Although there are no records of wave climate in the study area, wave conditions at the coastline can be inferred from studies by NEU (1971, 1982) and WALKER (1984). These suggest that wave energy levels are lowest in the summer months but rise from October onwards, to peak in December, when most energy is associated with waves approaching from the south and southeast with periods between 6 s and 7 s. Sea-ice cover ($>40\%$ normally) is present by January 31 and remains until after April 30. Tidal range is approximately 0.8 m (mean) and 1.2 m at large tides (CANADIAN HYDROGRAPHIC SERVICE, 1987).

Sea-Level Changes

The history of Late-Quaternary relative sea level in this part of the island is not well known. The models of QUINLAN and BEAUMONT (1981, 1982) placed the area within either zone C (early-Holocene drop in relative sea level, followed by a rise) or zone D (continuous rise throughout the Holocene). JENNESS (1960) showed that the region lay within the zone of high Late-Wisconsinan relative sea level. Raised deltas in Bonavista Bay, at the seaward ends of outwash valley trains, occur at about +30 m elevation. An increase in deltaic elevation toward the west suggests a marine limit in the study area above +30 m. GRANT (1980) showed a Late-Wisconsinan marine limit of +43 m, mid-way along the coast in the study area. Regarding the timing of the high stands, BROOKES (1989) tentatively assigned strandlines at elevations up to +26 m on the Bonavista Peninsula, on the south side of Bonavista Bay, to the period 13–12 ka BP. The highest elevated strandlines in the study area may date approximately to this period.

A sample of marine barnacles contained in silty clay at Parsons Point (Figure 1) in western Bonavista Bay (D.G. VANDERVEER, *pers. comm.*, 1988) yielded a date of 12,000 ± 240 BP (GSC-4182). The sample was at an elevation of +2 m, indicating not only that Bonavista Bay was ice-free by this time, but also that relative sea level was above the present level. DAVIS and WICKHAM (1987) published a date of 10,290 ± 380 BP (WAT-888) for basal birch (*Betula*) wood, contained in peat exposed on the beach several kilometres southwest of Cape Freels (Figure 1). Relative sea level was probably below the present datum at that time.

JENNESS (1960) cited evidence obtained from local fishermen and others which suggested that, relative to rocks in a number of harbours in Bonavista Bay, sea level had fallen during the first part of this century at rates of 0.3–0.6 m per 100 years. It is not clear whether the accounts refer to bedrock or to boulders. If the latter we suggest that the apparent movement may have been due to ice heave. Otherwise, these observations are puzzling, since they are at variance with the very limited change registered at the St. John's tide gauge (FORBES, 1984).

METHODS

Grab samples of beach and dune sand were obtained from surface exposures, natural sections and shallow pits. Samples for pollen analysis were taken from an exposed peat face at site 1 (Figure 2) by the insertion of 4 cm diameter plastic vials. A Hiller borer was used to define the stratigraphy along the cross-section at Man Point (Figure 3), and for detailed coring at site 2, sites 3 and 4 (Deadman's Bay), and at Eastport. Topographic profiles and sample elevations were surveyed using standard methods, taking sea level as a local datum. Tide tables were used to estimate all elevations relative to mean water level (MWL). Vertical air photographs at various scales dating from 1966 to 1976 were used for geomorphological analysis and interpretation of recent coastal changes.

Numerical simulations of wave refraction were run on a Cyber 173 mainframe computer using a modified version of the Fortran program published by MAY (1974), with wave heights and periods characteristic of the region. In the laboratory, iron contents were determined by sequential leaching (FITZGERALD *et al.*, 1987) and total organic carbon amounts using a Leco(TM) carbon analyzer. Radiocarbon samples were dated at the Radiocarbon Dating Laboratory, Geological Survey of Canada (GSC), Ottawa, and at Beta Analytic Inc., Coral Gables, Florida. Excepting GSC-4509, all dates referred to in the text are corrected for $\delta^{13}C$. Radiocarbon determinations discussed in the text are listed in Table 1.

Pollen samples were prepared using standard techniques. Preliminary heating in sodium hydroxide was followed by treatment in hot hydrofluoric acid and by acetolysis. Towards the end of the process, when the samples were in distilled water, sodium hexametaphosphate was added. An ultrasonic vibrator was used to wash unwanted fines through a 10μm sieve before staining and mounting in glycerol. *Lycopodium* tablets were added to determine absolute concentrations of pollen and spores. The pollen diagrams are based on counts of 300 grains of all pollen and spores.

RESULTS

Man Point Foreland

General Description The foreland at Man Point (Figures 1, 2) is composed of a series of peat-covered parallel ridges and swales, trending southeast to east, truncated by the present coastline. Crest and swale elevations are typically +2 m and +1 m (respectively) above MWL, with local relief of up to 2 m in places. The foreland, composed of medium sand, is lowest in the central part of the cross-section (Figure 3) where some of the swales are at MWL. High-angle crossbedding seen in beach exposures suggests that the upper parts of the

Table 1. *Radiocarbon determinations discussed in the text. All dates are $\delta^{13}C$ adjusted, except GSC-4509.*

Location, material[a]	Lab. number[b]	Unadjusted	Adjusted	$\delta^{13}C$ (0/00)	Elevation (m asl)
Man Point, P	GSC-4509	2740 ± 60	—	—	1.10
Man Point, P	GSC-4520	3320 ± 90	3150 ± 90	35.4	1.14
Man Point, M	GSC-4592	2940 ± 90	2980 ± 90	− 22.7	− 0.15
Man Point, P	GSC-4604	270 ± 50	210 ± 50	− 28.9	2.40
Man Point, P	GSC-4662	3120 ± 90	3060 ± 90	− 29.0	− 0.10
Deadman's B., P	Beta-27233	1770 ± 80	1780 ± 80	− 24.1	- 0.56
Deadman's B., P	Beta-27234	1290 ± 70	1260 ± 70	− 26.9	0.67
Cape Freels, P	GSC-4542	1670 ± 50	1630 ± 50	− 27.6	4.71
Eastport, P	Beta-27231	5490 ± 120	5490 ± 120	− 25.1	− 3.30
Parsons Point[1],S	GSC-4182	12000 ± 240	12000 ± 240	0.5	~ 2
Newtown[2], W	WAT-888	?	10290 ± 380	− 28.3	~ 0

[a] Materials coded as follows: P freshwater peat and organic mud; M salt-marsh peat; W wood; S marine shells. GSC-4182: barnacles.
[b] Beta—Beta Analytic Inc.; GSC—Geological Survey of Canada; WAT-Waterloo University.
[1] D. G. Vanderveer, *Pers. Comm*, 1988.
[2] Davis, A. M. and Wickham, S. M., 1987.

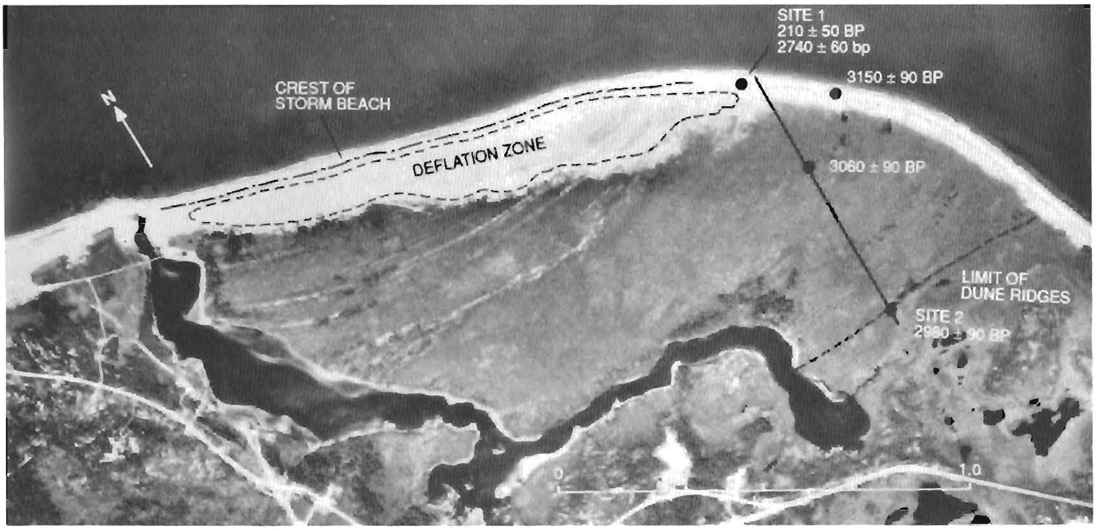
thick, with relatively low amounts of iron and organic material. The underlying 10–20 cm of sand is typically red-brown in colour. It overlies a unit of dark brown to black semi-indurated sand containing stringers and seams of black indurated sand. This unit has relatively high amounts of iron and organic carbon.

The dune ridges are mantled by a domed bog. Along the cross-section (Figure 3) the vegetation to 200 m inland is a low crowberry (*Empetrum*) heath, succeeded by a zone of low shrubs, notably sweet gale (*Myrica gale*) and members of the heath family (Ericaceae), with *Sphagnum*. Beyond 300 m inland, tussocks of deer grass (*Scirpus cespitosus*) are a dominant component of the bog vegetation, together with cotton grass (*Eriophorum*), and with *Sphagnum* in pools. Isolated clumps of spruce (*Picea* sp.) and larch (*Larix laricina*) are aligned along the crests of underlying dune ridges. Beyond the most landward dune ridge, at 650 m, a low wet area contains a mosaic of sedge marsh, pools with *Sphagnum*, and clumps of sweet gale and bog birch (*Betula pumila*).

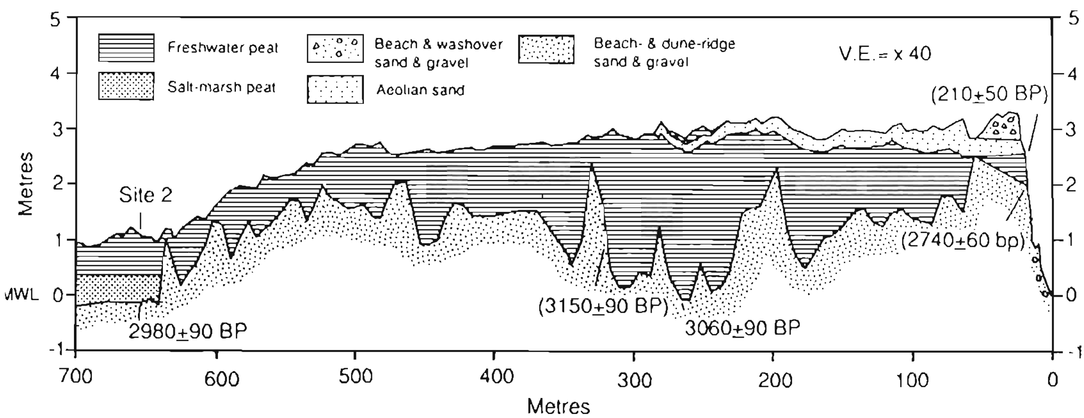
The bog is thickest (up to 2.9 m) in the middle of the foreland (Figure 3) and thins to the north and south, where the peat is absent from the highest crests. At beach exposures (Figure 4 a,b) the lower part of the peat is dark, moderately-well humified, with numerous woody remains, both horizontal trunks and branches, and *in situ* stumps. Woody remains of heath-type plants (the Ericales group, which includes the Ericaceae and Empetraceae) are present, in places concentrated in compacted seams. The upper peat is typically lighter in colour, poorly humified, contains less wood and is composed chiefly of *Sphagnum* remains. The bog is partly covered by a sheet of blown sand which thickens northwards towards an extensive deflation plain. At the landward limit, 250 m on the cross-profile (Figure 3), the sand interfingers with the peat to a depth of 0.1 m.

Site 1 At this site, a beach-cut exposure, dark brown-stained medium sand is overlain by 2 cm of light grey-brown sand, 17 cm of well humified dark brown peat with disseminated sand and some woody remains, 85 cm of dark brown well-humified peat with occasional sandy seams and numerous woody remains, including many *in situ* stumps, and 30 cm of light, yellow-brown, poorly-humified *Sphagnum* peat. The pollen diagram (Figure 5a) has two local pollen assemblage zones. Zone 1 (62–132 cm) is defined by relatively large amounts of shrub pollen: *Myrica, Alnus* (alder) and *Salix* (willow). These types decrease upwards in the zone, as does *Betula* (birch). *Nuphar* (yellow pond lily) pollen is present in relatively large amounts at some levels. Zone 2, whose lower boundary at 62 cm is defined by a sharp rise in amounts of *Sphagnum*, contains much lower levels of shrub pollen and relatively high levels of Ericales.

A basal sample 4 cm thick of freshwater peat,



'igure 2. Airphoto of Man Point beach and dune-ridge foreland, showing locations of surveyed cross section (Figure 3), sampling ites and radiocarbon-dated samples. Part of photograph no. NFA24172-136, Newfoundland and Labrador Department of Forest Resources and Lands, 1975-09-11.



'igure 3. Cross section of the foreland at Man Point showing positions of sampling sites and radiocarbon dates. The location of the cross section is shown on Figure 2. Dates in parenthesis are on samples offset from the cross section.

ridges, at least, may be wind-blown, and that the pattern seen in the airphoto (Figure 2) represents a sequence of foredune ridges (BIRD and JONES, 1988). On the other hand, the presence of a few well-rounded cobbles within the cross-bedded sand implies wave or ice-push processes and therefore limited elevation above sea level at the time of formation. An exception to this is the well-developed dune ridge along the southern border of an extensive deflation basin in the northwestern part of the foreland (Figure 2).

In pits, and in sections exposed along the beach, the dune-ridge sand shows a podzolized profile. Immediately below the overlying peat is a layer of light grey sand, several centimetres

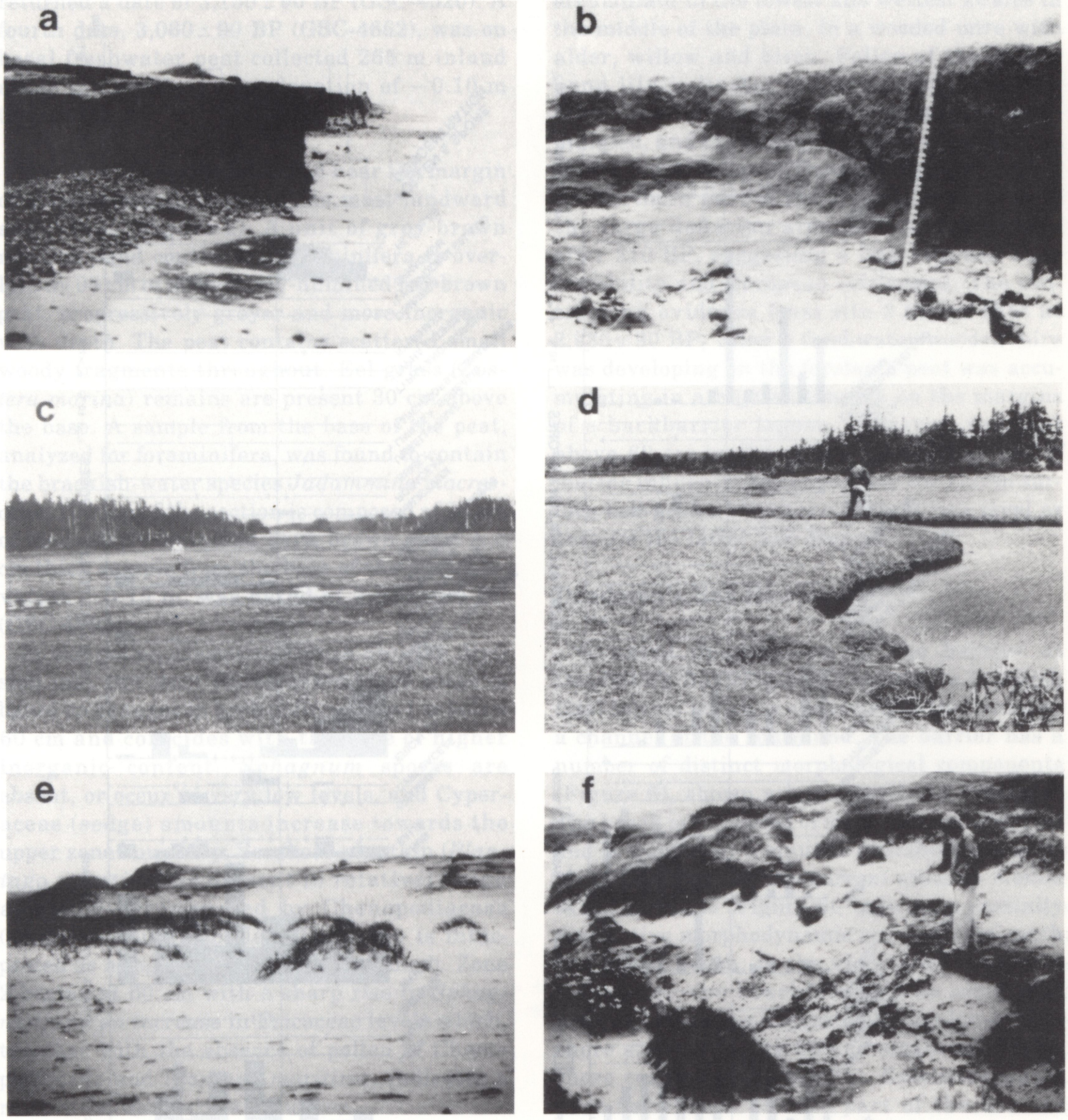
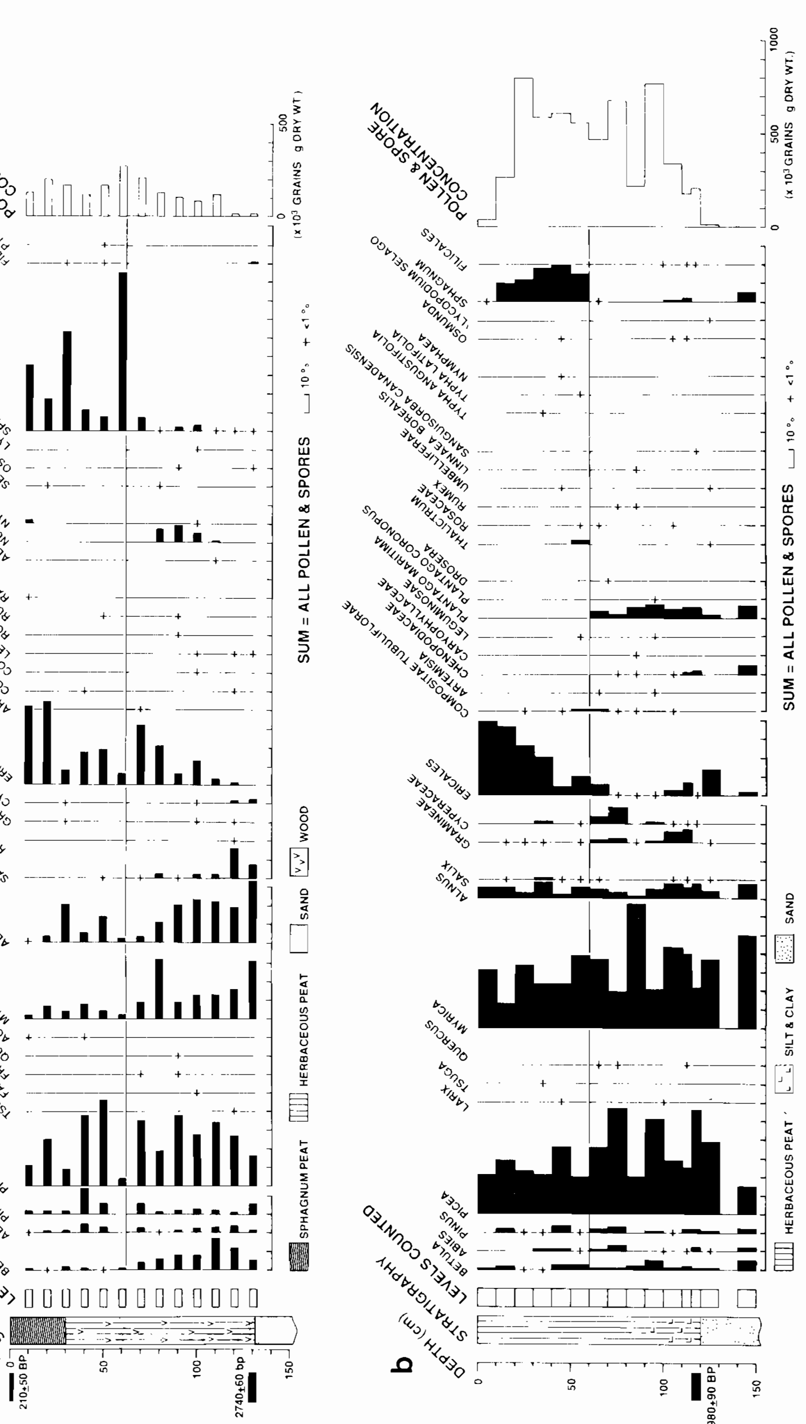


Figure 4. Photographs of locations discussed in the text: (a) Peat exposed by wave erosion along the front of Man Point foreland, near site 1. (b) The peat at Man Point overlies indurated dune-ridge sand. (c) The sedge marsh at Deadman's Bay, near site 4, overlies flood tidal delta sediments. In the distance (looking seaward) a narrow washover channel is located between wooded washover fans. (d) The ponds at Deadman's Bay (site 4) are remnants of former shore-parallel flood channels. In the foreground, approx. 1 m of sedge peat overlies 1 m of organic-rich mud. (e) View from the beach at Cape Freels, looking towards erosional remnants of the dune ridges shown in Figure 8c. (f) Author standing on partially-buried, relict organic horizon which overlies several dune ridges at Cape Freels. The dark material below this horizon is indurated sand.

at +1.10 m elevation, returned an uncorrected date of 2,740 ± 60 BP (GSC-4509). The top 2 cm of freshwater peat, immediately below the sand sheet, at an elevation of +2.40 m, was dated at 210 ± 50 BP (GSC-4604). At a nearby beach exposure (Figure 2) a basal sample 1 cm thick


a
DEPTH (cm)
STRATIGRAPHY
LEVELS COUNTED
210±50 BP
2740±60 bp
POLLEN & SPORE CONCENTRATION
(x 10³ GRAINS g DRY WT.)
SUM = ALL POLLEN & SPORES
10 % + <1 %
SPHAGNUM PEAT
HERBACEOUS PEAT
SAND
WOOD
b
2980±90 BP
HERBACEOUS PEAT
SILT & CLAY
SAND
BETULA
ABIES
PINUS
PICEA
TSUGA
FAGUS
FRAXINUS
QUERCUS
ACER
MYRICA
ALNUS
SALIX
RHUS
GRAMINEAE
CYPERACEAE
ERICALES
ARTEMISIA
LARIX
CHENOPODIACEAE
CARYOPHYLLACEAE
LEGUMINOSAE
PLANTAGO MARITIMA
PLANTAGO CORONOPUS
DROSERA
THALICTRUM
ROSACEAE
RUMEX
RANUNCULACEAE
ALISMA
NUPHAR
NYMPHAEA
SELAGINELLA
OSMUNDA
LYCOPODIUM SELAGO
SPHAGNUM
FILICALES
PTERIDIUM
UMBELLIFERAE
LINNAEA BOREALIS
SANGUISORBA CANADENSIS
TYPHA LATIFOLIA
TYPHA ANGUSTIFOLIA
COMPOSITAE TUBULIFLORAE
COMPOSITAE LIGULIFLORAE

of freshwater peat at +1.14 m elevation returned a date of 3,150 ± 90 BP (GSC-4520). A fourth date, 3,060 ± 90 BP (GSC-4662), was on basal freshwater peat collected 265 m inland along the profile, at an elevation of −0.10 m (Figures 2, 3).

Site 2 This site is located near the margin of a sedge marsh, close to the most landward sand ridge (Figure 2). A unit of grey-brown medium sand containing foraminifera is overlain by 95 cm of moderately-humified red-brown peat, progressively greyer and more inorganic with depth. The peat contains scattered small woody fragments throughout. Eel grass (*Zostera marina*) remains are present 30 cm above the base. A sample from the base of the peat, analyzed for foraminifera, was found to contain the brackish-water species *Jadammina macrescens*. The top of the section is composed of 25 cm of moderately-humified dark brown peat. A 5 cm thick sample from the base of the peat, elevation −0.15 m, was dated at 2,980 ± 90 BP (GSC-4592).

In the pollen diagram (Figure 5b), the division into two local pollen assemblage zones is based on changes in herb pollen. Zone 1 is below 60 cm and coincides with the zone of higher inorganic content. *Sphagnum* spores are absent, or occur at very low levels, and Cyperaceae (sedge) amounts increase towards the upper zone boundary. Seashore plantain (*Plantago maritima*) is present in relatively high amounts, accompanied by Chenopodiaceae (goosefoot family) pollen. This zone is interpreted as a high salt-marsh environment. Zone 2 begins at 60 cm with a sharp rise in *Sphagnum* and an increase in Ericaceae levels which, together with the absence of pollen of Chenopodiaceae and *Plantago maritima*, indicates a removal of the marine influence.

Evolution of the Man Point Foreland The beach and dune-ridge foreland was constructed prior to 3,150 ± 90 BP. The variation in dates supports the hypothesis that peat first began to accumulate in the lowest and wettest swales in the middle of the plain, in a wooded mire with alder, willow and birch. Pollen of the yellow pond lily indicates the presence of shallow pools. The mire spread laterally as peat accumulated, and the eutrophic status declined as a raised bog developed. The sand sheet overlying the northern part of the bog was derived from the large deflation area, and was deposited after 210 BP, suggesting a link between dune instability and European settlement. The contrasting evidence from site 2 shows that at 2,980 ± 90 BP, when a freshwater wooded mire was developing on the foreland, peat was accumulating in a high salt marsh on the margins of a backbarrier lagoon. However, the peat above 60 cm in the core accumulated free of marine influence, either because the marsh surface had grown above the highest tide level or because the latter had dropped.

Figure 5 *(facing page)*. Pollen diagrams from contrasting settings at Man Point. (a) Section through freshwater peat overlying beach/dune ridges at site 1. An early wooded phase was followed by a transition to a nutrient-poor raised bog. (b) Core through freshwater peat into salt-marsh peat in the former backbarrier lagoon, at site 2. Early peat accumulation was in a high salt marsh, characterized by pollen of seashore plantain (*Plantago maritima*), a typical component of high salt marsh associations on the island. Other indicators of salt marsh conditions are Chenopodiaceae pollen and foraminifera.

Deadman's Bay Barrier

General description The barrier at Deadman's Bay (Figure 1) encloses a brackish tidal lagoon which is connected to the ocean by a channel at the south end. The barrier has a number of distinct morphological components (Figure 6), shown schematically in Figure 7. The beach is composed of mixed sand and gravel and is fronted by a sinuous nearshore bar complex. This, and the rip-current systems visible in the airphoto (Figure 6), indicate a partially dissipative morphodynamic state. At the south end of the beach, in the vicinity of the active tidal inlet, the beachface may be somewhat more reflective (as suggested by the lower foreshore step on Figure 8b and small-scale foreshore cusping in Figure 6a). Extensive washover flats occur on this part of the barrier (Figures 6 and 8b). An extensive flood delta occurs adjacent to the present inlet and the most recent southward migration of the inlet has produced a number of shore-parallel channels on the lagoon side of the barrier to the north (Figure 6).

Profile 8a (Figure 8a), located just north of site 4 (Figure 6) shows dunes up to +4 m. The terminal lobe of a narrow washover fan, located between older vegetated washover sheets, is composed of sand with some fine gravel. The lobe is spread across sedge marsh overlying

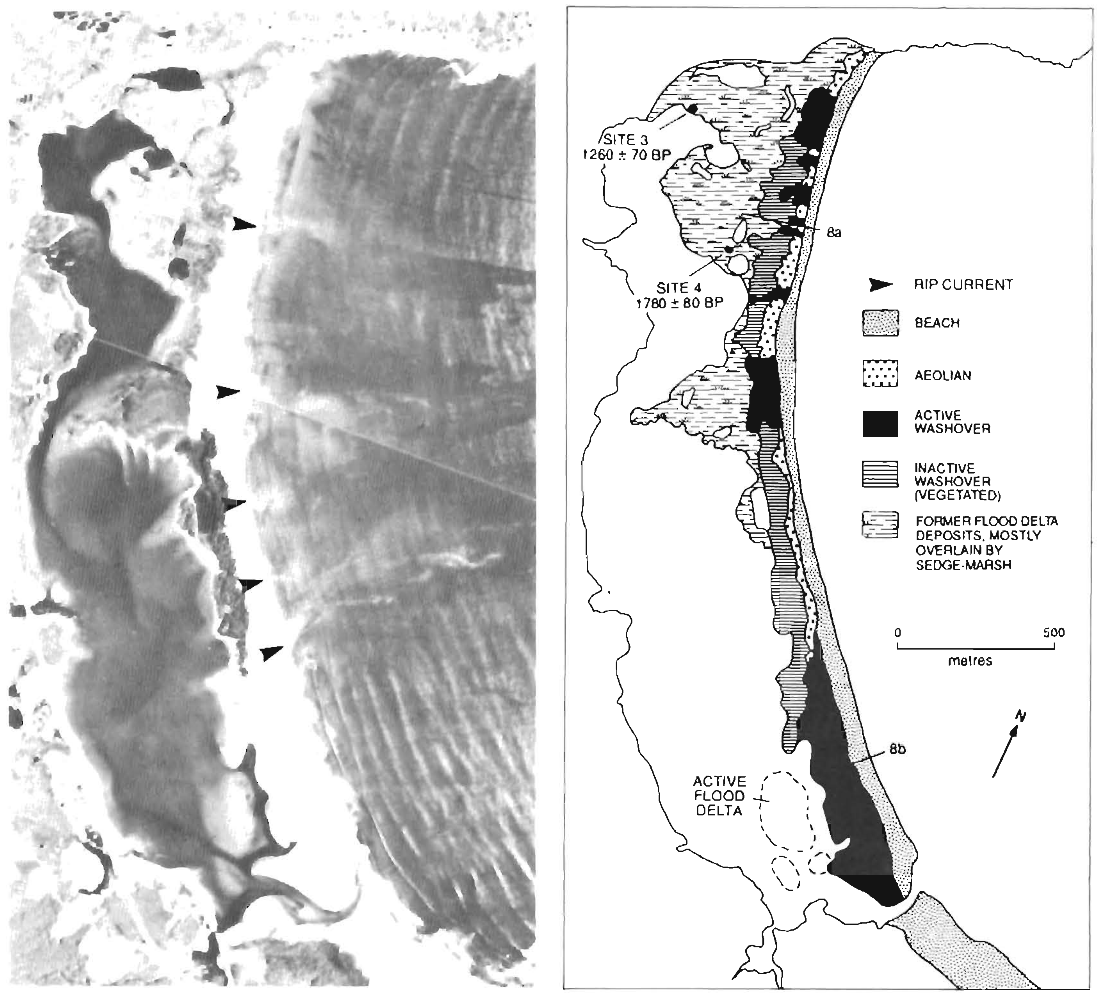


Figure 6. Air photograph of the barrier at Deadman's Bay, with an interpretative diagram showing locations of sampling sites and radiocarbon dates. From parts of photographs nos. NFA31090-43 and NFA 31088-170, Newfoundland and Labrador Department of Forest Resources and Lands, 1976-06-27.

flood tidal delta sediments. Profile 8b, located close to the inlet (Figure 6), includes the lower foreshore step referred to above, a contemporary storm beach with crest elevation just above +2 m, and an active washover sheet extending landward to a steep slipface at the lagoon.

Flat-lying areas of sand at elevations up to +0.7 m, mainly on the northern half of the barrier, are interpreted as relict flood-delta deposits. They are overlain by up to 1 m of sedge peat (Figure 4c) which supports a sedge/cinquefoil (*Carex*/*Potentilla*) association, with minor amounts of sweet gale. The ponds on the barrier (Figure 4d) are remnants of formerly more extensive flood-delta channels which extend down to −0.6 m. They contain extensive stands of bulrush (*Scirpus validus*). Where channels have been infilled they contain up to 0.6 m of fibrous sedge peat, in places overlying about 1 m of organic-rich mud.

Thick spruce woodland is developed on stabilized coalesced washover fans of sand and gravel which partly overlie the flood-delta deposits (Figures 6, 7). A dune ridge vegetated by American beach-grass (*Ammophila brevili-*

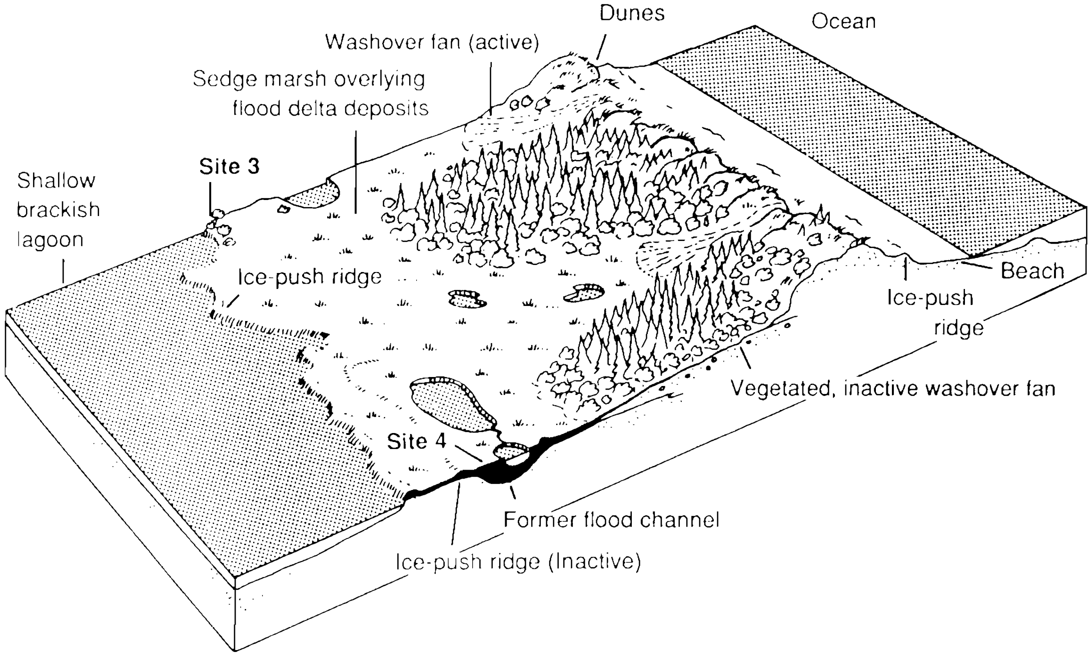


Figure 7. Schematic illustration showing major morphological elements of the barrier at Deadman's Bay.

gulata) with American dune-grass (*Elymus mollis*) and patches of scrubby spruce, stretches along the backshore. The eroding dune front is penetrated in several places by narrow active washover channels which extend landward between lobes of the older inactive fans. Sandy lobes associated with these active channels extend to the sedge marsh in places, as do two more extensive washover sheets, which are spreading sand and gravel onto the sedge marsh in the northern half of the barrier (Figure 6).

Site 3 At this site, located on the former flood-delta deposits (Figure 6), well-sorted fine-medium sand is overlain by 14 cm of poorly-humified orange-brown sedge peat with some disseminated fine sand and a 5 mm clay layer at its base. Samples from the base of this zone analyzed for foraminifera were barren. The overlying unit is 48 cm of very dark brown well-humified herbaceous peat with scattered woody remains, including a layer of rooted stumps in the lower 20 cm. The present vegetation is a crowberry heath. A 2 cm thick sample from the base of the organic deposit, at +0.67 m elevation, was dated at 1,260 ± 70 BP (Beta-27234).

The pollen record of this location contains three local pollen assemblage zones (Figure 9a). In zone 1, 45–62 cm, Cyperaceae amounts are high, with relatively high Gramineae (grass) amounts in the lowest two levels. *Sphagnum* amounts rise through the zone, to peak in the level immediately above the zone boundary. In zone 2, 15–45 cm, *Betula* peaks, Ericales rise throughout, and Cyperaceae and Gramineae are absent. In zone 3, 0–15 cm, Gramineae and Cyperaceae rise throughout and Ericales are high. These zones indicate that after an initial sedge marsh phase, birch woodland developed. The wooded phase was brief however, and a crowberry heath subsequently formed. The high amounts of grass pollen towards the top of the peat may be due to human clearance for pasture around the nearby settlement.

Site 4 This site is located on an infilled channel on the former flood delta (Figure 6). The stratigraphy consists of coarse sand and granules at the base, overlain by 5 cm of dark olive-grey sandy mud; 97 cm of compact dark olive-grey fibrous mud; 18 cm of reddish brown, poorly-humified, fibrous sedge peat; and 50 cm

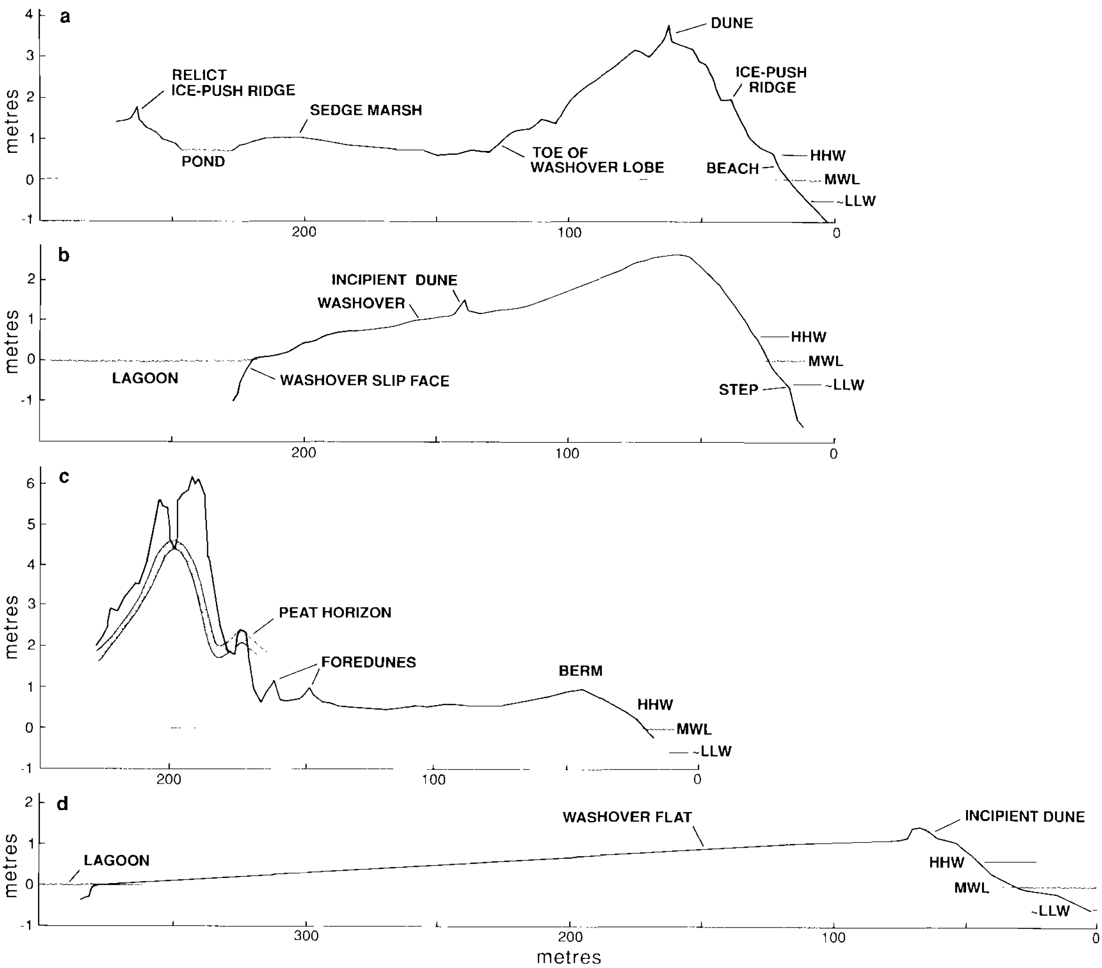
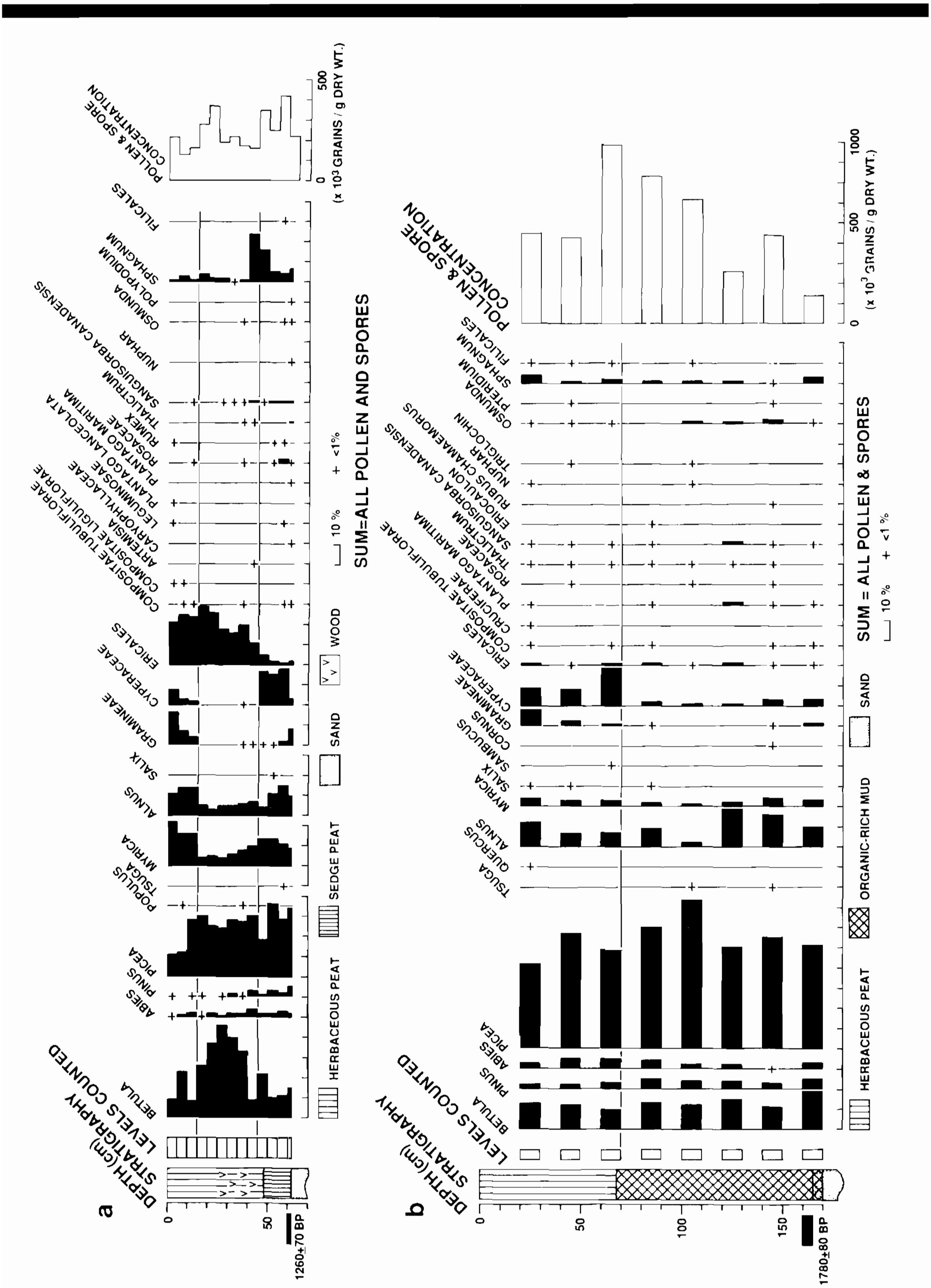


Figure 8. Surveyed profiles from Deadman's Bay (a,b), see Figure 6 for locations, and Cape Freels (c,d), see Figure 10.

of dark brown, soft, fibrous sedge peat. Organic carbon averages 15% in the peat and 7% in the underlying mud. Samples from the base of the mud were analyzed for foraminifera and found to be barren. A 5 cm thick sample from the base of the mud, at −0.56 m, was dated at 1,780 ± 80 BP (Beta-27233).

The pollen diagram for site 4 is shown in Figure 9b). Two local pollen assemblage zones can be delineated, primarily on the basis of sedge pollen amounts. Zone 1, from 70–170 cm, contains lesser amounts of sedge pollen than zone 2, 0–70 cm. *Osmunda* (flowering-fern) spores are also more abundant in the lower zone. The zone boundary corresponds with the lithological boundary between organic-rich mud and overlying fibrous sedge peat. The earlier phase of sedimentation was in a pond. The high inorganic content of the lower mud implies a greater external sediment input and suggests that the pond was connected to the lagoon, while the paucity of marine indicator pollen suggests that the lagoon was brackish to fresh. In the second phase, peat accumulated in a sedge marsh, similar to that which is present today.

Figure 9 *(facing page)*. Pollen diagrams from Deadman's Bay. (a) Where peat overlies flood delta sand (site 3). After an initial sedge marsh, woodland briefly developed on the site, followed by a return to open conditions. (b) Where organic-rich mud and peat infill a


a
DEPTH (cm)
STRATIGRAPHY
LEVELS COUNTED
BETULA
ABIES
PINUS
PICEA
POPULUS
TSUGA
MYRICA
ALNUS
SALIX
GRAMINEAE
CYPERACEAE
ERICALES
COMPOSITAE TUBULIFLORAE
COMPOSITAE LIGULIFLORAE
ARTEMISIA
CARYOPHYLLACEAE
LEGUMINOSAE
PLANTAGO LANCEOLATA
PLANTAGO MARITIMA
ROSACEAE
RUMEX
THALICTRUM
SANGUISORBA CANADENSIS
NUPHAR
OSMUNDA
POLYPODIUM
SPHAGNUM
FILICALES
POLLEN & SPORE CONCENTRATION
0 500 (x 10³ GRAINS / g DRY WT.)
1260±70 BP
HERBACEOUS PEAT
SEDGE PEAT
SAND
WOOD
10 % + <1%
SUM=ALL POLLEN AND SPORES
b
DEPTH (cm)
STRATIGRAPHY
LEVELS COUNTED
BETULA
PINUS
ABIES
PICEA
TSUGA
QUERCUS
ALNUS
MYRICA
SALIX
SAMBUCUS
CORNUS
GRAMINEAE
CYPERACEAE
ERICALES
COMPOSITAE
CRUCIFERAE
COMPOSITAE TUBULIFLORAE
PLANTAGO MARITIMA
ROSACEAE
THALICTRUM
SANGUISORBA CANADENSIS
ERIOCAULON
RUBUS CHAMAEMORUS
NUPHAR
TRIGLOCHIN
OSMUNDA
PTERIDIUM
SPHAGNUM
FILICALES
POLLEN & SPORE CONCENTRATION
0 500 1000 (x 10³ GRAINS / g DRY WT.)
0 50 100 150
1780±80 BP
HERBACEOUS PEAT
ORGANIC-RICH MUD
SAND
SUM = ALL POLLEN & SPORES
10 % + <1 %

Evolution of Deadman's Bay Barrier The woodland and marshes at Deadman's Bay cloak the various morphological elements of a transgressive barrier. Most actively-overwashing transgressive barriers in Newfoundland do not have this degree of vegetative development. A good comparison can be made, for example, with the barrier at Grand Beach (FORBES, 1984) on the Burin Peninsula, where sand and gravel washover fans slope downwards onto the sand and gravel of coalesced flood delta flats, and the sparse vegetation is limited to those associations typical of gravel beaches in Newfoundland (THANNHEISER, 1984). We believe that the Deadman's Bay barrier was in a similar condition prior to ca. 1.8 ka. Early in its development the inlet was located in the north. Later, it migrated to the south, where it appears to be fixed today. During a period when there was little change in relative sea level, former flood channels became infilled with organic-rich sediments, and sedge marsh formed on flood deltas, succeeded by woodland in places. Woodland also developed on washover sheets.

The exception to this pattern is the southern end of the barrier, near the present tidal inlet, where washover processes still control the barrier crest development. The relative importance of a reduced rate of sea-level rise versus inlet stabilization, changes in refraction patterns and associated changes in morphodynamic controls within the bay, remains unclear.

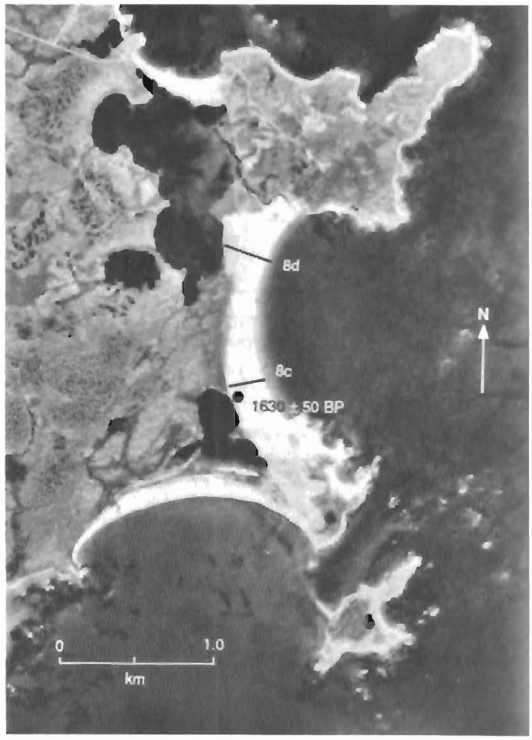


Figure 10. Air photograph of the barrier at Cape Freels, showing locations of surveyed profiles and radiocarbon-dated sample. Part of photograph no. NFA24115-2, Newfoundland and Labrador Department of Forest Resources and Lands, 1975-07-01

Cape Freels

In this area, four sandy barriers anchored to rocky headlands enclose shallow, slightly brackish lagoons (Figure 10). The two northern barriers are in an actively transgressive phase (Figure 8d). A broad, low-angle washover sheet of sand extends to the lagoon, where it ends abruptly in a steep slipface. Further seaward, the washover sand forms a thin veneer over dark-stained marsh and lagoonal sediments. Low dunes north of line 8d are interrupted by numerous blowouts where former garden plots have been abandoned to the drifting sand.

On the next barrier to the south, at the back of a wide beach, aeolian sand covers the eroded remnants of an older system of shore-parallel dune ridges (Figures 4e, 8c). The two prominent ridges which remain have crests at +4.5 m and +2.5 m. The top of the old dunes is marked by a persistent peat horizon 30 cm thick (Figure 4f). This can be traced landward of the dunes, where it merges with peat in a spruce woodland. Immediately below the compacted dry woody peat is a layer of light grey sand overlying red-brown sand over very dark red-brown to black indurated sand, with black stringers. A sample of the lowest 3 cm of peat returned a radiocarbon age of 1,630 ± 50 BP (GSC-4542). The dune ridges pre-date this by an unknown time interval. Staining and induration of sand which occurred at these relatively high elevations is identical to that which occurred at a lower level at Man Point.

flood delta channel (site 4). Here there was no wooded phase, but a transition from sedimentation in a pond to a sedge marsh.

Eastport

At Eastport in Bonavista Bay, 70 km south of Cape Freels (Figure 1), a low transgressive sandy barrier lies across a small sedge marsh traversed by a meandering sand-bed stream. The marsh surface lies between HHW, mean and large tides, and appears to be freshwater-dominated, although it is probably occasionally inundated by brackish water. A Hiller core in the marsh revealed a sequence of peats, muds and muddy sands, containing numerous freshwater macrofossils, which were deposited in a freshwater marsh with a strong fluvial influence. A sample of freshwater organic-rich mud from a depth of −3.30 m was dated at 5,490 ± 120 BP (Beta-27231).

DISCUSSION

Changes in Relative Sea Level

Radiocarbon-dated evidence from a number of sites enables us to draw some preliminary conclusions about relative sea-level changes in the region. These depend on the following assumptions. (1) That tidal range in the area has remained unchanged at about 0.8 m (mean) and 1.2 m (large tide). The range at Eastport differs by a few centimetres. (2) That freshwater peats accumulated above HHW (large tides), 0.58 m above MWL. (3) That salt-marsh peat formed between MWL and HHW (large tides). (4) That the range in tidal lagoons is (and was) identical to that of the open coast. Although deviations from these assumptions are possible (*cf.* SCOTT and GREENBERG, 1983), we take them to be reasonable working hypotheses.

The date on freshwater organic material from Eastport, at −3.30 m, suggests that MWL was below −4 m at 5,490 ± 120 BP. Although the distance of this site from the main study area is considerable, the pattern of Late Wisconsinan marine limits suggests that the sea-level history may be similar.

Salt-marsh peat at Man Point at −0.15 m, dated at 2,980 ± 90 BP, indicates MWL between −0.15 and −0.73 m at that time. Nearby freshwater peat at −0.1 m, dated at 3,060 ± 90 BP, implies that MWL was at least 0.68 m below the present. Taken together, this pair of dates from the same locality tends to show that MWL was at approximately 0.7 m below today's level at about 3 ka BP.

At Deadman's Bay, site 3, sedge peat at 0.67 m, dated at 1,260 ± 70 BP, appears to show no brackish influence, suggesting that MWL was not more than a few cm above todays level at that time. The underlying flood-delta deposits were formed before 1.3 ka BP, with a MWL which was not below the present level, and may have been higher. Also, the development of woodland at the site tends to suggest no subsequent (post 1.3 ka) rise in water level. At site 4, organic-rich mud in a former flood channel, at −0.56 m, dates to 1,780 ± 80 BP. If, when it was active, the channel was as deep as lower low water (large tides), then MWL was at least as high as the present level before 1.8 ka BP. The organic-rich sediments probably accumulated in a pond isolated from the lagoon, and the low elevation of the radiocarbon sample does not, in this setting, indicate a lower than present MWL. Viewed as a whole, the data from Deadman's Bay suggest relative sea levels very close to the present during the last 2 ka.

Figure 11 summarizes our understanding of postglacial relative sea-level changes in the region, based on the data presented above. It shows relative sea level falling from a high postglacial marine limit and passing below present sea level between 12 and 10 ka BP. The depth of the subsequent minimum is unknown at present. Relative sea level was still below −4 m at 5.5 ka BP, but reached −0.7 m within approximately 2,500 years, by 3 ka BP (an average rise of at least 1 mm/a). Our evidence suggests that local sea level has been close to the present since 2 ka BP. This is an early date for cessation of relative sea-level rise in southeastern Canada, where relatively rapid rates of contemporary rise have been considered the norm (GRANT, 1970; FORBES *et al.*, 1989). However, other evidence we have obtained recently indicates relatively stable sea levels over the past 2,000 years in the Placentia area (SHAW and FORBES, 1988; SHAW, 1989), suggesting that glacial forebulge collapse is largely completed in the eastern-most part of the island.

Coastal Evolution

In the context of Newfoundland, the northeast coast is anomalous in several respects. The coastal sediment systems in the study area are

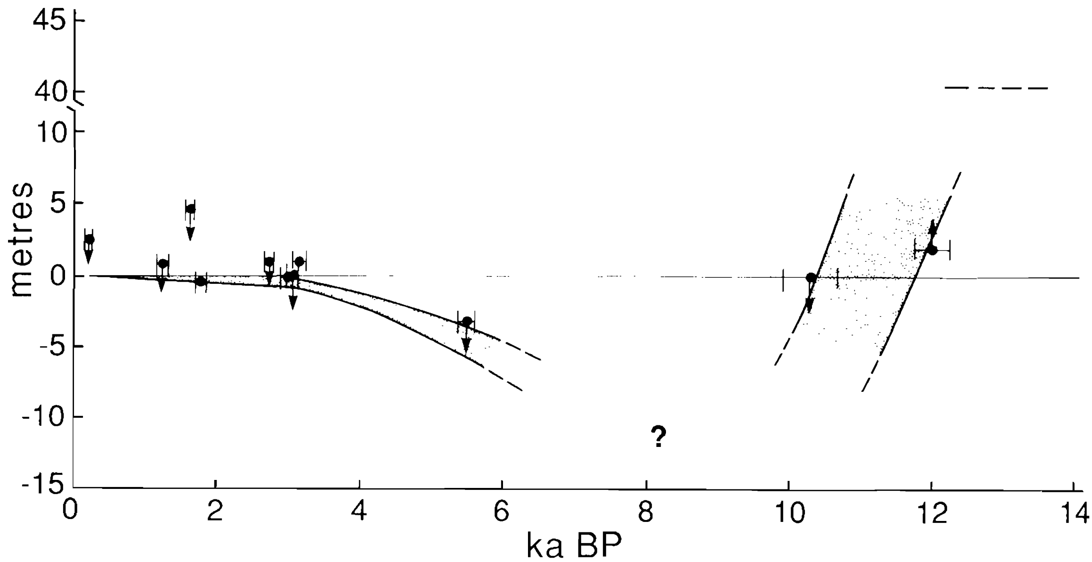


Figure 11. Relative sea-level curve for the region. The dashed horizontal line is the approximate Late-Wisconsinan marine limit (after Grant, 1980).

sand-rich, in contrast to the largely gravel-dominated barriers elsewhere on the island. In addition, we observe no major sources of sediment in the study area, whereas elsewhere on the island substantial coastal sediment accumulations are generally located adjacent to large glacigenic sources. Furthermore, as suggested in the introduction, the relatively great thickness of peat overlying coastal deposits at Man Point contrasts with generally thinner peats observed elsewhere in Newfoundland.

Organic Deposits in the Coastal Environment The thickness and age of the Man Point peat, and of organic sediments at Deadman's Bay and Cape Freels, reflect the early attainment of a relative sea level similar to that of today. One question of importance at both Man Pont and Cape Freels is whether a significant lag occurred between dune ridge formation and the initiation of peat accumulation. The length of this interval is constrained by the rise of relative sea level. Modern beach ridges at Ragged Harbour, just north of Man Point, have crests at +1.4 m, with the lowest swale at 0.5 m. The crests of a modern dune ridge at Shalloway Brook, 8 km to the south, are about +4 m. Using these as analogues, the ridges at Man Point (with crests at about +2 m, and the lowest swales at 0 m), may have formed when relative sea level was between −0.5 m and −2.0 m relative to present datum, probably not earlier than about 4 ka BP. This implies a hiatus before peat accumulation of less than 1,000 years (possibly much less).

The dunes at Cape Freels are higher than those at Man Point, and organic accumulation may have been correspondingly hindered there, raising the possibility that these dunes are actually as old as those at Man Point. The presence of indurated sand below the peat at both sites raises an additional possibility, namely that induration led to a perched water table and peat accumulation.

Factors Favouring Sand Abundance Is the predominance of sand on the northeast coast somehow due to the early attainment of a relative sea level similar to that of today? There is insufficient information on relative sea-level change across the island to isolate this as a factor. However, there are other formerly-glaciated areas where sandy barrier systems occur, and where patterns of relative sea-level change differ from that in the study area. In Ireland, for example, such systems are located in both the northwest (SHAW, 1985), where relative sea level was close to the present by the mid-

Holocene (CARTER, DEVOY and SHAW, 1989), and the southwest (CARTER *et al.*, 1989), which has been submerging throughout the Holocene. However, in both these regions, the earliest phases of progradation were often gravel-dominant, so that coastal dunes up to 30 m high rest on gravel beach ridges. Furthermore, where glacigenic deposits are being eroded today, they feed sediment onto gravel-dominated systems, such as the beach-ridge foreland at Derrymore in County Kerry (TAYLOR *et al.*, 1986). These comparisons suggest that in formerly glaciated terrain, where glacigenic sediment is a major source for barrier construction, progradation may occur whether relative sea level is stationary or slowly rising (FORBES *et al.*, 1989), and that the early phases of progradation tend to be gravel-dominated. On the northeast coast of Newfoundland, we observe little or no exploitation of glacigenic sources but considerable remobilization of sediment from pre-existing systems. Therefore, given the sand-dominance and the background of rising relative sea level, we postulate that glacigenic sources which may have supplied sand to the coast lay on the present inner shelf. In addition, the granitic bedrock in the area may have been conducive to production of large quantities of sand.

Physiographic setting may also play a role in determining the abundance of sand. In the St. George's Bay area of southwest Newfoundland (Figure 1 inset), the major coastal barriers are composed of gravel beach ridges (SHAW and FORBES, 1987). However, the eroding bluffs which have sustained these systems comprise a wide range of sediment types, including glacial till, proglacial sand and gravel, and glaciomarine mud (MacCLINTOCK and TWENHOFEL, 1940; BROOKES, 1974). The sand component of the eroded bluffs forms submerged barrier platforms up to 40 m thick, with seaward lips at about 25 m water depth. The gravel beach ridges are superimposed upon these platforms. Because of the presence of deep basins close to shore in St. George's Bay, the sand component has been captured in an effective nearshore sink. By contrast, the shallow inner shelf in the study area has little relief. We suggest that the sand component, removed from an unknown glacigenic source somewhere on the inner shelf, may have moved onshore with the transgression.

Coastal Development and Episodic Sand Dispersal Wave refraction analyses show that, north and west of the compartment at Deadman's Bay (which receives small amounts of energy), net littoral sediment transport is toward the northwest. Man Point is located near the end of this transport corridor, at a location where waves refracted around the Penguin Islands approach from offshore. This implies that the location of the foreland is controlled by refraction around the islands. With relative sea level 5 m below present, the Penguin Islands would have been linked to the mainland, forming an embayment. We suggest that as relative sea level rose during the Holocene, reworked glacigenic sediment (mainly sand), was moved generally westward across the gently-sloping inner shelf, to accumulate in an embayment in the vicinity of the present Penguin Islands. The destruction of this setting, accomplished during the period of the last few metres of relative sea level rise, resulted in the release of a pulse of sandy sediment which accumulated in the Man Point foreland, the location of which was determined by wave refraction around the islands.

The Deadman's Bay sediment body probably became isolated from the northwest-directed littoral drift at an early stage, as the headland to the northwest gained prominence. Thereafter the compartment retained an essentially finite sediment package, with very little additional supply. During the last several thousand years, when sea level has generally been stable, the barrier has been mainly stationary. This type of response to relative sea level has been described elsewhere in the coastal literature (for example, RAMPINO and SANDERS, 1981).

Recent Trends All three sites are now in various states of disequilibrium. The cause, whether increased storminess (see NEU, 1984), rising sea level (FORBES *et al.*, 1989), changes in sea-ice regime, or other factors, remains uncertain. At Cape Freels, wind action is eroding both the oldest dune ridges and the later, vegetated, sand cover. Overwashing is occurring on a large scale, particularly on the northern barriers (Figure 8d), but also through a breach in the dunes immediately south of line 8c (Figure 10). At Deadman's Bay, the south end of the barrier is an area of active washover (Figures 6, 8b). The Man Point foreland appears to be in disequilibrium with the present wave climate. It is undergoing erosion in the south, where washover sand and gravel is strewn across the bog, and indurated sand is exposed in the intertidal zone. To the northwest, a mixed sand-gravel storm beach is located in front of the deflation zone (Figure 2). Sediment appears to have moved along this beach toward the northwest, past several headlands and into Ragged Harbour (Figure 1), where a prograded series of beach ridges has formed within the last 100 years or so. Ragged Harbour may become the ultimate sink for much of the Man Point sediment, especially if a postulated rise in global sea level becomes a reality.

SUMMARY AND CONCLUSIONS

New evidence points to a complex pattern of relative sea-level change on the northeast Newfoundland coast and to early cessation of the Late-Holocene transgression in the area. Organic deposits on dune ridges at Cape Freels and Man Point reflect this pattern. Contrasting organic deposits on the barrier at Deadman's Bay indirectly reflect it also, in that they overlie the elements of a formerly transgressive barrier whose switch in style may be conditioned by rates of relative sea-level rise, but also by other factors. We suggest that the abundance of sand in the study area may arise from unidentified sources on the inner shelf and be related to shallow shelf topography and granitic bedrock. We draw the following specific conclusions relating to the three primary objectives of the paper:

(1) Evidence from the northeast coast of Newfoundland shows that relative sea level fell below present datum between 12 and 10 ka BP, reached an undetermined minimum, and subsequently rose. It was still below -4 m at 5.5 ka BP, but reached -0.7 m by about 3 ka BP, and ~ 0 m circa 2 ka BP.

(2) The early attainment of sea level close to the present has resulted in the accumulation of organic deposits on top of coastal sediment bodies at a minimum of three locations. These include Man Point, where a prograded beach- and dune-ridge foreland is covered by a thick bog (up to 2.9 m deep), Deadman's Bay, where the stabilized elements of a transgressive barrier are mantled by bog, sedge marsh and woodland, and Cape Freels, where an extensive organic horizon caps early dune ridges.

(3) In contrast to other parts of Newfoundland, large quantities of sand have accumulated in a region where glacigenic sources of sediment are not apparent. We suggest that the source lay on the inner shelf, and that reworked sand was moved onshore during the transgression.

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RESUMEN

Las playas de arena y las dunas son las formas predominantes en la costa al nordeste de "Newfoundland," entre la Bahia de Bonavista y Hamilton Sound. Esto contrasta con la mayor parte dle resto de la isla, donde la degradación costera conduce principalmente a la formación de playas de gravas. En Man Point, próximo a Musgrave Harbour, se extiende una zona de playas y dunas cubierta parcialmente por una capa de turbas de aproximadamente 2.9 m de espesor. La datación realizada a partir de la turba basal estima que dicha turba es de 3150 ± 90, 3060 + 90 y 2740 ± 60 años antes de la fecha actual. La base de la marisma tierra adentro respecto a la barra está datada en el año 2980 ± 90 antes de la fecha actual. En la Bahia de Deadman, donde deltas relictos y canales en la parte norte del sistema de barras son muestra del proceso transgresivo, se datan los depósitos orgánicos en dos puntos diferentes, entre el 1780 ± 80 y 1260 ± 70 antes de la fecha actual. Una extensa capa de turba, parcialmente enterrada, que se encuentra cubriendo antiguas dunas en el cabo Freels se ha datado en el 1630 + 50 antes del año actual. Asimismo, localizamos el núcleo de una barra en Eastport, área de la Bahia de Bonavista, donde la materia orgánica a la −3.3 m se dató como perteneciente al año 5490 ± 120 antes de la fecha actual. De los datos obtenidos, tanto en estas como en otras localizaciones, se desprende que hace 12 a 10 ka, el nivel medio relativo del mar descendió hasta alcanzar un minimo. Durante la siguiente transgresión llegó a estar por debajo de la 4 m hacia el 5.5 ka, llegando sin embargo a la 0.7 m hacia el 3 ka. La terminación, relativamente rápida, de la transgresión holocénica condujo a la estabilización de algunos depósitos costeros en dicho área, quedando éstos cubiertos por bosques, fangos y pantanos. Cabe destacar la aparente ausencia de caracteristicas glaciocénicas, tales como aquéllas que han dado lugar a la aparición de sistemas costeros degradados en otras zonas de la isla y que sugieren una evolución postglacial semejante para otros sistemas sedimentarios de la región.—*Department of Water Sciences, University of Cantabria, Santander, Spain.*

RÉSUMÉ

Dans la partie NE du Newfoundland, entre la baie de Bonavista et Hamilton Sound, s'étendent plages et dunes de sable. Ces ensembles contrastent avec les autres parties de l'île où les formes de progradation sont des cordons de graviers. A Mean Point, près de Musgrave Harbour, d'importants cordons de plage sont recouverts par de la tourbe pouvant atteindre 2,9m d'épaisseur. Des datations au radiocarbone de la base de la tourbière donne 3150 ± 90 BP, 3060 ± 90 BP et 2740 ± 60 BP (non ajustée). La base de la tourbière du pré salé de la barrière située vers la terre est datée 2980 + 90 BP. Dans la baie du Deadman, deltas de marée moribonds, chenaux de flot et éventails de ressuyage au nord du système de barrières prouvent l'arrêt d'une phase transgressive. Les dépôts organiques de deux sites sont datés 1780 ± 80 BP et 1260 ± 70 BP. A Cap Freels, une tourbière étendue et partiellement enfouie qui recouvre d'anciens cordons dunaires est datée 1630 ± 50 BP. On se reporte aussi à un sondage dans un marais d'arrière barrière à Eastport (W de la baie de Bonavista), où le matériau organique d'eau douce est daté à −3,3m 5490 ± 120 BP.
Tout ceci suggère que entre 12 et 10 Ka BP, le niveau relatif de la mer était au dessous de l'actuel. Il est descendu jusqu'à un niveau indéterminé. Au cours de la transgression subséquente, il était encore à −4m à 5,5 Ka BP, mais atteignait −0,7m vers 3Ka BP. Avec la fin relativement précoce de la transgression Holocène, des dépôts littoraux furent stabilisés et recouverts de forêts, marais et marécages. On notera l'absence apparente de sources d'origine glaciaire semblables à celles qui fournissent le matériau de progradation du système côtier partout sur l'île. On suggère que l'évolution postglaciaire a suivi un cours similaire à ceux des corps sédimentaires côtiers de la région.—*Catherine Bressolier (Géomorphologie EPHE, Montrouge, France).*

ZUSAMMENFASSUNG

Strände und Küstendünen sind bekannte Merkmale der Nordostküste Neufundlands. Im Gegensatz dazu dehnt sich in den meisten anderen Teilen der Insel die Küste durch Kies- und Sandbänke aus. Nahe Musgrave Habour befindet sich ein ausgedehntes Strand- und Dünenkettenvorland, das mit einer 2,9 m dicken, ca. 2740 bis 3150 Jahre alten Schicht Süßwassertorf bedeckt ist. Die Basis dieser Marschablagerungen landwärts der Küstenlinie ist ca. 2980 Jahre alt. Bei Deadman's Bay befindet sich am Nordende eines Strandwalles ein Komplex verlandender Tidedeltas, Rinnen und Schwemmfächer, der den Beweis einer Transgressionsphase verhindert. Dort vorhandene organische Ablagerungen sind 1780 bzw. 1260 Jahre alt. Ein ausgedehntes, teilweise von alten Dünenketten eingebettetes Moorgebiet bei Cape Freels ist ca. 1630 Jahre alt. Berichtet wird auch über eine Bohrung im rückwärtigen Bereich eines Strandwalles, wo ca. 5490 Jahre alte Süßwassertorfe in 3,3 m Tiefe anstehen. Diese und andere Aussagen deuten darauf hin, daß der Meeresspiegel zwischen 12000 und 10000 vor heute auf ein nicht bestimmbares Niveau abgesunken ist. Während der nachfolgenden Transgression lag der Meeresspiegel vor 5500 Jahren unterhalb −4 m, erreichte aber um 3000 vor heute etwa 0,7 m. Mit dem relativ frühen Ende der holozänen Transgression wurden in diesem Bereich die küstennahen Ablagerungen stabilisiert und von Wäldern, Marschen und Sümpfen überlagert. Auffälligerweise fehlen eiszeitliche Ablagerungen, die sonst überall auf der Insel die Materialquelle für vorrückende Küsten bilden. Ein ähnlicher Verlauf der nacheiszeitlichen Entwicklung wird jedoch vermutet.—*Reinhard Dieckmann, WSA Bremerhaven, FRG.*