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LATE QUATERNARY GLACIAL AND GLACIOMARINE SEDIMENTS IN SOUTHERN ST. GEORGE'S BAY

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ABSTRACT

Extensive coastal exposures of unconsolidated sediments in southern St. George's Bay, western Newfoundland were deposited during the last (Late Wisconsinan) glaciation and subsequent deglaciation. The topography of the area shows contrasts between planar surfaces and hummocky ridges. The sediments observed show considerable lateral and vertical variablity. The main sediment types seen are diamicton, either structureless or stratified; fossiliferous muds; sand and silts, often deformed by loading and soft-sediment deformation; and gravels, mostly planar bedded and rarely deformed. These sediments were deposited by a number of processes, including debris flow, suspension settling, underflow, and traction currents. Two new radiocarbon dates confirm deglaciation occurred prior to 13 400 years BP. The greatest complexity is found in, or adjacent to, the hummocky ridges, whereas sedimentary sequences away from these features are comparatively simple. The complexity of the sedimentary sequences and the variability of depositional environment indicate that most of these sediments were deposited in a grounding line fan, with sediment being supplied by subglacial fluvial systems. The point of entry of these fluvial systems to the sea is marked by the hummocky topography.

INTRODUCTION

The St. George's Bay area of Newfoundland has extensive exposure of unconsolidated sediments, deposited during the Late Wisconsinan glaciation and deglaciation. The land surrounding St. George's Bay has the thickest and most continuous surficial cover of any region in Newfoundland. Sections are exposed nearly continuously along the coastline between Highlands, at the foot of the Anguille Mountains, and Romaines, west of Stephenville (more than 60 km) (Figure 1). These sections expose varied sequences of glacial, glaciomarine, marine, fluvial, and aeolian sediments.

During deglaciation of St. George's Bay, the interaction of rising sea level and waning glaciers resulted in a complex sedimentary depositional environment. Understanding the sequences exposed here is critical for a number of reasons. Sections in this area were the subject of descriptions and interpretations in the 1940s (MacClintock and Twenhofel, 1940), 1960s and 70s (Brookes, 1969, 1974, 1977), but have received little attention since. This area is thought to show evidence for a late-glacial readvance, marked by the Robinson's Head moraine (Brookes, 1977). Recent understanding of the late glacial environment has led to the delineation of rapid climatic shifts in the 12 000 to 10 500 years BP time range. Brookes (1977) suggested that re-advance in this area occurred earlier than these climatic changes. Thus, the deglacial history of the area is of interest, in that the relationship between this readvance and climate change may be examined. As such, further understanding of the sedimentology and stratigraphy is of importance as a supplement to surficial mapping in the area.

This paper describes the results of reconnaissance logging and description of sections along the coast from Bank Head in the north to Highlands in the south (Figure 1). The objectives of this study are to examine the lateral and vertical variation in sedimentary sequences exposed; to supplement the brief descriptions in previous work; and to use a sedimentological approach in the interpretation of the depositional environments.

PREVIOUS WORK

Sections in St. George's Bay were identified by MacClintock and Twenhofel (1940), who described a

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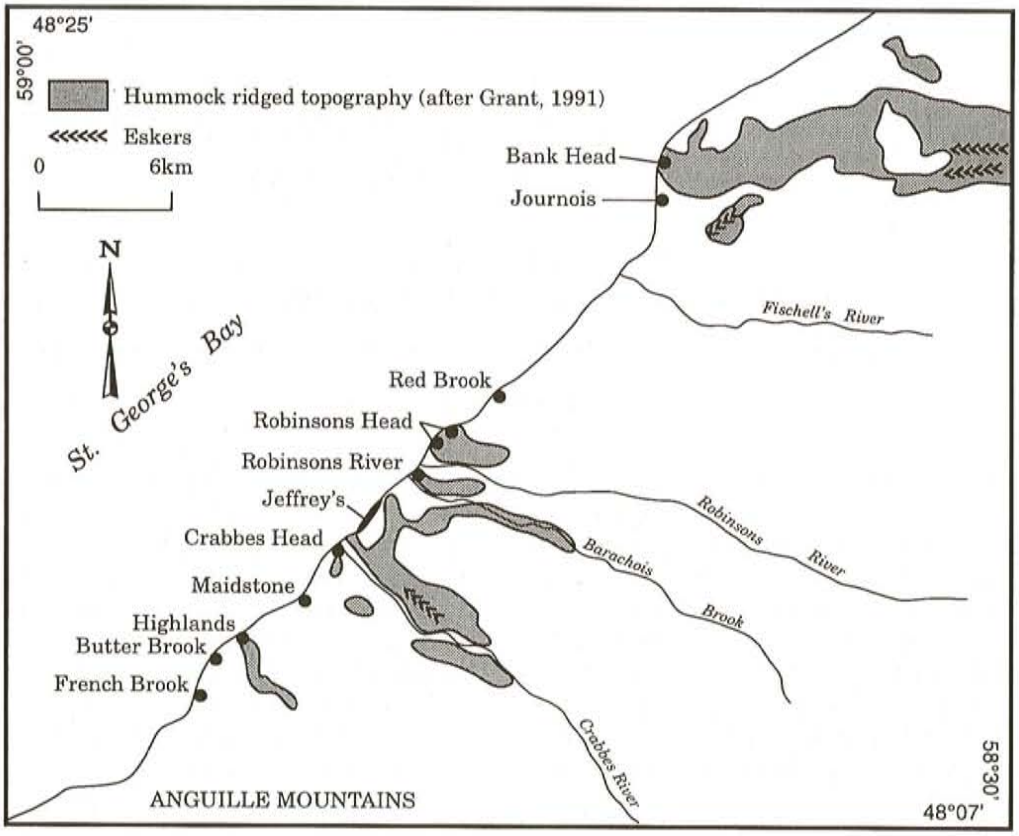

Figure 1. *Location map of study area, showing principal sections examined; also shown are hummocky ridges and eskers (from Grant, 1991).*

three-fold stratigraphy: a lower till (the St. George's River Drift) overlying bedrock; a deltaic sequence (the St. George's Bay Delta); and an upper coarse till and ice contact gravels, (known collectively as the Robinson's Head Drift). Later, Brookes (1969, 1974, 1977) described these sequences in more detail. He also identified, and briefly described, key sections at Highlands, Robinsons Head, and in the Stephenville–Port au Port area; provided chronological control on the stratigraphic units through dating of marine shells and terrestial peats; and developed a history of postglacial sea-level change (Brookes, 1969, 1974, 1977).

Brookes (1974) described the St. George's River Drift as 1 to 4.5 m of compact lodgement till directly overlying bedrock. He suggested that on the north shore of St. George's Bay, westward to northwestward ice flow at the glacial maximum was followed by southwest and southward ice flow, related to the development of a calving bay in St. George's Bay.

The St. George's Bay Delta was related by Brookes (1969, 1974) to postglacial marine invasion of the coastal margin up to 44 m asl. The marine limit was defined by the upper limit of sediments tentatively identified as foresets found in the Robinsons Head section, and a terrace of similar elevation on the coast between Fischells and Bank Head. Typical sequences were described as showing a basal unit of gravel up to 0.6 m thick overlain by up to 3 m of fossiliferous clay and silty clay, 1 to 3 m of clay silt rhythmites with rare marine fossils, delta foresets composed of sand and gravel, and rarely, delta topsets or terrace gravels. Several radiocarbon dates show the basal fossiliferous clays as being deposited at approximately 14 000 to 13 500 years BP (Brookes, 1974; Grant, 1987; Table 1).

The Robinson's Head Drift was described by Brookes (1974) as being "a coarse, loosely structured till of englacial and supraglacial origin". This till was related to ice-contact gravels deposited in nearby kames and eskers. At Robinsons Head, a moraine associated with this drift was identified by Brookes (1974) and consisted mostly of kame sediments, where sand and gravel beds dip inland toward a kettle depression. At Highlands, Brookes (1974) suggested that the Robinson's Head Drift is marked by a lodgement till overlying delta foresets. Brookes (1977) described shells dated at 12 600 ± 140 years BP (GSC-2295) found at Kippens, in northern St.George's Bay. He interpreted these as dating the culmination of a late glacial readvance that

Table 1: Radiocarbon dates, southern St. George's Bay

Date (years BP)	Lab Number	Location	Species	elevation (m asl)
13600 ± 120	GSC-5700	Robinsons Head	*Hiatella arctica*	12
13970 ± 100	TO-4536	Journois	*Portlandia arctica*	12
13500 ± 210	GSC-1200	Robinsons Head	*Hiatella arctica*	35.4
13600 ± 190	GSC-4270	Butter Brook	*Hiatella arctica*	20
13420 ± 190	GSC-598	Highlands River	*Macoma (sp.)*	5.5
13500 ± 120	GSC-4685	Highlands (Harbour Head)	*Mya pseudoarenaria*	1-3

GSC-5700 and TO-4536 are new dates, reported here for the first time. Other dates are from Batterson *et al.* (1992). The figure quoted for TO-4536 includes a 410 yr correction to account for the marine reservoir effect.

could be correlated to the deposition of the Robinson's Head Drift. The interpretation of this date has further been discussed by Batterson *et al.* (1993, *in press*), Brookes (*in press*), and Liverman and Batterson (1995).

The ice margin at the time of the Robinson's Head Drift readvance was portrayed by Brookes (1974) and Grant (1987). Brookes (1974) showed three lobes of ice reaching the coast in southern St. George's Bay, at Highlands, Robinsons Head, and Bank Head, with the intervening areas lying outside the limits of the readvance. It was also proposed that sea level stood at 28 m asl during the readvance (Brookes, 1969, 1974, 1977). Grant (1987) showed a single lobe of ice lying seaward of the present coast between Bank Head and Robinsons Head, then landward between Robinsons Head and Highlands. In contrast, Grant (1991) mapped an extensive area of hummocky outwash forming a distinctive ridge perpendicular to the coast. This ridge was shown by Grant (1987) as lying between two lobes of ice related to the Robinsons Head readvance.

In summary, the glacial and deglacial history of this area is thought to consist of a Late Wisconsinan advance of grounded ice to well beyond the present coast, retreat to, adjacent to, or landward of the present coast, with a maximum sea level at approximately 44 m asl, followed by a localized readvance or stillstand of ice when sea level stood at 28 m asl.

RESULTS

Field work was conducted over brief periods in 1993 and 1995. The coastal sections are complex, and merit very detailed bed by bed descriptions and careful mapping of lateral changes along the coast. Future field work will adopt this approach, but initial reconnaissance consisted of logging representative stratigraphic sections through the exposures, and briefly describing lateral variability. An altimeter was used to determine elevations of critical contacts within the sections. Clast-fabric analysis was used to characterize diamicton units.

TOPOGRAPHY AND SURFICIAL GEOLOGY

The coast along the southern part of St. George's Bay consists of a gently sloping lowland, dissected by a number of rivers. The upper level mostly consists of terrace surfaces, sloping at 15 m per km toward the coast. Lower terrace levels are found adjacent to major river systems. The lowland is interrupted by several hummocky ridges lying approximately perpendicular to the coast at Highlands, Crabbes Head, Jeffrey's, Robinsons Head (Plate 1) and Bank Head (Figures 1 and 2). These areas were mapped by Grant (1991) as consisting of ice-contact stratified drift, with kames, kettles and eskers. The highest ridge is that forming Robinsons Head itself, reaching 75 m asl or more. Three distinct planar surfaces are apparent on topographic profiles (Figure 2), a lower level at 18 to 20 m asl (south of Highlands, and north of Robinsons Head), an intermediate level at 24 to 26 m asl either side of Crabbes Head, and an upper level at 40 to 45 m asl (between Fischells and Bank Head; Plate 2).

Plate 1. *Hummocky topography typical of ridged areas, Robinsons Head.*

Plate 2. *Planar surface at 40 to 45 m asl between Bank Head and Fischells.*

SEDIMENTOLOGY AND STRATIGRAPHY

In total, 18 sections were logged along 30 km of coastline (Figures 1 and 3). The sections are complex, both laterally and vertically. Given the preliminary nature of this study, detailed descriptions of the sediments are not presented, instead simplified stratigraphic logs are given in Figure 3. The main sediment types are described below, and subsequently, the stratigraphic sequences are examined.

Diamicton

Diamictons are seen in many sections along the coast in a variety of stratigraphic positions and relationships. Diamicton units are most commonly tabular, thick bodies, which also occur as beds, interbedded with sorted sediment, 0.1 to 1 m thick, and as biconvex lens-shaped bodies up to 1.5 m thick in the centre, and pinching out laterally over 10 to 20 m (Jeffrey's North; Figure 3; Plate 3). Diamictons are both structureless and stratified. In general, tabular diamicton units are structureless and show clast fabrics that vary from moderate to well oriented (e.g., at Butter Brook, French Brook, and Highlands; Figures 1 and 3). Interbedded diamictons tend to be stratified, and have moderate to poorly oriented girdle fabrics (Jeffrey's; Figure 3).

It is proposed that two main styles of diamicton deposition are seen in the area. Massive tabular diamictons with well-oriented clast fabrics are likely basal tills, deposited either through melt-out, deformation processes, or lodgement (cf., Kruger, 1979; Shaw, 1986; Hicock and Dreimanis, 1992). Where fabrics are not well oriented, and the sediment contains stratification, the diamicton is likely resedimented through debris flow. Stratified and interbedded diamictons with girdle-clast fabrics are interpreted as being deposited by

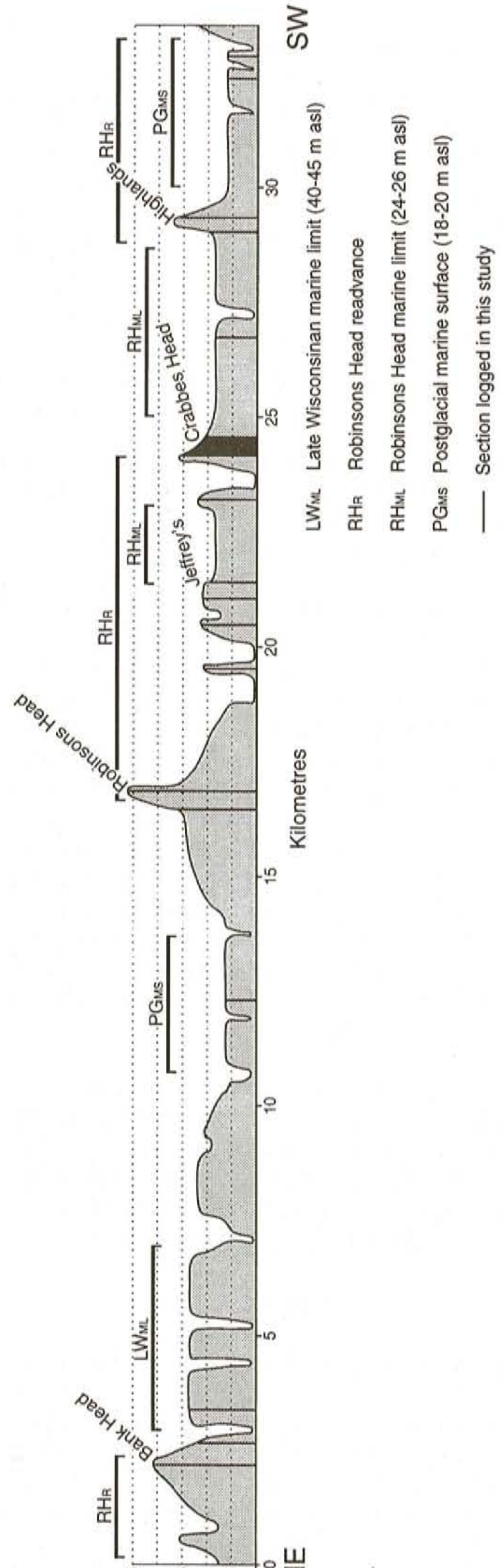

Figure 2. *Topographic profile parallel to the coast between Bank Head and Highlands.*

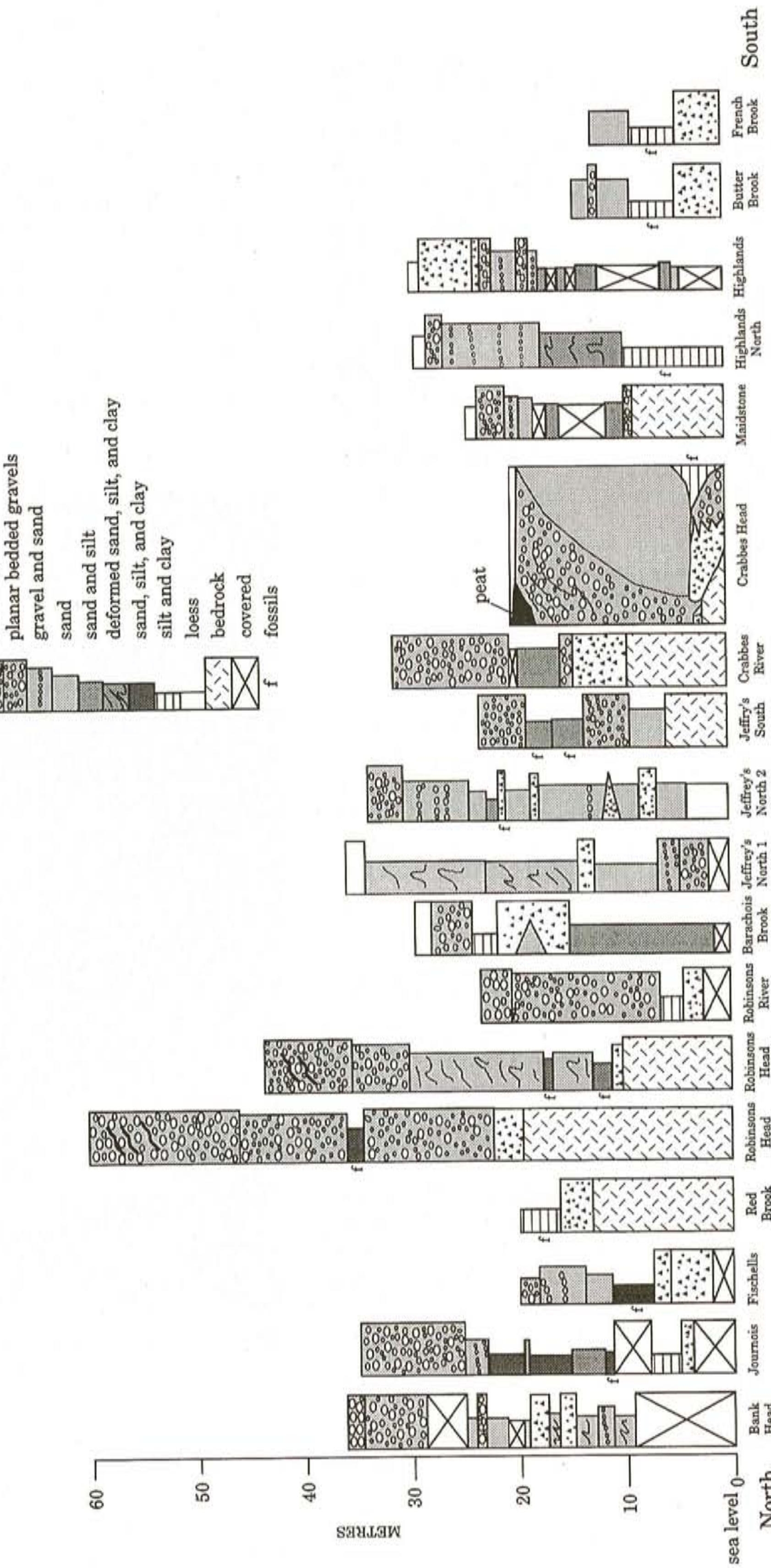

Figure 3. *Stratigraphic logs of sections examined in this study.*

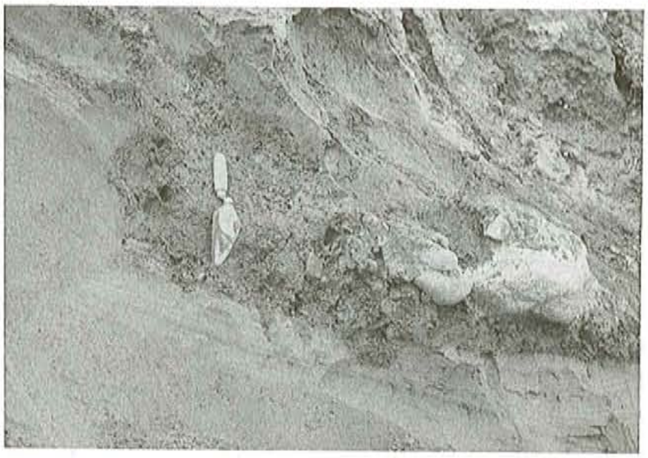

Plate 3. *Diamicton lens exposed in Jeffrey's North section.*

debris flows (cf. Lawson, 1979, 1981). The ubiquitous association with sediments interpreted as marine suggests that most of these debris flows were subaqueous.

Silt and Clay

Muds, mostly silty clay and clay-silt, up to 10 m thick are seen in many locations along the coast. The sediments are usually moderate to well sorted, contain rare dropstones and vary from structureless to rhythmically laminated. Individual laminae can be normally graded or structureless. The muds are commonly fossiliferous, with a variety of species including *Hiatella arctica, Portlandia arctica, Macoma (sp.), Mya pseudoarenaria,* and *Balanus* (sp).[1]

These fossiliferous muds were deposited in quiet water conditions marked by an abundant sediment supply. Their laminated character likely results from suspension settling from overflow plumes generated at a nearby ice margin (cf., Mackiewicz *et al.,* 1984; Powell, 1990). The absence of rip-up clasts, ripples and other characteristic structures indicates that underflow was not a major process in deposition (Ashley, 1988). The faunal assemblages closely resemble the mature *Portlandia* association of Syvitski *et al.* (1989) that is found in association with sediments deposited distal to a retreating ice margin where sedimentation rates are moderate. The presence of very sparse dropstones indicates ice rafting of material and suggests that calving glacial ice was supplying sediment to the area.

Sand and Silt

Well-sorted fine-grained sand and silt is common, and is mostly planar stratified. Ripple cross-stratification is commonly seen. Strata vary from structureless to normally graded, and bedding, where undeformed, is mostly horizontal. The sediment frequently shows abundant evidence of rapid sedimentation in the form of dewatering structures (flame structures, injection structures, minor faulting). In some cases, deformation is more intense, with beds oriented almost vertically (Plate 4). In other sections, discontinuous gravel interbeds, rare trough crossbedding and planar tabular crossbedding occur. Diamicton interbeds are found in some locations (Jeffrey's North 2).

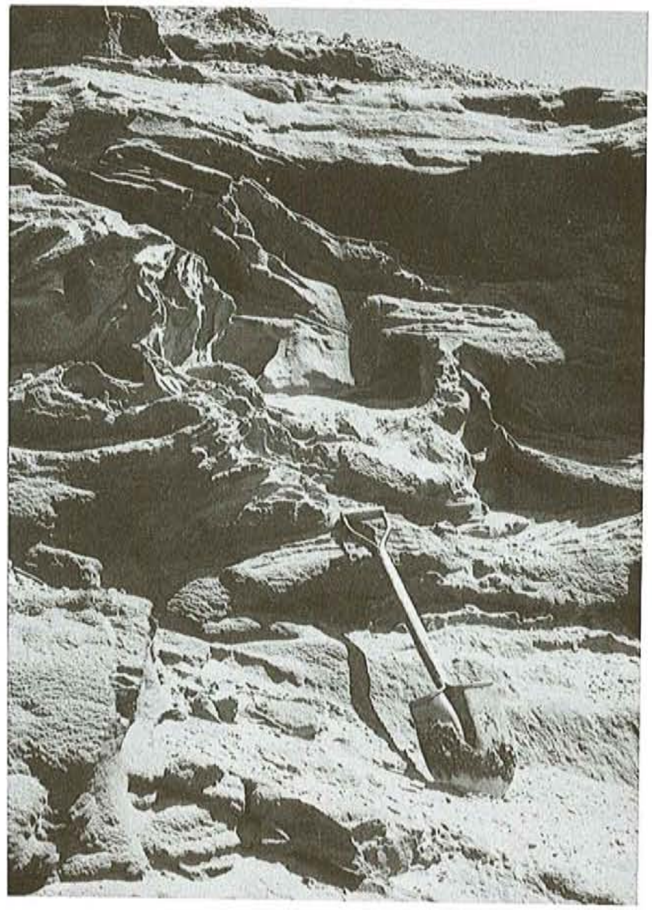

Plate 4. *Intensely deformed sand and silt, Robinsons Head.*

[1] *Hiatella arctica* recovered from the Red Brook section (Figure 3) have been dated at 13 600 ± 170 years BP (GSC-6024).

The sediments are interpreted as being deposited mostly by active current flow having a very high sediment supply. Underflow may have deposited normally graded beds, and suspension settling also may have contributed much sediment. High sediment supply and rapid deposition resulted in loading and intense soft-sediment deformation. Such sediment might be deposited in delta bottomsets or distal foresets, or as subaqueous outwash (Rust, 1977).

Gravel

Gravels are found in many locations along the coast and vary considerably in grain size, sorting, and stratigraphic position. Most gravels are granule to cobble, clast supported, and moderately sorted. The dominant structure is planar bedding, having rare trough crossbedding (Plate 5). Coarse cobble–boulder gravels occur in some sections (e.g., Robinsons Head, Bank Head), and tend to be poorly sorted. In places, gravel units are deformed, with beds standing near-vertical. In general, dips were variable, but gravels were rarely at the angle of repose.

Plate 5. *Crossbedded gravels exposed near top of coastal cliffs south of Bank Head.*

Planar-bedded gravels may be deposited either in a fluvial environment or as subaqueous outwash. Where interbedded with fine-grained sediments, the latter is favoured as an interpretation. Coarser gravels, especially when deformed, were likely deposited in an ice-contact environment. The scarcity of dipping beds at angle of repose indicates that true deltaic foresets are generally absent from these sections.

Loess

Well-sorted fine sand and silt commonly cap the coastal cliffs, and can be over 1 m thick at the cliff edge. This sediment was deposited as clifftop loess.

STRATIGRAPHY

The sediment types described above occur in a variety of stratigraphic positions. Diamicton commonly occurs at the base of sequences overlying bedrock, or extends to sea level (Robinsons Head, French Brook, Butter Brook). However, it is found throughout the vertical sequence, being underlain by sorted sediments at Jeffrey's North (1 and 2), and lying directly beneath loess at Highlands. Silt and clay are generally found low in the section, with the highest occurrence (35 m asl) being a thin bed containing dated marine shells at Robinsons Head north (Figure 3). In many places, sand and silt form the bulk of thick coastal cliffs, being found in stratigraphic positions ranging from the base to the top of sequences. Gravels are also found throughout the stratigraphic sequence, but commonly form the upper unit in a given section (apart from loess). Loess, where present, is always the uppermost unit.

STRATIGRAPHIC SEQUENCES

It is difficult to define a typical stratigraphic sequence in this area. The lateral variation is such that stratigraphy rarely remains consistent over more than a few hundred metres. When compared to the coastal topography, however, a pattern emerges. In areas away from the ridged topography, stratigraphic sequences are comparatively simple (Figure 3). For example, south of Highlands, the Butter Brook and French Brook sections show diamicton, overlain by fossiliferous silt, clay and sand, with gravel appearing sporadically at the top of sections. Similar sequences are seen at Fischells, Red Brook, Journois and Maidstone, differing only in that thick gravels are found toward the top of the sections and diamicton is not invariably exposed at the base. These sections are located away from the ridged topography, apart from Journois, which lies adjacent to the hummocky ridge at Bank Head.

Within the ridges, stratigraphy is more varied and complex. Three examples are used here; Jeffrey's, Robinsons Head, and Crabbes Head. At Jeffrey's (North), coastal exposure on either side of a major gully illustrates the lateral variation typical of this area. The northern section (Jeffrey's North 1) (36 m thick) exposes 12 m of interbedded moderate to well-sorted gravel and sand at the base, overlain by a thin bed of diamicton, sand with diamicton lenses, and 22 m of well-sorted interbedded sand and silt. The southern section (Jeffrey's North 2) (60 m south of the northern section) consists of 15 m of interbedded sand and diamicton, with diamicton constituting about 20 percent of the sediment. The sediments grade vertically toward gravel, and marine shells were recovered from a pebbly mud unit at 22 m asl. The upper 5 m of the section consists of planar-bedded pebble gravel. Lateral tracing of diamicton beds shows that they form lenses pinching out to both north and south.

At Robinsons Head, there is intermittent exposure over 1.5 km of coastal cliffs. The transect logged by Brookes (1974) was re-visited and briefly described. This transect is located at the northern end of the coastal cliff. A farther section at the southern margin of the Robinsons Head ridge was also described in detail. The northern transect shows bedrock at the base, overlain by a compact diamicton. This is in turn overlain by a loose diamicton or pebbly mud with clasts up to 1 m diameter, and then moderately sorted planar-bedded pebble gravels. A 1 m bed of silty clay containing shells (*Hiatella arctica*) is overlain by 1 to 2.5 m of silty sand with rare fossils, and capped by interbedded planar-bedded sand, pebble gravel and cobble gravel, dipping eastward (into the cliff) at approximately 10°.

The southern transect differs from the northern one in several respects. The basal diamicton (directly overlying bedrock) is fossiliferous, contains sand laminae and has a weak to unoriented clast fabric (two measurements). This is overlain by a thick sequence of interbedded sand, silt and silty clay, generally well sorted. Shells (*Hiatella arctica*) were recovered from a silty clay bed directly overlying the basal diamicton 12 m asl, and radiocarbon dated at 13 600 ± 120 year BP (GSC-5700, Table 1; Figure 3). The sediments generally become sandier vertically, and show considerable deformation throughout. Faulting, injection structures, folding and flame structures are commonly seen. The top of this 25 m sequence of finer sediment shows an interbedded contact with gravels. Gravels are dominantly planar bedded, and coarsen upward from mostly pebble gravel to cobble gravel over 15 m. The uppermost gravels are deformed, with some beds that dip at up to 60°, mostly to the southeast.

At Crabbes Head, excellent coastal exposure over several hundred metres allows lateral tracing of major units. At the north end of this exposure, ice contact gravels (showing large-scale deformation around a kettle hole now filled with peat) overlie an intermittently exposed structureless diamicton. Moving southward along the coast, the base of the section shows a transition into a thick tabular diamicton, which undergoes a further lateral transition into poorly sorted angular gravels. These gravels themselves dip below sea level and are replaced by fossiliferous muds at the base of the section. The upper ice contact gravels show a lateral transition to gravels with no deformation, and then to planar bedded sand and silt.

INTERPRETATION

NON-RIDGED AREAS

The relatively simple sedimentary sequences observed remote from the ridged topography are interpreted as showing deglaciation in a marine setting. Basal tills are either undisturbed (Butter Brook) or resedimented (French Brook). The occurrence of fine-grained, fossiliferous marine sediment directly overlying till, with no interceding littoral sediment, indicates that rapid marine inundation accompanied ice retreat (cf. Bednarski, 1988). The structureless to rhythmically laminated mud represents suspension settling in areas remote from meltwater input, but with abundant sediment supply from turbid overflow plumes. Occasional dropstones in the mud indicate ice rafting and the presence of a tidewater glacier margin in the vicinity. The date of 13 600 ± 190 years BP (GSC-4270) on shells at Butter Brook (Table 1) provides a minimum age estimate on initial ice retreat across the present coastline.

The overlying sand and silt beds, with some evidence of current flow, are interpreted to represent deposition from traction currents and suspension settling nearer to the point of meltwater inflow. Rapid sedimentation led to dewatering and deformation of these sediments. Upper gravels, where present (e.g., Fischells, Maidstone), appear to be mostly fluvial in origin, deposited after sea level had fallen.

RIDGED AREAS

Sediments exposed through the ridged topography display rapid vertical and lateral changes. Sediment characteristics suggest deposition by debris flow, underflow, current flow and overflow. Interbedding and lateral-facies transitions demonstrate that all these processes were operating simultaneously rather than sequentially. Radiocarbon dates on shells from fossiliferous units (sands and muds) in various stratigraphic positions display a range of dates between 13 500 and 13 900 years BP, supporting this hypothesis. Given the range of sedimentary processes operating over short distances and time frames, the sequences observed within the ridged topography may be explained in terms of morainal bank deposition in an ice-contact glaciomarine environment.

Morainal banks form when a glacier teminus is at a stable or quasi-stable position. These can be either continuous ridges or less continuous to fan-shaped. The fans originate from glaciofluvial point sources and can interfinger with other bank sediment. These grounding-line fans (previously named subaqueous outwash fans) are the marine forms of glacier contact fans (Figure 4). Fan apices are mainly composed of coarse marine outwash, where bedload is dumped from a highly sediment-charged jet issuing from a meltwater stream (Rust, 1977). In modern analogues, the jet often detaches from the bottom to form a buoyant plume as it enters the sea. More distally, fans are made up of deposits from sediment gravity flows, underflows, interflows and overflow plumes. These distal fan deposits interfinger with proglacial mud.

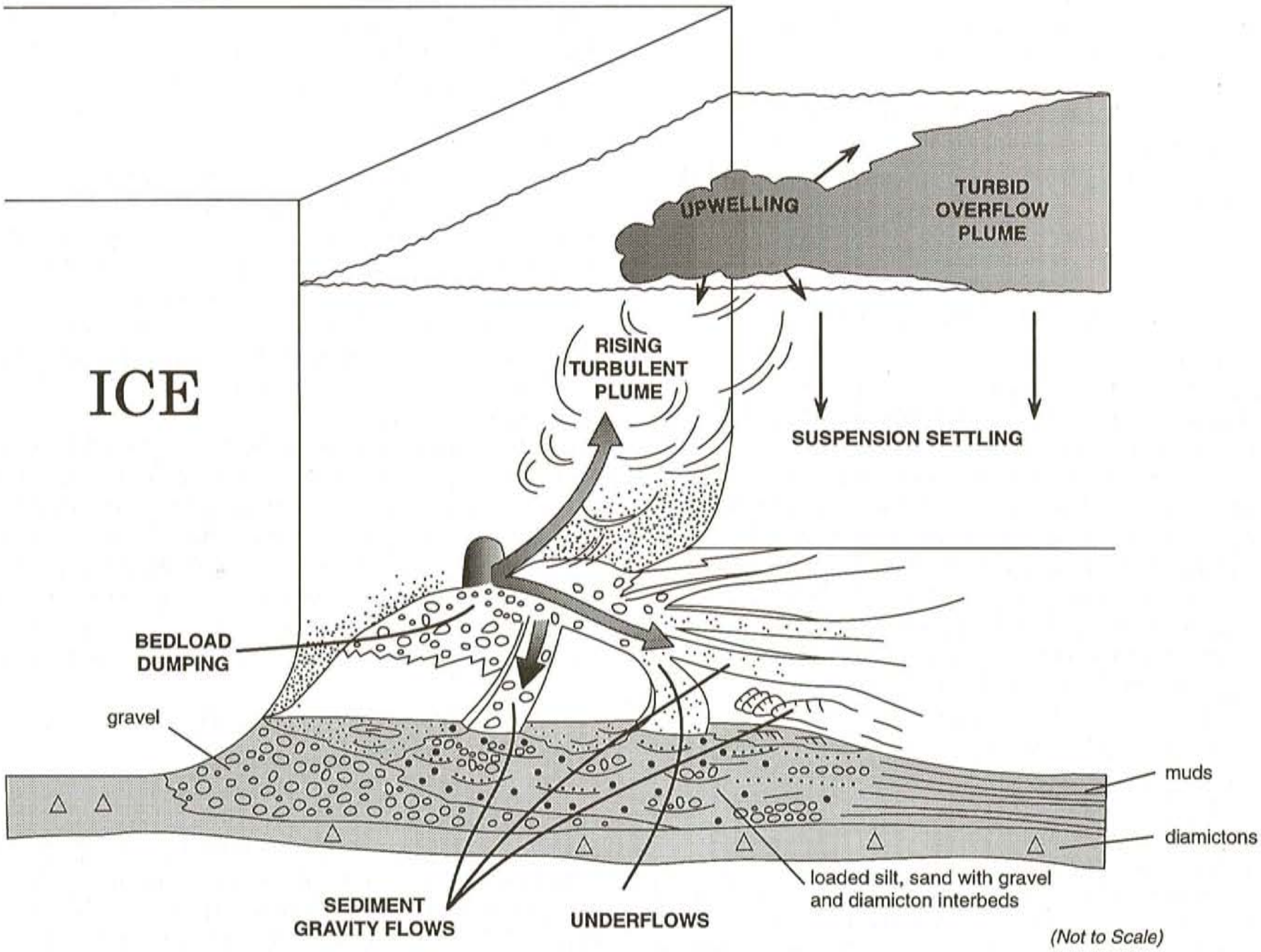

Figure 4. *Conceptual sketch of grounding-line fan (after Powell, 1990, 1991), showing a sediment-laden meltwater stream entering the sea at the base of a grounded ice margin.*

The sections exposed in ridged topography display sedimentary sequences consistent with a grounding-line fan environment. Interbedded gravel, sand and diamicton (Bank Head, Jeffrey's and Crabbes Head) represents alternating debris flows, sediment gravity flows and underflows originating at the grounding line and on the proximal fan slopes. The fossiliferous pebbly mud (Journois, Robinsons Head, Jeffrey's and Crabbes Hill) is indicative of relatively quiet water conditions and likely accumulated when the discharge jet was focused in another direction (cf. Powell and Molnia, 1989). In contrast, the thick gravel beds in each of the ridge sections are interpreted as being deposited as sediment dropped from suspension when the turbid freshwater plume lost its competency as it rose buoyantly or continued as an underflow beyond its efflux (cf. Powell and Molnia, 1989; Powell, 1990). At several sites, these gravel beds are deformed and steeply dipping toward the former ice margin. This is interpreted to represent post-depositional deformation due to the loss of ice support on the proximal fan slope as the glacier margin retreated.

In summary, the stratigraphy and sedimentology in the coastal sections between Bank Head and Highlands can be readily interpreted within the context of a retreating tidewater glacier system. The rapid vertical and lateral facies changes in ridged sections is consistent with the dynamic depositional environment at the grounding lines of temperate and subpolar tidewater glaciers (cf. Powell, 1990). Each of the ridges along the coast represent the former site of a grounding-line fan that has a sediment source from a glacial tunnel that discharges meltwater directly into the sea. Eskers inland of the ridges are further evidence of channelized subglacial meltwater flow. During slow ice marginal retreat, fans may aggrade rapidly building ridges normal to the tidewater front. The fan is made up of marine outwash, which includes a range of particle sizes from gravel to clay deposited by the jet of subglacial meltwater. Sediment gravity-flow deposits from the marine outwash and deposits settled from the buoyant plume of turbid meltwater after it detaches from the seafloor make up the more distal fan component. Non-ridged areas along the coastline are dominated to varying degrees by these distal fan sediments.

DISCUSSION AND DEPOSITIONAL MODEL

The complex vertical and lateral changes observed in coastal sections between Highlands and Bank Head are incompatible with a relatively simple three-fold stratigraphy as described by MacClintock and Twenhofel (1940) and Brookes (1974). Although the Highlands section and possibly the Robinsons Head section might initially be interpreted as showing three temporally distinct major depositional events, the detailed sedimentology does not fully support this. The basal diamicton, although variable in character, was likely deposited during initial deglaciation of the coast as previously suggested by MacClintock and Twenhofel (*op. cit.*) and Brookes (*op. cit.*). The overlying sediments, however, are generally not deltaic (as interpreted for the St. George's Bay Delta by MacClintock and Twenhofel, 1940, and Brookes, 1974). The most common sequence consists of well-sorted sand, silt and clay, commonly with load structures, and interbeds of gravel or diamicton at some locations. These units appear to have been deposited rapidly as underflows and sediment gravity flows and by suspension settling from turbid overflow plumes near the grounding line of a tidewater glacier margin. They do not necessarily indicate the inland retreat of the ice front and construction of a delta as implied by Brookes (1974).

The Robinson's Head Drift, consisting of an upper coarse till and ice-contact gravels (Brookes, 1974), is observed only intermittently along the coast and is interpreted in a somewhat different context than that suggested by MacClintock and Twenhofel (1940) and Brookes (1974). The upper diamicton at Highlands is strong evidence for the proximity of an ice margin whether deposited as a basal till (as suggested by Brookes, 1974) or resedimented (as indicated by moderate girdle fabrics observed in this study). Similarly, the upper part of ridged sections show a coarsening-upward sequence into chaotically bedded gravels, interpreted here as ice-proximal marine outwash. Although Brookes (1974, page 25) has argued that the Robinson's Head Drift represents a distinct "surge" of ice from its inland position, the alternative proposed here is that these sediments reflect the fluctuations of a quasi-stable tidewater margin near the present coast. Planar- and trough-bedded gravels capping non-ridged sections indicate fluvial deposition after sea level had fallen. Although some of these sections are located in areas unaffected by the Robinsons Head readvance (Brookes, 1974), others (e.g., Robinsons River) lie within its proposed limits.

If the sedimentary sequences associated with deglaciation can be interpreted as the product of grounding-line sedimentation at a tidewater glacier margin then ice-margin fluctuations need not be a response to climatic forcing. Whereas stability of marine glacial termini is ultimately a product of mass balance, factors affecting relative water depth such as eustasy, isostasy, and sediment yield are important second-order controls on termini fluctuations (Powell, 1991). The emergence history of St. George's Bay, Newfoundland, indicates a continually falling sea level between 13 500 and at least 12 000 years BP, which may have resulted in a temporary advance of the grounding line during overall glacial retreat (as discussed by Brookes, 1977). Alternatively, deposition of grounding-line systems can change relative water depth and consequently alter the stability of tidewater termini independent of climate and sea level. Ongoing fieldwork will attempt to address these issues.

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