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QUATERNARY GEOLOGY AND LANDSCAPE CHANGE, PORCUPINE STRAND, LABRADOR

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ABSTRACT

Fieldwork was carried out along Porcupine Strand, central Labrador coast, to verify the airphoto surficial geology interpretation of NTS map areas 13H/14E and W and 13I/3 W and to examine the postglacial changes in sea level and the history of aeolian deposition. During the late Wisconsinan glaciation, the Laurentide Ice Sheet crossed the Labrador Coast and extended offshore. The pattern of ice retreat suggests that Porcupine Strand may have been deglaciated as early as 12 000 years BP; however, in adjacent marine troughs, ice persisted until 8000 to 7000 years BP. Glaciofluvial sand and gravel, deposited in front of the retreating ice sheet, constitute a large proportion of the surficial sediment in the map area. Coastal exposures, extending tens of kilometres along the Strand, reveal thick deposits of glaciomarine mud and sand overlying rare occurrences of till and bedrock. Glaciomarine sediments were deposited by glacier-fed meltwater streams onto the glacio-isostatically depressed coastal lowlands. Raised shorelines were identified up to 116 m above present sea level. Fossiliferous mud and sand underlie much of the coastal lowlands, and in places is obscured by bog. Coastal hills and upland surfaces consist mostly of exposed or concealed bedrock having only minor till cover.

Organic samples (shells, driftwood) from raised marine sediments were collected for radiocarbon dating to determine the broad timing of postglacial sea-level change. In particular, fieldwork focused on evidence for recent coastal submergence, which at one location has been responsible for shoreline retreat and apparent burial of rooted tree stumps. Aeolian deflation of emerged glaciomarine sand has resulted in large blowouts, particularly at Sandy Point, and the development of dune systems discontinuously along the entire Strand. Buried soils and peaty horizons in the dunes indicate cycles of stabilization and reactivation. Abundant but disturbed (due to deflation) evidence for prehistoric occupation of the dunes over the last 7000 years suggest a close connection between human land use and dune stability.

INTRODUCTION

Porcupine Strand, southeastern Labrador, is a 40-km-long sandy beach backed by eroding cliffs of Quaternary fine-grained sediment (Figure 1; Plate 1). It is one of the longest unoccupied sandy coastlines in eastern North America. The Strand is located 13 km northwest of Cartwright, between Groswater and Sandwich bays, and forms the eastern boundary of the proposed Mealy Mountain National Park study area (Figure 1).

Field work in the summer of 2002 had two primary objectives: (i) to ground check preliminary airphoto interpretation of surficial geology, and (ii) to investigate landscape change due, in most part, to glacio-isostatic sea-level adjustments and aeolian activity since deglaciation. Only 10 percent of the project area (NTS map areas 13H/14 and 13I/3) was accessible by foot or canoe from the coast; however, the entire shoreline from North River (Sandwich Bay) to Cape Porcupine (~25 km) and selected areas from West Bay to Sandy Cove (Groswater Bay; ~10 km) were visited (Figure 1). Two base camps were established at either end of the Strand, one at the mouth of North River, near Sandy Point, the other at Fish Cove, at the northern end (Figure 1).

The research was conducted in collaboration with the Porcupine Strand Archaeological Project, the overall aims of which are to reconstruct the sequence of cultural occupation; to explain economic and social adaptations and interactions of the various populations (Maritime Archaic Indian, Intermediate Indian, Recent Indian, Pre Dorset, Groswater Palaeo Eskimo, Dorset Palaeo Eskimo, and Historic Inuit); and to determine the relationships between those populations and the environment in which they lived. Two surficial

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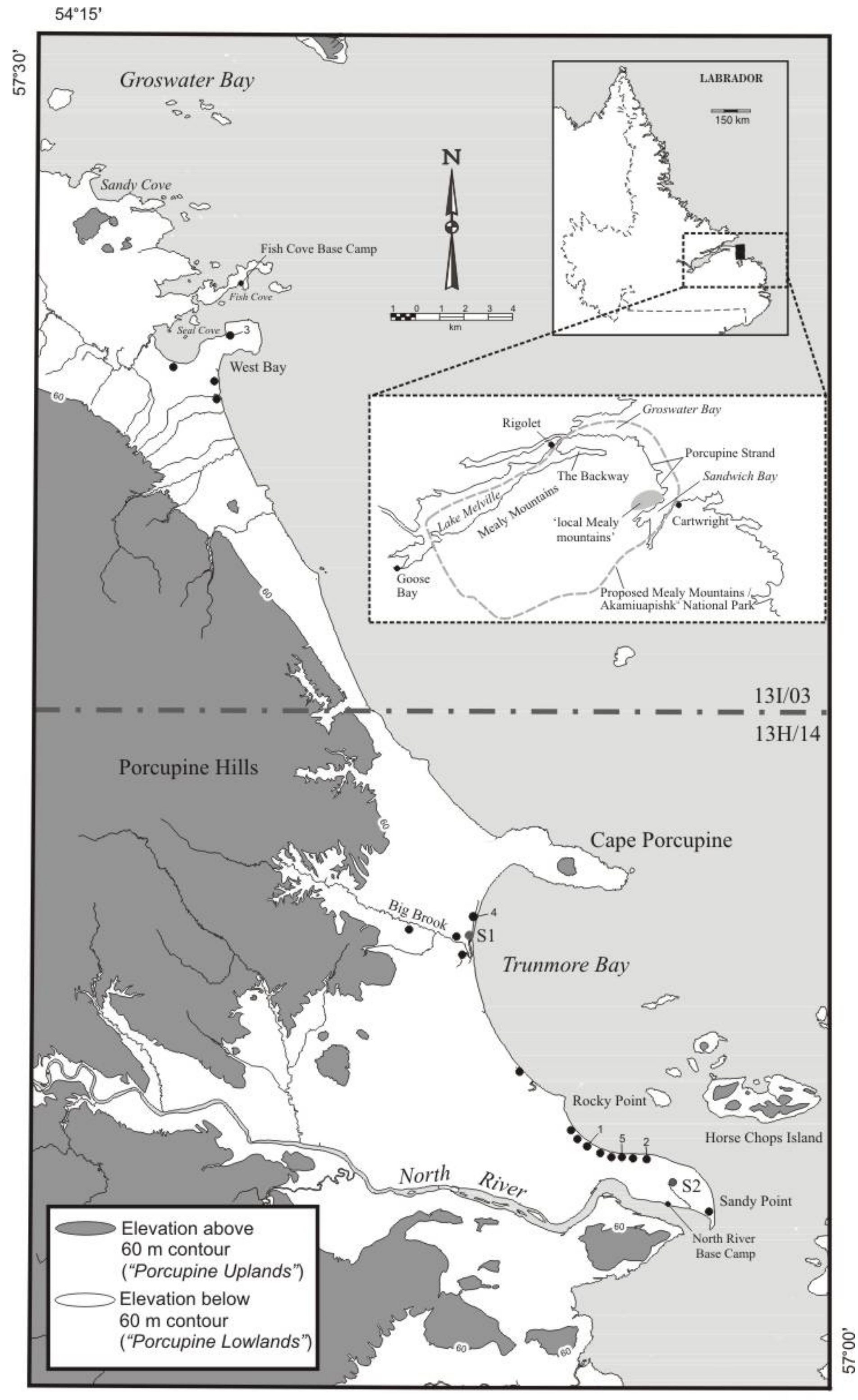


Figure 1. *Map of Porcupine Strand within the proposed Mealy Mountain National Park study area. The 60 m contour roughly separates the Porcupine Uplands and Porcupine Lowlands. Circles represent sites where coastal sections were measured. Sections S1 and S2 are reproduced in Figures 3 and 4. The numbered circles correspond to the locations of samples submitted for radiocarbon dating described in Table 2. The 'local Mealy Mountains' is an unofficial name (Rogerson, 1977) and is different from the Mealy Mountains farther inland.*

Plate 1. *View north along Porcupine Strand to Cape Porcupine, 3 km in near background. The Porcupine Hills (Uplands) are visible in the distance. They rise to 350 m asl above the coastal lowlands. The coastal cliffs backing the modern shoreline are composed of mud and sand. Active retreat of coastal cliffs is indicated by undercutting and collapse of the vegetated surface.*

geology maps are being produced for the Geological Survey of Newfoundland and Labrador and will be released as open files in the spring of 2003.

BACKGROUND

PHYSIOGRAPHY

The physiography of the Porcupine Strand region is divided into two main zones; the Porcupine Lowlands and the Porcupine Uplands (Figure 1; Rogerson, 1977). The Porcupine Lowlands form a broad plain extending 5 to 10 km inland of the modern shoreline and up to 60 m above sea level (asl). The plain is composed of glacial outwash, consisting primarily of sand and gravel, and is underlain by marine mud. The coastal lowlands are backed by the Porcupine Uplands that rise to 350 m asl in the Porcupine Hills and up to 670 m in the uplands along the north shore of Sandwich Bay, informally called the 'local Mealy Mountains' by Rogerson (1977). They are distinct from the Mealy Mountains that are located farther to the west and rise to 900 to 1100 m asl (Figure 1).

BEDROCK GEOLOGY

Porcupine Strand lies within the Grenville Province, the youngest of the five structural geological provinces of Labrador (Wardle *et al*., 1997). Grenville Province rocks display evidence of a long history of mountain building, igneous magmatism and deformation (Gower, 1996; Davison, 1998). Porcupine Strand is located in the Groswater Bay terrane. These rocks were strongly deformed during the late Mesoproterozoic Grenville Orogeny (1.3 to 1.0 Ga) and include grandioritic gneiss, granite, diorite and quartz diorite, along with intrusions of gabbronorite and anorthosite (Gower, 1996).

The rest of the region's bedrock is older (~1.6 Ga), and is also highly deformed. The lowlands are underlain by grandioritic gneiss that also forms the prominent headlands along the Strand (e.g., Cape Porcupine). Gabbronorite and anorthosite protrude through the grandioritic gneiss to form the Porcupine Hills and the 'local Mealy Mountains' (Rogerson, 1977; Gower, 1996). The eastern edge of the 'local Mealy Mountains' is made up of diorite and quartz diorite, whereas granitic rocks cropout on the south shore of Groswater Bay, north of Fish Cove (Gower, 1996).

ECONOMIC GEOLOGY

No significant mineral occurrences have been identified in the bedrock of this area; however, sand containing heavy minerals has been identified in the beach placers of northern Porcupine Strand (Emory-Moore and Meyer, 1992). This medium- to coarse-grained sand is found on the modern beach and in low-elevation terraces (< 10 m asl) and contains concentrations of titanium (up to 7.4%) and iron (average 30.4%). In contrast, glaciofluvial sand and gravel in higher elevation terraces (> 10 m asl) are less extensive, and have lower mineral concentrations. The difference in mineral concentrations between the two deposits may relate to sediment supply and coastal emergence rates (Emory-Moore and Meyer, 1992).

PREVIOUS WORK

During the last glaciation (late Wisconsinan), the eastern margin of the Laurentide Ice Sheet advanced across the present Labrador coastline onto the continental shelf (Josenhans *et al.*, 1986; Vincent, 1989). Ice flow diverged around local topographic barriers, such as the Mealy Mountains (Gray, 1969), and was influenced near the coast by marine troughs such as Sandwich and Groswater bays (Rogerson, 1977). On the basis of differential weathering and glacial geomorphology, Rogerson (1977) argued that the summit of the 'local Mealy Mountains' remained ice-free and consequently, ice may have extended only a few kilometres offshore. Ice-flow indicators, such as striae, suggest that coastal uplands, such as the Porcupine Hills, exerted topographic control on local ice movement, but it is uncertain whether this occurred during a restricted glacial maximum

(Rogerson, 1977) or upon deglaciation, when ice was thinner.

The pattern of ice retreat suggests early deglaciation of Porcupine Strand at about 12 000 years BP and persistence of ice in adjacent marine troughs, as late as 8000 years BP in Sandwich Bay and 7000 years BP in The Backway, outer Groswater Bay (Rogerson, 1977). Farther inland to the southwest, a regionally extensive, glacial still-stand is suggested by the prominent Paradise Moraine. Although the composition and genesis of the moraine is poorly understood, with elements described as hummocky till (Fulton and Hodgson, 1979) and glaciofluvial outwash (McCuaig, 2002a), it is thought to extend as far northeast as Sandwich Bay. Initially, the moraine was interpreted to represent the terminal position of the Laurentide Ice Sheet, based on a bulk sediment radiocarbon date of 21 000 years BP from a nearby lake basin (Vincent, 1989); however, subsequent resampling and dating by King (1985) provided a radiocarbon age of 10 000 years BP, suggesting that the earlier sample was contaminated by older carbon. The revised age of the moraine suggests that the associated Laurentide ice margin may indeed have extended to the Labrador coast farther north in Sandwich Bay and may correlate with proposed deglacial ice margins mapped by Rogerson (1977) across Porcupine Strand.

Upon ice retreat, the sea inundated the glacio-isostatically depressed Labrador coast. Marine limits reach elevations of 152 m asl in southern Labrador, 75 m asl in outer Groswater Bay and 135 m asl in inner Lake Melville (Clark and Fitzhugh, 1991). The spatial variation in the elevation of marine limit is due to ice configuration (differential loading of the crust) and asynchronous ice retreat (postglacial crustal rebound) across the region. It is not surprising that a marine limit of 116 m asl from Porcupine Strand (Rogerson, 1977) is higher than the one identified from outer Groswater Bay (75 m asl; Clark and Fitzhugh, 1991) because the latter was deglaciated several millennia later.

The proposed postglacial sea-level history for the region indicates an exponential decline in the rate of sea-level fall from establishment of marine limit to present, typical of a type-A sea-level curve that characterizes most of coastal Labrador (Figure 2; Clark and Fitzhugh, 1991). The relative sea-level history of the region is poorly documented, however, consisting entirely of data that provide only upper (archaeological sites) or lower (geological samples) constraints on sea-level position (Figure 2).

METHODS

Prior to fieldwork, preliminary interpretation of the surficial geology of Porcupine Strand was completed using

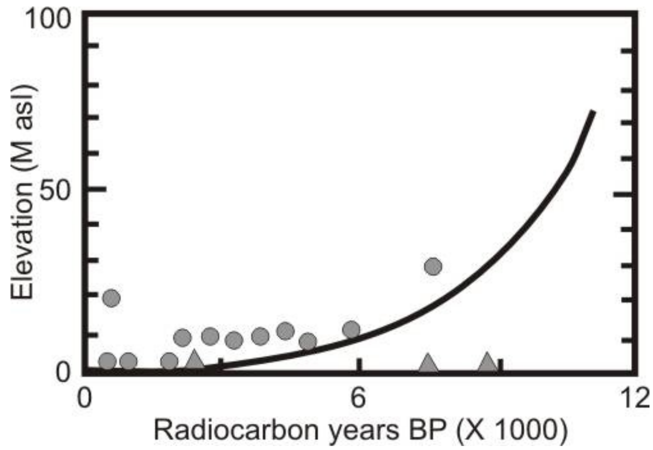


Figure 2. *Sea-level curve showing continual emergence of outer Groswater Bay modified from Clark and Fitzhugh (1991). Circles represent radiocarbon dates on charcoal material from archaeological sites. Triangles denote radiocarbon dates on marine shells.*

1:50 000-scale aerial photographs taken in 1968 and 1970. The classification of surficial materials follows the protocol used by the Geological Survey of Newfoundland and Labrador (e.g., McCuaig, 2002b). Surficial units on aerial photographs were differentiated based on their reflective characteristics, textural properties and surface patterns.

The UTM co-ordinates of sites visited were recorded using a handheld GPS. Site elevations were also recorded using a digital Sokkia altimeter (Model AIR-HB-IL), which has a resolution altitude of 0.1 m. All elevation measurements were corrected for temperature, as well as the time elapsed between zeroing and closing the altimeter traverse. Organic material including wood, freshwater peat, shells and whalebone were collected for radiocarbon dating. These samples will be dated using conventional and AMS methods to provide chronological control on landscape change. Sediment samples, taken from exposed sections and hand-dug test pits, will be analyzed for grain-size distribution so that units may be characterized by textural differences.

QUATERNARY GEOLOGY

Preliminary surficial geology maps were ground-checked by foot traverse and by observing sediments in exposed sections and test pits. In total, 23 sections were logged and 33 test pits were dug. Combined results from aerial photography and fieldwork allowed six surficial units to be identified: till, glaciofluvial, glaciomarine, marine, aeolian and organics. These units are similar to what was portrayed on Fulton’s (1986) 1: 500 000 scale map of the region, but for this project they have been mapped at a much higher resolution.

TILL

Surficial deposits of till cover only 5 to 10 percent of the study area and are mostly confined to uplands, where they occur as a thin veneer over bedrock. They are described as poorly sorted sand and gravel-dominated diamicton by Rogerson (1977) and Fulton (1986), similar to tills found elsewhere along the coast (e.g., McCuaig 2002a). Till is presumed to underlie the wedge of glaciomarine and glaciofluvial sediments that dominate the coastal lowlands behind Porcupine Strand, but it was only observed in one poorly exposed section at the north end of the Strand. Near West Bay, a fine-grained stony diamicton outcrops adjacent to striated bedrock (105º) and is overlain by glaciomarine mud. Upper and lower contacts are obscured by slumped material. The textural contrast between this deposit and the more common sandy tills in upland areas may simply reflect the finer grained marine sediment over which the ice sheet advanced in an isostatically depressed coastal margin.

GLACIOFLUVIAL

Glaciofluvial deposits are most extensive on NTS map area 13I/3, where they form a more or less continuous outwash plain between 70 and 115 m asl. The surface of the outwash has distinct terraces or levels that were abandoned as meltwater graded to progressively lower base levels during postglacial emergence. Abandoned meltwater channels are in places preserved on the outwash surface. Localized ice-contact outwash deposits characteristically are pitted with kettle ponds, some of which occur in curvilinear patterns, perhaps outlining former buried ice margins. Elsewhere, outwash is confined to valley bottoms and in places, also appears kettled. In some valleys, outwash may grade down-valley to flat-topped, steep-sided landforms, interpreted as glaciofluvial deltas. These deltas record local marine limit and vary in elevation from 36 to 92 m asl. Glaciofluvial deposits range between 1 and 15 m in thickness and consist of poorly sorted sand and gravel (Rogerson, 1977; Fulton, 1986).

GLACIOMARINE

Glaciomarine sediments consist mostly of emerged deposits of mud and sand, which formed the sea bed when postglacial sea level was higher than present. Glaciomarine sediments are therefore only found below marine limit and are most commonly observed near the present coast, either at the surface or underlying a thin cover of glaciofluvial deposits. Glaciomarine sediment underlying glaciofluvial deposits are evident in steeply incised gullies, and in the 10- to 24-m-high coastal cliff sections that back the Porcupine Strand. The bulk of coastal exposures are composed of fine to medium sand underlain by mud, which in places is visible only at low tide (Plate 2). The contact between mud and sand rises inland to about 10 m asl, as observed along a 10 km river-bank section near the mouth of North River.

Plate 2. *Emerged glaciomarine mud and sand located at the mouth of Big Brook (Figure 1, Section 1).* See *Figure 3 for detailed log of this section.*

In total, 17 stratigraphic sections were described from the coastal cliffs along the length of Porcupine Strand (Figure 1); a representative example is reproduced in Figure 3. In general, the basal mud consisted of well-sorted, structureless silt and clay, with occasional pebble- to cobble-sized clasts and rare shells (Table 1). It has a sharp erosional contact with the overlying sand, and is typically overlain by a thin bed of gravelly sand with rip-up clasts of mud. The overlying sand has a fine to medium texture, is moderately to well sorted and contains lenses and laterally continuous beds of coarse sand and granule gravel. Dewatering structures such as convolute bedding and load casts are common above the mud contact, whereas horizontal beds and planar crossbeds occur throughout the unit. Trough and ripple crossbeds were observed less frequently, and herringbone crossbeds were observed only toward the top of the sand unit. The upper sand contains parallel- and cross-laminations that are highlighted by their heavy mineral content. The upper 1 to 1.5 m of sand is commonly indurated and stained very dark brown (7.5 YR 2.5/2) to dark reddish brown (5YR 2.5/2). Post-depositional modification may be due to pedogenesis and/or the chemical reactions of heavy mineral concentration. This may be confirmed by analysing the composition of these sands. Whole and fragmented marine shells were collected from the sand at four locations along the Strand between 2 and 8 m asl (sample sites 1, 2 (Sample Site 1, Section north of 1, 2 section north of 5) and 3, Figure 1). The samples include 18 different marine species, some of which are shallow-water fauna (Table 1). A selection of these samples together with some from the underlying mud have been submitted for radiocarbon dating. One radiocarbon date on *Mya arenaria* from the mud yielded an age of 7730 ± 160 years BP (GSC-1284; Fulton, 1986; Lowden and Blake, 1973).

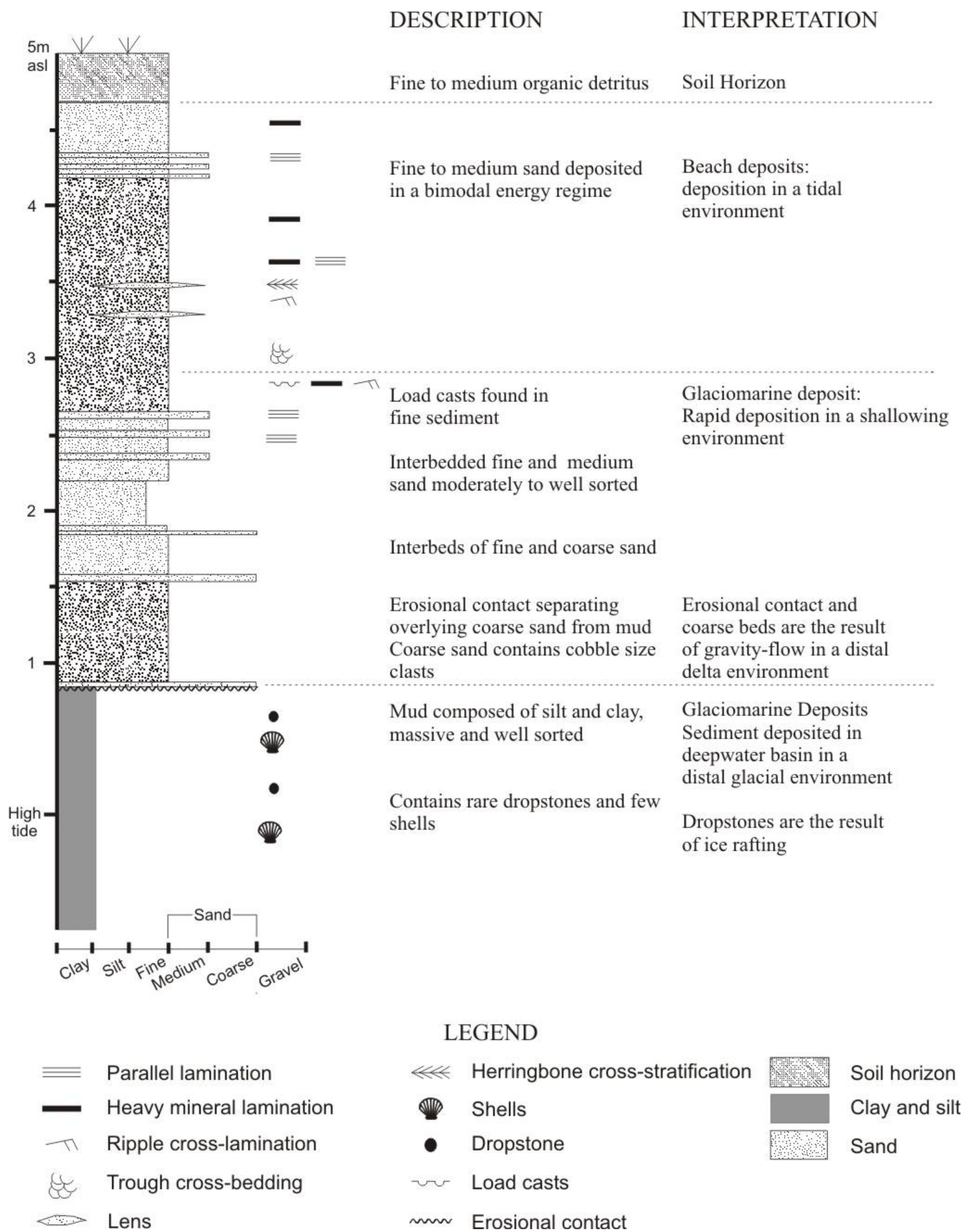


Figure 3. *Section log of the glaciomarine sediments found at the mouth of Big Brook. A photograph of this exposure is shown in Plate 2.*

Table 1. Species composition of shell samples collected from fossiliferous sediments in the study area. Identification by J. Maunder, Newfoundland Museum. Shallow water species denoted by *, commonly occur in water depths less than 10 m, whereas other species denoted by **, exceed this water depth (Peacock, 1993; Abbot, 1960)

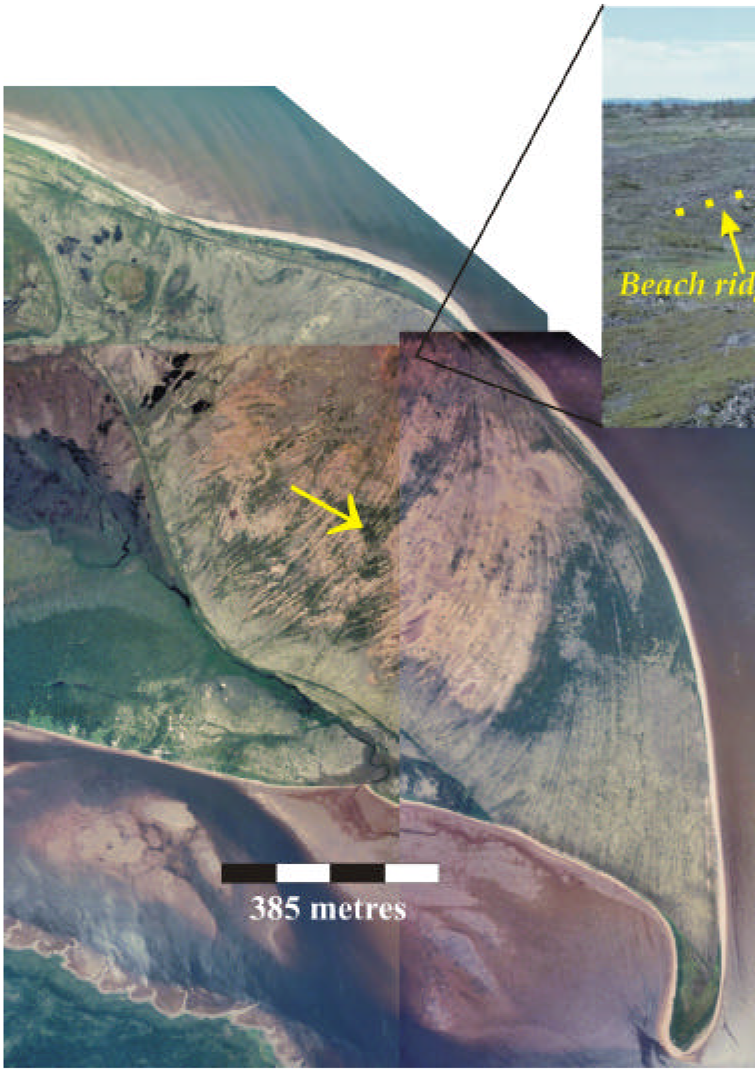
Glaciomarine sand (n=4)	**Glaciomarine mud (n-1)**	**Gravel Beach (n=2)**
Astarte sp.	*Balanus* sp.	*Mya* sp.
Astarte borealis? *	*Clinocardium ciliatum* **	*Mya arenaria* **
Astarte elliptica	*Nucula tenuis*	*Mytilidae*
Astarte undata	*Macoma calcarea* **	*Mytilus edulis s.l* *
Balanus sp.	*Yoldia hyperborea* **	*Volsella Modidus* **
Balanus crenatus		
Clinocardium ciliatum **		
Cockle?		
Hiatella arctica **		
Macoma balthica **		
Macoma calcarea **		
Mya sp.		
Mya arenaria		
Mya truncata **		
Mytilidae		
Mytilus edulis s.l *		
Serripes groenlandicus		
Trichotropis borealis?		
Turridae		

Preliminary interpretation of the coastal stratigraphy suggests that the mud was deposited in a relatively deep-water marine environment remote from glacial input, although lonestones are likely ice-rafted dropstones. The overlying gravelly sand beds may have been deposited by gravity-flow in a distal deltaic environment, whereas the bulk of the sand shows evidence of rapid sedimentation, which likely occurred as the delta prograded during the early to mid Holocene. A shallowing marine environment is indicated by sediments at the top of the cliff sections that contain herringbone crossbedding, typical of tidal environments, and shallow-water molluscan assemblages (Dalrymple, 1992; Boggs, 1995). The upper metre or so of the sand is interpreted to represent deposition in a littoral environment, based on similarities with sand beds exposed in nearby raised beaches (*see below*). Thus, there was first a glaciomarine environment, into which a glaciofluvial delta later prograded. Sea level fell as the delta formed, and wave action eventually reworked its upper parts into beaches.

MARINE DEPOSITS

During the postglacial emergence of Porcupine Strand, marine processes largely reworked sublittoral sand into well-defined beaches that are now raised up to 92 m above present sea level (Rogerson, 1977). Where not overlain by organic or aeolian deposits or concealed by forest, these sandy beach berms are clearly visible rising inland as a series of steps (e.g., Sandy Point, Plate 3) or are outlined by subtle changes in drainage and low shrub vegetation on aerial photographs. Blowouts on berm surfaces expose moderately to well sorted fine to medium sand with occasional flat-lying, rounded discoid cobbles. The bottoms of blowouts contain a lag of these cobbles, which armour the sediments against further erosion. Horizontal laminations, sometimes marked by concentrations of heavy minerals, suggest sorting by swash and backwash wave action. Raised beach sands display similar characteristics of induration and staining observed in the upper part of coastal sediments (Plate 4).

Gravel-dominated beaches are more common along the rocky coastline north of Porcupine Strand, especially in exposed locations where wave energy was high (e.g., Fish Cove, Plate 5). One site, however, exposed through storm erosion above high tide level near Sandy Point, revealed a 0.72-m-thick cobble gravel beach, containing driftwood and shell fragments, which is overlain by aeolian sand. Considering that the present shoreline is dominated by sand and that coastal cliffs backing the shoreline are composed predominantly of sand and mud, the cobble beach indicates a former period of higher wave energy and/or coarser sediment supply compared to present conditions. Samples of driftwood and shell have been submitted for radiocarbon dating.



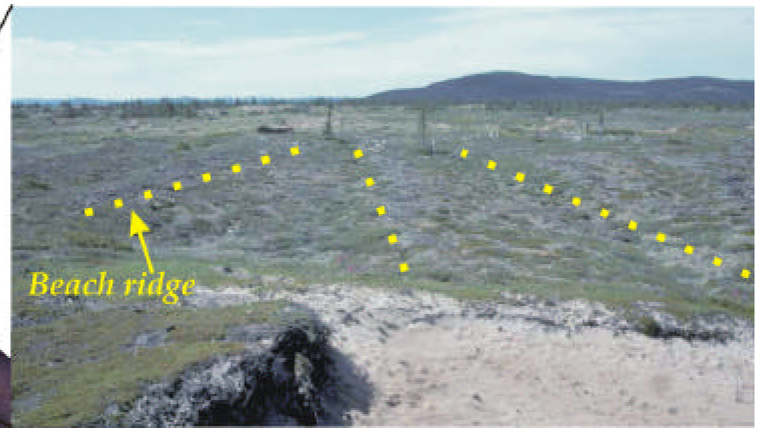


Plate 3. *The left photograph is a composite of three 1:12 500-scale air photographs that show a series of emerged beach berms. The arrow shows the direction in which successive beach berms were built as sea level fell. The inset shows an oblique photograph looking southwest across the berms. Note the aeolian deflation and blowout of beach sand in the foreground.*

AEOLIAN DEPOSITS

Aeolian sediments have been identified along the entire length of Porcupine Strand, but they occur as discontinuous deposits, representing only a small proportion of the mapped area (~2%). Fine sand and silt make up the bulk of aeolian sediments that commonly form dunes. Deflation of marine and glaciomarine deposits is the likely source of the sand and silt, and thus it is not surprising that dunes occur, i) inland, and on top, of eroding coastal cliff exposures along the Strand, ii) on Sandy Point, where deflation of beach berms provides a sediment source, and iii) at bayhead locations in the northern part of the study area, where wind is funnelled through bedrock gaps and valleys. In the latter case, it is speculated that sub-aerial exposure of shallow bayhead sediments, when sea level was lower than present in the late Holocene (*see below*), may have provided a potential sediment source for dune construction.

The largest dunes observed occur south of Rocky Point and are classified as parabolic dunes (Plate 6). They are crescent-shaped and have an open end that faces upwind, a U-shaped blowout and arms anchored by vegetation. They have a relief of up to 20 m above the surrounding terrace, have arms between 50 and 100 m in length, and appear to be aligned with predominant wind directions of west and west-northwest (Rogerson, 1977). For the most part, these dunes appear stable and have almost complete vegetation cover. Elsewhere, dunes are smaller, varying between transverse and longitudinal forms, depending on local wind conditions.

In section, aeolian sediments typically rest on littoral sand, which has a characteristic indurated and stained appearance (Figure 4). The contact is normally marked by an organic layer, in some cases containing abundant charcoal, which is interpreted to represent the former vegetated (forested in some cases) beach surface. Within the sand

Plate 4. *Section through raised beach deposit and overlying aeolian sand. The contact (arrowed) is marked by an organic layer, which represents the former vegetated beach surface. Note the indurated, rust-stained beach deposits beneath the organic layer.*

Plate 5. *Raised gravel beach at approximately 20 m asl near Fish Cove.*

dune, other buried organic layers may be evident. Wood and peat samples from selected sections have been submitted for radiocarbon dating. Dark heavy mineral laminations highlight the successive slipfaces of the leeward slope as the dune migrated in the predominant wind direction.

ORGANIC DEPOSITS

Bogs and organic deposits occupy much of the coastal lowlands, as well as surface depressions or valley bottoms where drainage is poor. South of Cape Porcupine, organic deposits extend up to 70 m asl, whereas in the northern part of the field area they are most extensive between sea level and 30 m asl. These deposits are generally found overlying fine-grained, poorly drained glaciomarine sediments and were observed to be more then 1 m thick in coastal sections. Generally, the peat is fine to medium texture, although some coarse peat with preserved woody fragments was also observed.

LANDSCAPE CHANGE

Porcupine Strand has experienced dramatic landscape changes since deglaciation: sea level has fallen over 110 m; the former sea bed now lies exposed, forming the coastal lowlands; powerful glacier-fed braided rivers flowed across the northern lowlands, carrying sand and gravel to the sea; the coastline configuration has evolved with sea-level change from a large indented embayment to a relatively straight shoreline. Although most of this landscape change occurred quite rapidly during the two or three millennia following deglaciation, considerable change must have been witnessed by humans since they first occupied the Strand over 7000 years ago (Rankin and Wolff, 2002). Perhaps the most notable of these were changes in sea level and related coastline displacement, climate variability and its impact on landscape processes (e.g., coastal erosion, sand dune activity), and vegetation change. Because prehistoric cultures relied heavily on marine resources and located their habitation sites close to the active shoreline, the position of ancient shorelines is critical in planning archaeological surveys and interpreting site function in the context of local environment and landscape.

The focus of the sea-level research in the study area was the generation of sea-level index points from the raised marine record. An index point consists of a documented sea-level position and an established age for when the sea occupied this position. A series of index points outlines the course of sea-level change over time in the region. A total of five organic samples retrieved from glaciomarine, littoral and organic deposits have been submitted for radiocarbon dating and should generate either sea-level index points or minimum/maximum constraints on the elevation and timing of former sea level at the sample site (Table 2). Although it has been suggested that the region has experienced continual emergence since deglaciation, at least one sample may indicate a recent period of sea-level history lower than present, and hence a current trend of rising sea level. A 38-cm-diameter *Picea* (spruce) stump was observed in a vertical position in the intertidal zone on Porcupine Strand near Big Brook (Plate 7). Excavation to a depth of 50 cm revealed an apparently *in situ* stump rooted in gravelly sand. Its location within the intertidal zone suggests that at the time the tree was growing, high tide must have been at least several metres below its present position. Thus, for recent prehistoric occupation of the Strand, the active shoreline was seaward of its present location.

Many archaeological sites along Porcupine Strand are buried in sand dunes and have been re-exposed through deflation. As a result, much of the artifact evidence and related cultural features (e.g., fire hearths) are reworked onto the bottoms of blowouts and have lost their stratigraphic context. Age determination and correlation of buried

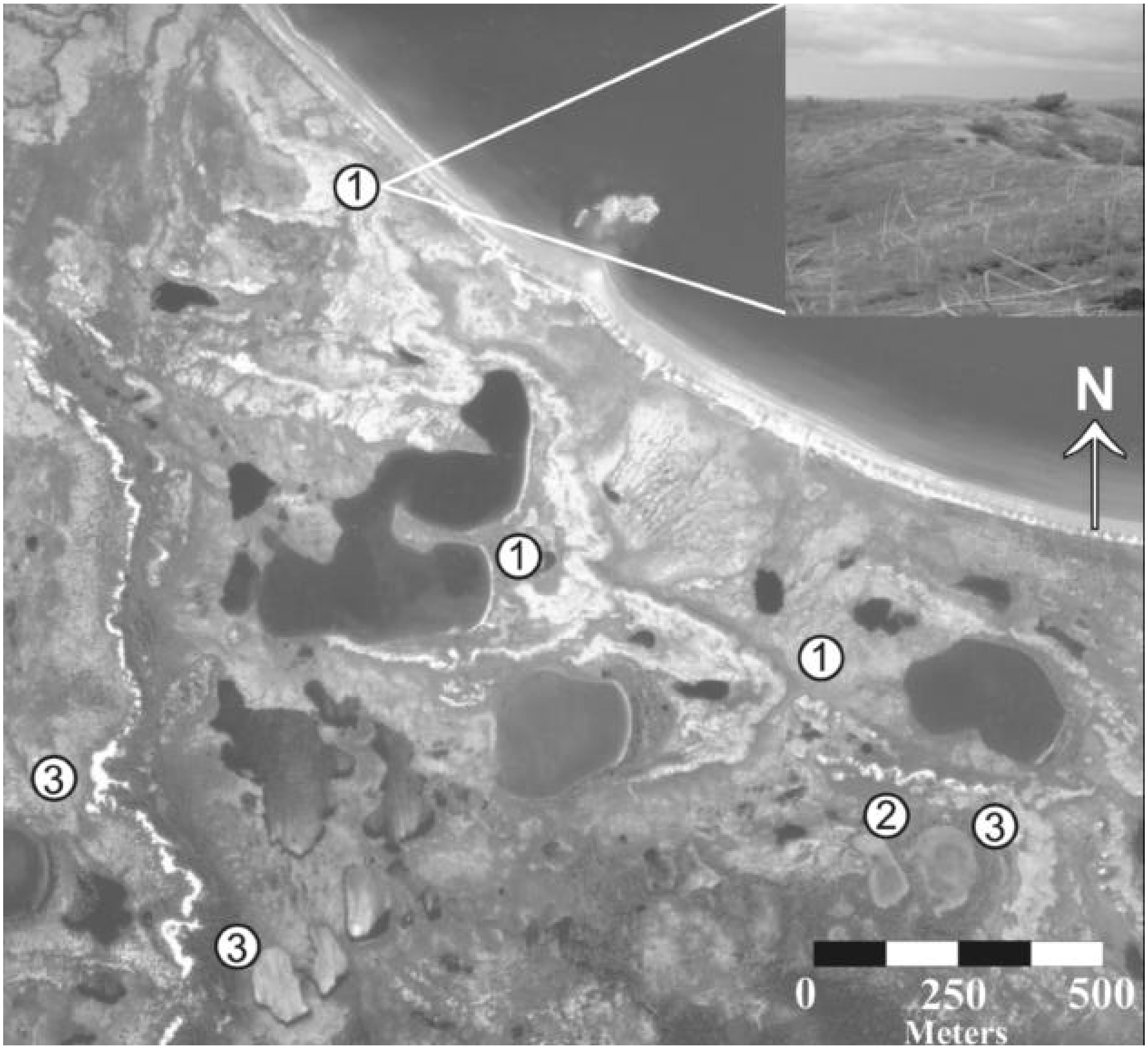


Plate 6. *Vertical air photograph (1:12 500 scale, 1992) showing the distribution and orientation of sand dunes south of Rocky Point. Three types of dunes are present: (1) parabolic, (2) longitudinal, (3) barchan-like. The prevailing wind directions as indicated by dune orientation appear to be west to west-northwest (Rogerson, 1977). Inset shows sharp crest along one arm of a parabolic dune. Note evidence for recent forest fire.*

soil/organic horizons within and between sand dune systems may therefore provide a chronological context for archaeological material and an opportunity to relate sand dune stability and reactivation to proxy climate and hydrological records (Plate 8). For example, wetter/colder or drier/warmer climate conditions would likely cause fluctuations in the elevation of the local water table, which in turn may reduce the protective vegetation cover on dunes and initiate re-activation. Other factors such as forest fire may also de-stabilize sand dunes on a local scale.

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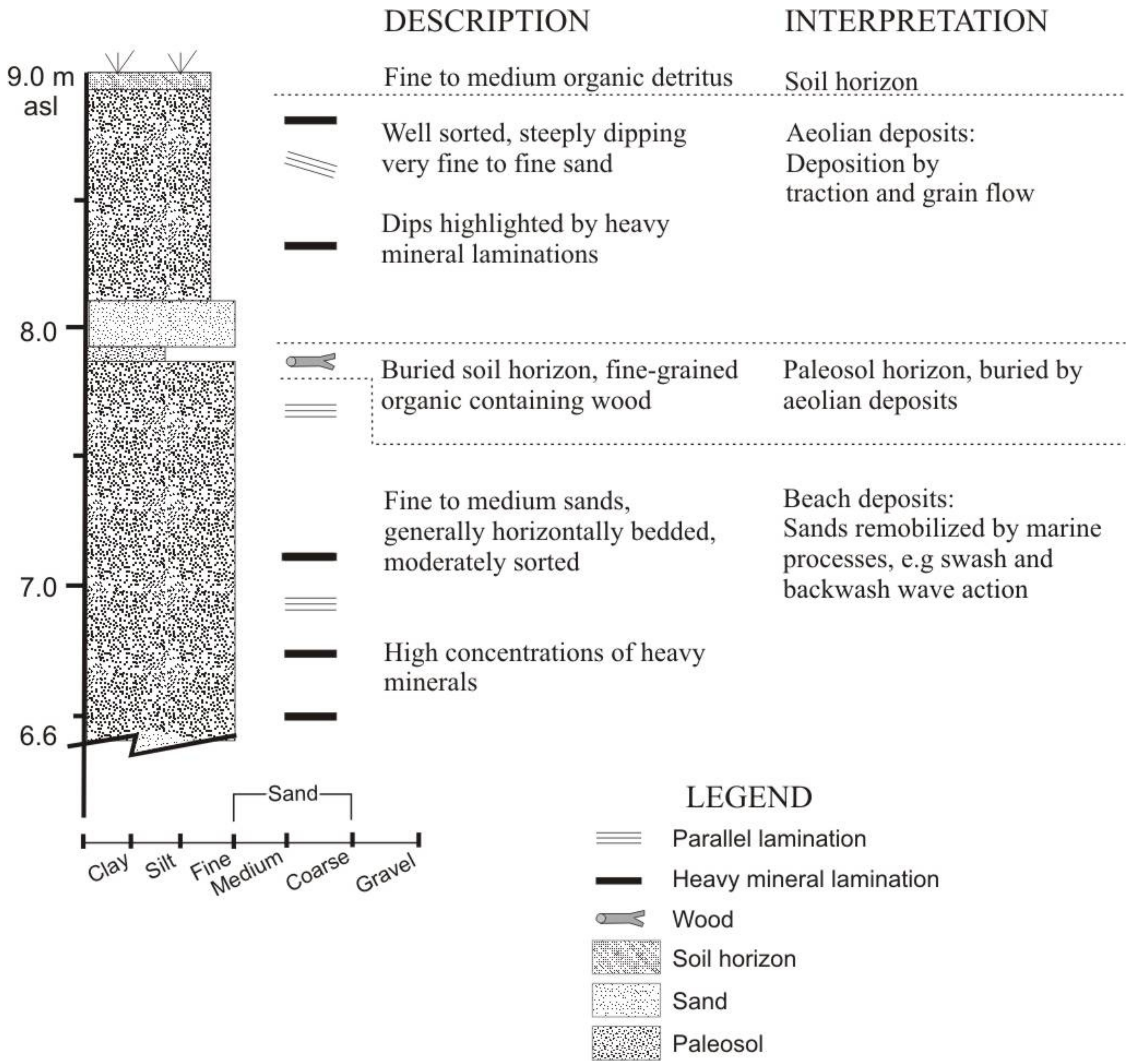

Figure 4. *Section log of aeolian and marine sediments found on Sandy Point.*

enthusiastic field assistance. Shell taxa were identified by Dr. John Maunder, Newfoundland Museum, while Dr. Peter Scott, Biology Department, Memorial University of Newfoundland identified wood samples. Terry Sears of the Geological Survey provided valuable assistance in the drafting of figures. Dave Liverman and Shirley McCuaig are thanked for their critical review of the manuscript.

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Table 2. Samples submitted for radiocarbon dating that relate to sea-level studies. Sample locations are identified in Figure 1

Site	Location	Sample Type	Species	Enclosing Material	Elevation (m)
1	South of Rocky Point, Porcupine Strand	marine shells	*Hiatella arctica*	sand	1.8
2	South of Rocky Point, Porcupine Strand	marine shells	*Mya* Sp. *Mytilus edulis s.l*	sand and cobbles	3.6
3.	Seal Cove	marine shells	*Volsella modiolus* *Mytilus edulis s.l* *Mytilidae*	sand and gravel	0.5
4	North of Big Brook, Porcupine Strand	wood	*Picea*	sand	intertidal zone
5	South of Rocky Point, Porcupine Strand	freshwater peat	Not available	peat	7.4

Plate 7. Picea *tree stump excavated in the intertidal zone near Big Brook. The stump appears to be rooted in gravelly sand below 50 cm of fine to medium beach sand. The stump protruded 65 cm above the beach level.*

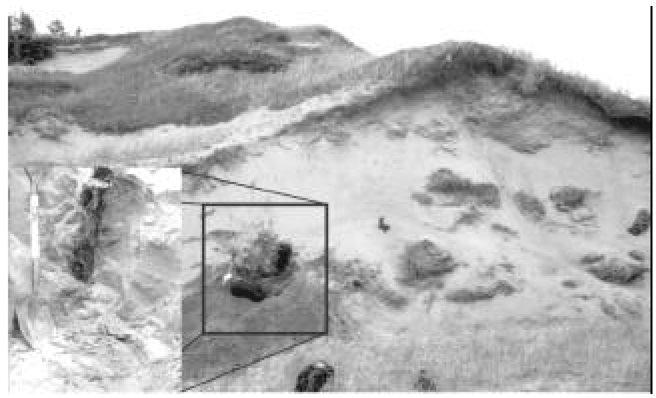

Plate 8. *Sand dunes along Porcupine Strand, formed from the deflation of emerged marine and glaciomarine sediments, have undergone cycles of stabilization and reactivation, as indicated by buried soils and peaty horizons in stratigraphic section. For example, deflation (blowout) of a dune in Sandy Cove has exposed a buried forest floor, complete with rooted tree stumps (inset), which represents a former stabilized dune surface. The overlying sand was deposited during a period of sand dune reactivation, whereas the modern vegetated surface indicates a recent period of renewed stabilization. Local re-activation and migration of sand dunes were commonly observed in the area.*

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