Current Research (2008) Newfoundland and Labrador Department of Natural Resources
Geological Survey, Report 08-1, pages 35-44

A RE-EVALUATION OF THE COASTAL STRATIGRAPHY ALONG THE SOUTHWESTERN BURIN PENINSULA

T. Bell, M. Batterson[1] and P. Blundon
Department of Geography, Memorial University, St. John's, NL A1B 3X9

ABSTRACT

Quaternary sections exposed along the southwest coast of the Burin Peninsula, Newfoundland, have yielded critical information for prevailing ideas on regional glacial history, including multiple glaciations predating the Wisconsinan, Sangamonian marine transgression, and restricted late Wisconsinan ice extent. New field observations on these coastal sections indicate much greater stratigraphic and sedimentological complexity than described by previous researchers, the occurrence of fossiliferous tills and a more substantial deglacial sedimentary record associated with onshore ice flow. A preliminary interpretation suggests that the entire sedimentary sequence exposed in coastal bluffs postdates the mid-Wisconsinan and was deposited in a deglacial tidewater environment associated with several ice-flow events.

INTRODUCTION

This paper describes preliminary results of a multi-year project to re-evaluate the Quaternary stratigraphy exposed in coastal sections along the southwestern Burin Peninsula, Newfoundland. Three sites were visited in 2007 – Great Dantzic Cove, Little Dantzic Cove and Allan's Island (Figure 1). These sites were reported by both Grant (1975) and Vanderveer (1977), and later documented in more detail by Tucker (1979) and a related publication (Tucker and McCann, 1980). Later, Grant and Batterson (1988) provided additional details in a local field guide. These sites have attracted research attention because they expose some of the most extensive Quaternary sections in Newfoundland and are interpreted to represent one of only two documented sites where evidence for multiple late Quaternary glaciations is preserved. The sedimentological and stratigraphical interpretations provided by these authors have remained untested in the literature, even though our understanding of glacial and glaciomarine depositional models have advanced in the interim. This project proposes to address this issue and test the interpretations.

The Quaternary sections described from the southwestern Burin Peninsula have generated critical insights to the regional glacial history, including the recognition of pre-last glacial episodes and the non-glaciation of much of the peninsula during the late Wisconsinan. Given the rarity of pre-last glacial deposits in Newfoundland (*cf.,* Grant, 1989) and the growing recognition that insular Newfoundland was completely inundated by late Wisconsinan ice (Shaw *et al.*, 2006), including coastal mountains (Gosse *et al.*, 2006), it is important to re-evaluate the original data and interpretations on which these important conclusions were based.

PREVIOUS INVESTIGATIONS

The sediments exposed in coastal sections at Great Dantzic Cove (GDC), Little Dantzic Cove (LDC) and Allan's Island (AI) are central to the chronology of regional glacial events. Two till units were described by Tucker (1979) and Tucker and McCann (1980) at all three sites (Figure 2) and consisted of a lower compact grey-pink silty till between 14 and 37 m thick and an upper brown sandy till between 7 and 9 m thick, which was substratified at GDC and iron-stained in its lowermost 2 m at LDC. The two tills were separated by a 4-m-thick, crossbedded sand unit at AI, and a similar bed (faulted and crossbedded fine sand and silt within the lower till, 26 m below the contact of the two till units) was described at GDC (Tucker, 1979; Tucker and McCann, 1980).

The sand unit was only fossiliferous at GDC where it contained a diverse marine foraminiferal assemblage, on the basis of which it was interpreted to represent marine overlap of the lower Burin Peninsula to at least 15 m above present sea level and "tenuously" correlated by Tucker and McCann (1980) with the Salmon River Sand of Nova Scotia, dated by

[1]Geochemistry, Geophysics and Terrain Sciences Section

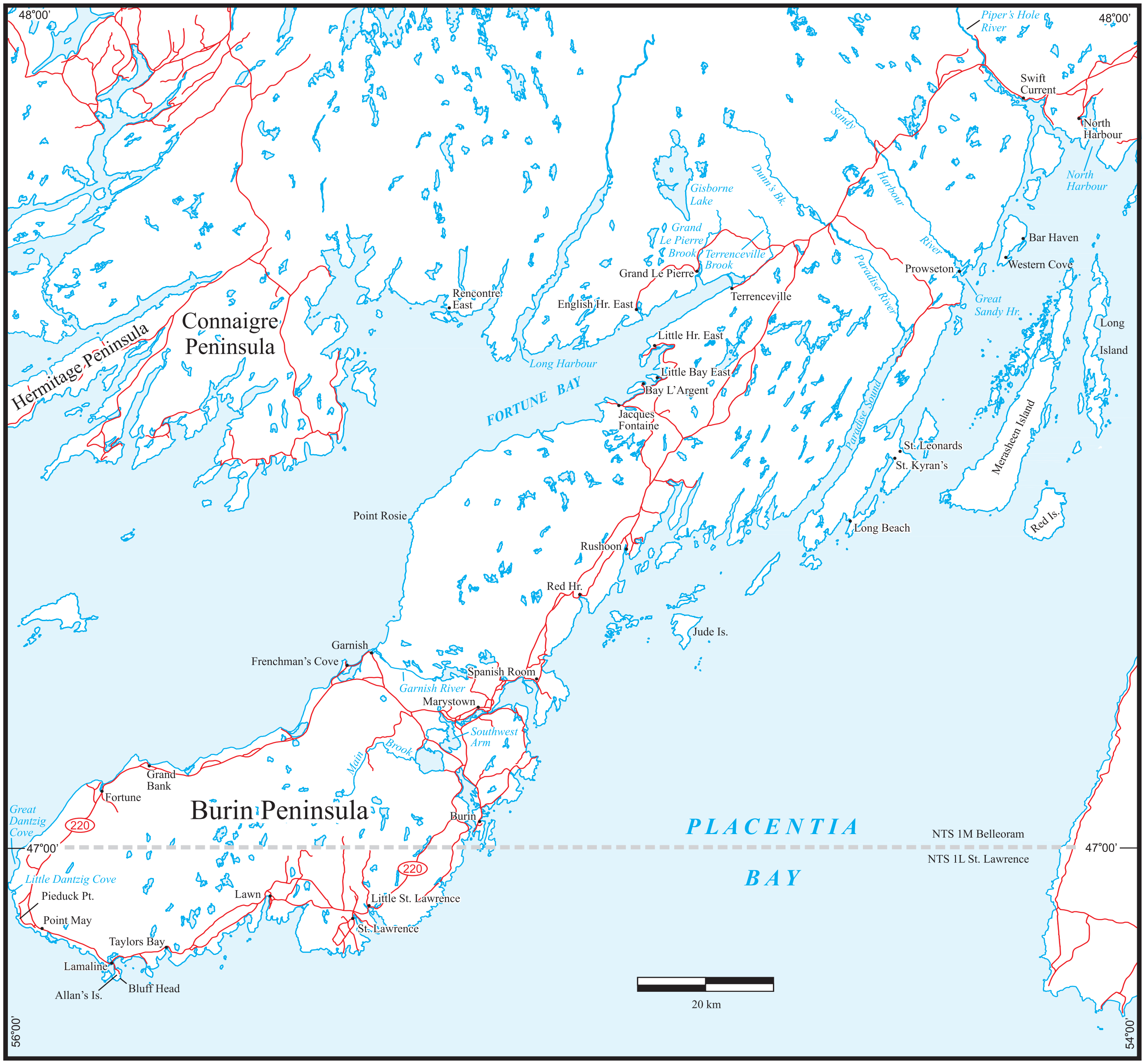

Figure 1. *Location map with place names mentioned in the text.*

Neilsen (1974) at mid-Wisconsinan. On this basis, Tucker (1979) and Tucker and McCann (1980) assigned an early Wisconsinan age to the underlying till. A subsequent revision assigned the Salmon River beds to the Sangamon interglaciation (Clarke *et al.*, 1972), and this implied that the underlying till at GDC predated the Wisconsinan. The marine origin and *in situ* context of the sand unit was questioned by Grant and Batterson (1988) who noted the mixed foraminiferal facies, ranging from arctic to temperate, deep-water to nearshore and open ocean to low salinity, and thus reinterpreted the unit to represent redeposited marine mud and foraminifera in a non-marine environment. In a regional synthesis of Quaternary events across Atlantic Canada, Grant (1989) concluded that both lower and upper tills of southwestern Burin Peninsula predate the last interglaciation and possibly correlate to oxygen isotope stage 12 and 6, respectively.

Largely on the basis of striation patterns, and to a lesser degree glacial geomorphology and drift lithology, Tucker and McCann (1980) associated the lower till at GDC, LDC and AI with the "Fortune Bay" glacial event, that inundated the lower Burin Peninsula and ice flowing southeast (120-170°) across Fortune Bay from Hermitage and Connaigre peninsulas. The interpretation that the upper till was related to a north and northwest flow of ice from an offshore source on the continental shelf was considered by Tucker and McCann (1980) to be more "contentious" because it contra-

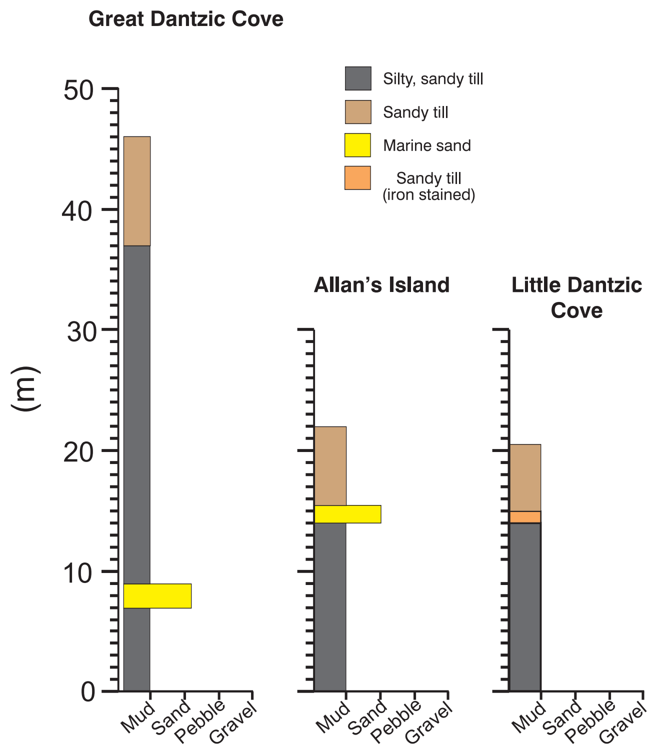

Figure 2. *Stratigraphic logs of coastal sections at Great Dantzic Cove, Allan's Island and Little Dantzic Cove (redrafted from Tucker and McCann, 1980).*

dicted the classical view of highland glaciation and radial ice flow to lowlands and the coast. Nevertheless, their interpretation was based on a strongly developed striae pattern (280-320°) on the south coast and well-defined ice-marginal landforms on the lower Burin Peninsula; although till fabric and pebble lithology data from the upper till were inconclusive (Tucker and McCann, 1980).

Regional Quaternary mapping by Batterson and others (Batterson *et al.*, 2006; Batterson and Taylor, 2007) documented new details on palaeo ice-flow history for the Burin Peninsula. Their striation and landform data substantiate the pervasive south-southeastward flow from an ice source to the north and identify a younger regionally extensive westward ice flow that crossed the Burin Peninsula from Placentia Bay to Fortune Bay. This event was not recognized by Tucker and McCann (1980) for the central part of the peninsula and it is uncertain whether the westward to northwestward ice flow documented by both Tucker and McCann (1980) and Batterson *et al.* (2006) on the south coast of the peninsula is part of the same event or a separate younger event. Unfortunately, the lack of striated bedrock in critical areas means that the two striation datasets cannot be linked.

COASTAL STRATIGRAPHY

SITE DESCRIPTIONS

Field work was conducted during July 2007 from a base in Grand Bank. The coastal sections at GDC, LDC and AI are extensive but poorly exposed. Wave activity during storms and high tides erode the lower sediments and cause subsequent slumping. The largest section is at GDC where a broad embayment over 1.5 km wide is backed by up to 50-m-high cliffs of Quaternary sediments. Fine-grained siliciclastic sedimentary and minor limestone bedrock of the Late Proterozoic to Middle Cambrian Young Cove Group (O'Driscoll *et al.*, 1995) is exposed at either end of the section and in places along the base of the section. The reconnaissance half-day visit focused only on the southern end of the section, which sufficed to illustrate the lateral and vertical variability of exposed sediments and to reveal the presence of fossiliferous beds. Radiocarbon dates on two shell samples are reported here, and on the basis of these limited but key results, re-investigation of GDC section is justified. Access to the cove was by foot from Highway 220; a 2-hour trudge over predominantly blanket bog.

Little Dantzic Cove is 0.75 km wide and has less extensive and more poorly exposed Quaternary sediments than GDC. A total of 5 days was spent on the section and although detailed bed by bed descriptions and careful mapping of lateral changes would be preferred, the available exposure permitted logging of only a single composite stratigraphic section and some description of lateral variability. Clast fabric analysis was used to characterize diamicton units. Access was along a coastal path from Pieduck Point, 1 km to the southeast.

Allan's Island is connected to the coast by a 600-m-long causeway, which also links the two communities of Lamaline and Allan's Island. The seaward side of the island, from the lighthouse (Bluff Head) to the causeway, has intermittent exposures of Quaternary sediments, with the thickest section at the northwestern end. A reconnaissance half-day visit focused on this latter section and despite poor exposure and weather conditions, a composite stratigraphic section was logged and two clast fabrics recorded. The section sits on striated bedrock.

LITTLE DANTZIC COVE

The Quaternary section at LDC is up to 25 m thick and sits in a bedrock depression between two rocky headlands (Plate 1). Bedrock is Late Proterozoic to Middle Cambrian

Plate 1. *View looking south across the coastal section at Little Dantzic Cove. The stratigraphic log in Figure 3 was composed from discontinuous exposures in the central part of the section, where wave action is eroding the base of the coastal cliff. Note person in foreground for scale.*

fine-grained siliciclastic sedimentary rock and minor limestone of the Young Cove Group (O'Driscoll *et al.*, 1995). Glacial striations are preserved on resistant bedrock surfaces between LDC and Pieduck Point and indicate a consistent southward ice flow (170 to 175°). Within LDC the bedrock surface is largely exposed in the intertidal zone. Where it rises above high tide, it is severely weathered and shattered, and has a transitional contact with the overlying diamicton. The colour of this diamicton closely reflects the local clast content and underlying bedrock, ranging from bluish grey to pinkish brown. With height above the bedrock contact, the diamicton is less stony and had greater variability in clast lithology.

A composite stratigraphic log (Figure 3) based mostly on discontinuous exposures near the centre of the section revealed three main sedimentary units: basal diamicton, stratified sandy gravel with interbedded diamicton, and upper diamicton. These units are described briefly below.

Basal Diamicton

The lower 10 to 12 m of the section rests directly on bedrock and is composed of a matrix-dominated compact diamicton ranging from reddish to brownish grey (Munsell colour 2.5YR 5/1 to 5/2). The matrix is silt dominated but becomes sandier and contains thin lenses of pebble gravel toward the upper contact. It displays a fissile structure. Clast content ranges from 30 to 60% and consists of subangular to subrounded pebbles, cobbles and boulders. Cobbles and boulders are facetted and striated. Three of four clast fabrics display weak to moderately strong clusters (S_1 = 0.6-0.64; K = 1.1-1.5), with shallow mean plunge angles (2-14°) and mean orientations ranging from northwest to northeast (17°, 46°, 310°). The basal diamicton is interpreted to represent a subglacial till deposited by ice moving generally southward across the coast (Hicock *et al.*, 1996).

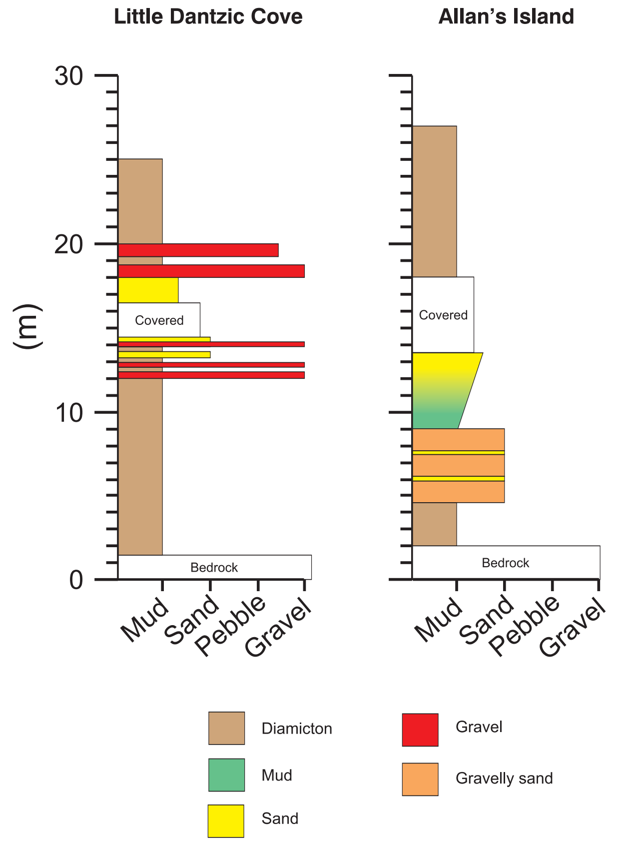

Figure 3. *Composite stratigraphic logs of coastal sections at Little Dantzic Cove and Allan's Island based on new observations from fieldwork in 2007.*

Stratified Sand and Gravel

The middle unit at LDC is highly variable, ranging in composition from a diamicton to clast-supported cobble and boulder gravel, to finely laminated sand and silt (Plate 2). The lowermost 2 m consists of interbedded sandy gravel and diamicton. A pebble to cobble, poorly sorted sandy gravel rests on the basal diamicton along an abrupt and wavy contact. Gravel clasts are iron-stained on their undersides. Diamicton beds are of variable thickness and geometry and range in matrix texture from sandy silt to silty sand. In places, thin (1 to 2 mm) sand lenses appear beneath larger cobbles within diamicton, and clasts of diamicton occurred within gravel.

At 14 m above sea level (asl) there is a 30- to 40-cm-thick bed of cobble-supported gravel with an indistinct line of boulders and large cobbles. The unit is abruptly and conformably overlain by 30-cm-thick interbedded medium- to fine-sand and sandy silt with some individual beds fining upward to silt. Above a 2-m-high obscured section there is a 1.5-m-thick exposure of predominantly laminated fine sand and silt. The lowermost part of the unit is highly compact and deformed with faulted, folded and brecciated laminae.

Plate 2. *A) Photograph of finely bedded medium to fine sand and silt abruptly overlying sandy gravel from the middle unit at Little Dantzic Cove. Note iron staining on some of the cobble gravel. B) Photograph of coarse gravel beds underlying the upper diamicton at Little Dantzic Cove. The gravel is poorly sorted, faintly stratified and clast-supported in places. A metre-rule is present for scale.*

At 18 m asl the laminated fine sediment is abruptly overlain by clast-supported, grading upward to matrix-supported, cobble to boulder gravel having a distinct boulder line occurring near the contact. A 10-cm-thick, brownish, silty diamicton bed overlays the gravel along an abrupt and irregular contact and underlaid a second clast-supported pebble to cobble gravel bed, which is faintly stratified and contains rafts of brown diamicton near its base. Clasts in both gravel beds are iron-stained.

The middle unit at LDC is interpreted to represent subaqueous outwash deposition near a meltwater outlet along a tidewater glacier front. The interbedded sandy gravel and diamicton beds are typical of a grounding line environment where meltwater-transported sand and gravel deposited on local subaqueous fans alternates with debris-flow sedimentation along the grounding-line front (Benn, 1996). Suspension settling from turbid overflow plumes, along the tidewater margin, results in laminated fine sand and silt, and may abruptly alternate with coarse, clast-supported gravel where high-energy meltwater jets issuing from ice-front portals shift orientation across the subaqueous fan and deposit coarse bedload (Benn, 1996; Lønne, 1995). Iron staining of clasts is interpreted to represent fluctuations in the water table within gravel beds, rather than evidence for major ice-free periods during deposition of the middle unit.

Upper Diamicton

The 5-m-thick unit that, for the most part, caps the LDC section is composed of a pinkish grey to brown diamicton (Munsell colour 5YR 5/2 to 7.5YR 5/2) with beds, stringers and lenses of both gravelly (granule) sand and silt with granules and pebbles. The contact with the underlying unit varies from gradational to abrupt between gravelly sand and silty sand diamicton. The diamicton contains 20 percent clasts between pebble and cobble size, with faceting and iron-staining. Two of three clast fabrics display moderately strong girdles (S_1 = 0.58-0.66; K = 0.8-0.9) with low mean plunge angles (3° and 8°) and diagonally opposite plunge directions (21° and 227°). A third fabric has a moderately strong cluster with a plunge direction of 19° and a mean plunge angle of 5°.

The upper diamicton is tentatively interpreted to be remobilized subglacial till. The interbedded diamicton and gravelly sand and silt layers are characteristic of stacked subaqueous debris flows originating at a grounding-line margin, and the two girdle clast fabrics are consistent with debris-flow movement (Benn, 1994). In addition, the gradational lower contact suggests a transition from subaqueous fan to ice-contact or ice-proximal deposition. The moderately strong cluster fabric with low plunge angles, however, is typical of a subglacial meltout process (Shaw, 1982), which suggests a subglacial origin for some components of the diamicton. There is no clear ice-flow direction preserved in the fabric as the low plunge angles may imply either north-northeast or south-southwest ice movement.

ALLAN'S ISLAND

The discontinuous exposure logged at AI (Figure 3) thickened from 17 to 29 m along the coast (Plate 3) and consisted of three sedimentary units – an upper and lower diamicton and intervening gravel, sand and mud. The upper diamicton was only observed where the section thickened to the north. Rhyolite ash-flow tuff bedrock of the Neoproterozoic Marystown Group that underlies the basal diamicton was striated with two primary ice-flow directions (Plate 4a); the oldest set was pervasive on the bedrock surface and recorded ice movement toward the south (187°), whereas the younger set occurred only on the uppermost surface of the outcrop and indicated an ice movement toward the north-northwest (337°).

Basal Diamicton

The diamicton overlying bedrock is a uniform, stony (40 percent clast content), matrix-supported, reddish brown diamicton (no Munsell colour code available) with a mostly silty matrix. It displays a fissile structure and is dominated by a few local rock types that impart a pinkish hue. The diamicton has variable thickness, up to 3 to 4 m in places. Clasts preserve striations and faceting. One clast fabric recorded a moderately strong primary eigenvalue but was classified as a weak girdle (S_1 = 0.65; K = 0.9; E = 332°). The fissile structure of the diamicton and the striated bedrock on which it rests tentatively suggests a subglacial origin.

Gravel, Sand and Mud

Weakly stratified gravelly sand ca. 4 m thick, with intrabeds of well-sorted medium sand (Plate 4b), overlay the basal diamicton along a sharp contact. A several metre-thick, compact mud rests directly on the gravelly sand along a conformable, sharp contact. The mud appears to coarsen upward into compact fine sand with stringers of coarse sand and granule/pebble gravel. Slumped material obscures much of the section between 13 and 19 m asl, and although the exposure typically resumes with the upper diamicton, in one place it is underlain by well-sorted sand at 21 m asl. The sand appears similar to the bed exposed at 13.5 m and therefore it may compose much of the section between 8 and 21 m asl. Farther south along the section, however, a poorly sorted pebble to boulder gravel is exposed between 10 m asl and the section surface at 17 m asl. Some of the boulders were 1 to 2 m in diameter. Farther north, the mud and sand are not seen in section and the lower sandy gravel is overlain by almost 5 m thickness of steeply dipping (30–40°) well-sorted to poorly sorted sandy gravel. The gravel beds appears to dip northward into the section.

Plate 3. *Low aerial view of northern end of coastal exposure at Allan's Island. The community of Allan's Island appears in the left background. The section rests on striated bedrock (Plate 4a) and is capped by diamicton at this end of the exposure. Brown mud and sand beds overlying the lower diamicton are visible in the right middle ground.*

The middle unit at AI is interpreted to be subaqueous outwash, with abrupt changes in grain size representing fluctuations in energy and/or sediment supply at a tidewater glacier margin (Benn, 1996; Lønne, 1995). Similar to the middle unit at LDC, depositional processes likely ranged from suspension settling of fine sand and mud from turbid plumes to rapid deposition of gravel and coarse sand from meltwater jets (*cf.,* Bell *et al.*, 2001).

Upper Diamicton

A highly compact, silty diamicton with recurring stringers of gravelly sand caps the northern end of the section at AI. The clast content is between 30 and 40 percent with subrounded cobbles and pebbles most common. It is up to 9 m thick in places. One clast fabric produced a weak to moderately strong cluster (S_1 = 0.62; K = 2.2) with a principal plunge direction of 248°. The diamicton structure resembles stacked debris flows (Hicock *et al.*, 1996) and its discontinuous lateral extent may suggest a local lense only. The single clustered clast fabric was not consistent with a debris-flow origin and further data collection is needed to resolve the apparent contradiction.

Plate 4. *A) Photograph of striated bedrock underlying glacial diamicton at the base of Allan's Island section. The pick axe handle is oriented parallel to the pervasive striation set (187°) on the bedrock surface, whereas the metre-rule parallels the younger striation set (337°) preserved only on the uppermost surface of the outcrop. B) Photograph of steeply dipping beds of gravelly sand at Allan's Island. Gravel clasts vary from subangular to subrounded and range in grain size from pebbles to boulders. The beds represent fluctuating discharge on a subaqueous fan in a tidewater glacier environment. Note yellow 10-cm-long pencil for scale.*

GREAT DANTZIC COVE

A one-half day reconnaissance visit to the coastal section at GDC revealed some important new information on site stratigraphy and sediment characteristics and justifies more detailed fieldwork in 2008. Key findings include:

1) There was a greater range of sediment types exposed (Plate 5) than previously described, including multiple diamictons, two separate stony mud units, and stratified gravel, and there is much greater horizontal and vertical variability in sediment units (Figure 3).

2) At least three distinct diamicton beds are observed in exposures; one basal unit overlying stony mud, one diamicton capping the section, and at least one other diamicton in mid section (Figure 3). They are initially distinguished by colour and textural characteristics.

3) Two diamictons are fossiliferous, containing fragments of marine shells. A single fragment from the basal diamicton provided a radiocarbon date of 39 810±470 BP (Beta 237892), whereas another fragment from a diamicton more than 30 m higher in the section provided a date of 39 370±450 BP (Beta 237891). The two age ranges overlap and suggest that much of the GDC section was deposited during a short interval sometime after 40 000 BP, likely during the late Wisconsinan glacial stadial.

4) The occurrence of two stony mud units is interesting because, assuming they represent relatively low-energy marine environments, it suggests that the GDC section records two marine transgressions, the highest of which may be more than 35 m asl and late Wisconsinan.

Detailed stratigraphic mapping and sedimentological analysis are planned for the extensive section at GDC in

Plate 5. *A view of one small area of the coastal section at Great Dantzic Cove. It is shown here to illustrate the variability in sedimentary units and complex stratigraphy observed during a reconnaissance visit to this site. A lower diamicton (at person level) is overlain by seaward-dipping gravelly sand (most clearly visible in right middle ground), a second diamicton (dark brown unit) and a coarse, poorly sorted gravel capping the section. Note the interfingering of the coarse gravel and second diamicton in the upper left side of section.*

2008. In particular, lateral and vertical tracing of fossiliferous diamictons is required, together with a fuller understanding of the relationships between the regional ice-flow history deciphered from the bedrock striation record and the clast-fabric and erratic content of multiple diamictons exposed in section. The possibility that GDC preserves a record of at least two marine transgressions is intriguing and presents potential new insights to the glaciomarine history of the region.

DISCUSSION

Reconnaissance mapping of sedimentary exposures at GDC, LDC and AI illustrates much greater stratigraphic complexity than described by previous researchers. The published stratigraphic model of two tills, in places bracketing a sand unit (GDC, AI), oversimplifies the sedimentary sequences exposed along the coastal bluffs and demands a re-evaluation of the glacial and marine events that were proposed on the basis of this model. For example, the revised stratigraphic log for LDC suggests that the entire sedimentary sequence may represent a single deglacial cycle; from subglacial till deposition to grounding-line and subaqueous fan accumulation at a tidewater glacier margin. The presence of a second diamicton at the top of the section, in this case interpreted to be of debris-flow origin, may simply imply a fluctuating tidewater margin, as has been proposed for St. George's Bay, Newfoundland (Bell *et al.*, 2001), and not necessarily a discrete glacial event from an opposing trajectory (Tucker and McCann, 1980). Ice-flow directional indicators from the lower till are consistent with the regionally pervasive Fortune Bay glacial event, which originated from a Newfoundland-centred ice source.

The two radiocarbon dates on shell fragments from diamictons at GDC provide another example of how new data, albeit at a reconnaissance level, allow the established glacial history of the region to be questioned. The mid-Wisconsinan age of ice-transported shells suggests that they were eroded and transported by late Wisconsinan ice. Their overlapping ages suggest that a substantial thickness of the GDC section was deposited over a very short period of time. Both interpretations contradict the established glacial chronology, which asserts that the lowest till in coastal bluffs is at least pre-Wisconsinan and may be oxygen isotope stage 12 and that each till unit is separated by at least one interglaciation (Grant, 1989). This chronology is based, in large part, on the correlative age of foraminiferal assemblages from a mid-section sand unit that commonly outcrops along the coast. Sand samples collected from LDC and AI in 2007 will be analyzed for foraminiferal content to substantiate (or refute) this argument.

Finally, the new observations from AI question both the simple tripartite sedimentary sequence described by Tucker and McCann (1980) and the origin of glacial events responsible for local deposits. A comparison of Figures 2 and 3 reveals that the middle unit is much more complex and diverse than originally described and may be more readily interpreted in terms of a deglacial glaciomarine sequence than a non-glacial, marine transgression. Furthermore, the recognition that the sedimentary sequence at AI sits on bedrock preserving two sets of striations, the younger of which records a northward ice flow, implies that the overlying sediments are unrelated to the Fortune Bay glacial event and solely record the deglaciation of an ice advance originating offshore. Such an ice advance has previously been postulated on the basis of bedrock striations along the south coast of the peninsula, which have been recorded as far west as Point May (Taylor, 2001) and has been tentatively associated with the upper till in coastal sections, although ice-directional indicators in the till were inconclusive (Tucker and McCann, 1980). The recognition that coastal sections comprising a range of sediments from diamicton to mud to stratified sand and gravel may be associated with this glacial episode provides new opportunities to investigate the configuration and timing of a contentious event in the glacial history of the region (*cf.*, Batterson *et al.*, 2006; Brushett *et al.*, 2007).

ACKNOWLEDGMENTS

The authors would like to thank Dr. David Liverman for his constructive comments on the paper. Terry Sears (Geological Survey) and Charles Conway (Geography Department, Memorial University) assisted in drafting the figures. Funding for this project was provided by the Natural Sciences and Engineering Research Council of Canada.

REFERENCES

Batterson, M., Taylor, D., Bell, T., Brushett, D. and Shaw, J.
2006: Regional ice-flow mapping, surficial geology and till geochemistry of the northern Burin Peninsula and adjacent Placentia Bay. *In* Current Research. Newfoundland and Labrador Department of Natural Resources, Geological Survey, Report 06-1, pages 161-176.

Batterson, M. and Taylor, D.M.
2007: Till geochemistry surveys and preliminary Quaternary mapping of the Burin Peninsula and adjacent areas. *In* Current Research. Newfoundland and Labrador Department of Natural Resources, Geological Survey, Report 07-1, pages 197-214.

Bell, T., Liverman, D.G.E., Batterson, M.J. and Sheppard, K.
2001: Late Wisconsinan stratigraphy and chronology of southern St. George's Bay, southwest Newfoundland: a re-appraisal. Canadian Journal of Earth Sciences, Volume 38, pages 851-869.

Benn, D.I.
1994: Fabric shape and the interpretation of sedimentary fabric data. Journal of Sedimentary Research, Volume 64A, pages 910-915.

1996: Subglacial and subaqueous processes near a glacier grounding line: sedimentological evidence from a former ice-dammed lake, Achnasheen, Scotland. Boreas, Volume 25, pages 23-36.

Brushett, D., Bell, T., Batterson, M.J. and Shaw, J.
2007: Ice-flow history of Placentia Bay, Newfoundland: multibeam seabed mapping. *In* Current Research. Newfoundland and Labrador Department of Natural Resources, Geological Survey, Report 2007-1, pages 215-228.

Clarke, A.H., Jr., Grant, D.R. and Macpherson, E.
1972: The relationship of *Atractodon stonei* (Pilsbry) (Mollusca, Buccinidae) to the Pleistocene stratigraphy and paleoecology of southwestern Nova Scotia. Canadian Journal of Earth Sciences, Volume 9, pages 1030-1038.

Gosse, J.C., Bell, T., Gray, J.T., Klein, J., Yang, G., and Finkel, R.
2006: Using cosmogenic isotopes to interpret the landscape record of glaciation: Nunataks in Newfoundland. *In* Glacier Science and Environmental Change. *Edited by* P.G. Knight. Blackwell Publishing Ltd., pages 442-446.

Grant, D.R.
1975: Glacial features of the Hermitage-Burin Peninsula area, Newfoundland. *In* Current Research, Part C. Geological Survey of Canada, Paper 75-1, pages 333-334.

1989: Quaternary geology of the Atlantic Appalachian region of Canada. *In* Quaternary Geology of Canada and Greenland. *Edited by* R.J. Fulton. Geological Survey of Canada, Geology of Canada no. 1, pages 393-440.

Grant, D.R. and Batterson, M.J.
1988: Guidebook for CIM field trip to the Burin Peninsula. Unpublished report, 19 pages.

Hicock, S.R., Goff, J.R., Lian, O.B. and Little, E.C.
1996: On the interpretation of subglacial till fabric. Journal of Sedimentary Research, Volume 66, pages 928-934.

Lønne, I.
1995: Sedimentary facies and depositional architecture of ice-contact glaciomarine systems. Sedimentary Geology, Volume 98, pages 13-43.

Neilsen, E.
1974: A mid-Wisconsinan glacio-marine deposit from Nova Scotia. *In* Quaternary Environments. *Edited by* W.C. Mahaney. York University-Atkinson College, Toronto, Ontario, Geographical Monographs No. 5, pages 59-60.

O'Driscoll, C.F., Stapleton, G.J. and King, D.W.
1995: Mineral Occurrence Map, Belleoram/St. Lawrence, Newfoundland. Map 95-16. Scale 1:250 000. Newfoundland Department of Natural Resources, Geological Survey.

Shaw, J.
1982: Melt-out till in the Edmonton area, Alberta. Canadian Journal of Earth Sciences, Volume 19, pages 1548-1569.

Shaw, J., Piper, D.J.W., Fader, G.B., King, E.L., Todd, B.G., Bell, T., Batterson, M.J. and Liverman, D.
2006: A conceptual model of the deglaciation of Atlantic Canada. Quaternary Science Reviews, Volume 25, pages 2059-2081.

Taylor, D.M.
2001: Newfoundland Striation Database. Newfoundland Department of Mines and Energy, Geological Survey, Open File NFLD/2195, version 4.

Tucker, C.M.
1979: Late Quaternary events on the Burin Peninsula, Newfoundland. Unpublished Ph.D. thesis, McMaster University, Hamilton, Ontario, 282 pages.

Tucker, C.M. and McCann, S.B.
1980: Quaternary events on the Burin Peninsula, Newfoundland, and the islands of St. Pierre and Miquelon, France. Canadian Journal of Earth Sciences, Volume 17, pages 1462-1479.

Vanderveer, D.G.
1977: Surficial and glacial geology gravel resource inventory, Burin Peninsula. Newfoundland Department of Mines and Energy, Mineral Development Division, Open File NFLD/958, 7 pages.