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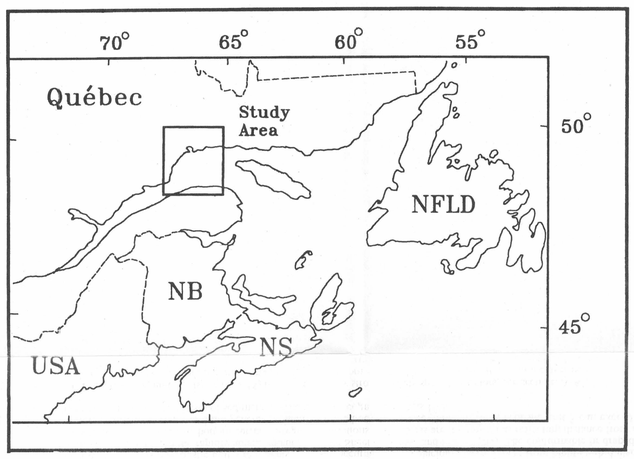
J.P. Syvitski, S.J. Hinds and H. Josenhans, 1992



QUATERNARY MARINE GEOLOGY OF THE N.W. GULF OF ST. LAWRENCE

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INTRODUCTION

Syvitski & Praeg (1989) recognised five regional Quaternary stratigraphic units in the Gulf of St. Lawrence as being related to the advance and retreat of the Late Wisconsinan Ice Sheet, subsequent marine transgression/regression, and reworking of postglacial deposits. This open file map series presents the distribution and acoustic properties of these unconsolidated Quaternary units through a series of isopach and depth to reflector maps, describing the distribution and character of each seismo-stratigraphic units. Ice-contact and glaciomarine units (acoustic units 1 and 2) were emplaced between >18 ka and 14.5 ka BP, marking equilibrium positions of the ice margin and reflecting ice proximal sedimentation associated with ice-terminal stillstands. Deepwater muds (acoustic unit 3) represent ice-distal accumulation of glaciomarine sediment from glaciofluvial plumes between 11 ka and 13.5 ka BP. After this time exceptionally thick nearshore coarse-grained deltaic and estuarine successions (acoustic unit 4) built up. The uppermost proglacial sediment (acoustic unit 5) forms the seabed, reflecting a reworking phase, concomitant with a lowered sea level and ablated Late Wisconsinan ice sheets. For more information readers are referred to Hein et al. (1992) and Syvitski and Praeg (1989).

METHODS

Much of the offshore data was obtained during the C.S.S. Dawson 86-016, 87-023 and 88-008 cruises from the Bedford Institute of Oceanography. Survey data from C.S.S. Dawson 89-007 (Vilks & Rodrigues, 1989) and C.S.S. Baffin 89-008 (Josenhans et al., 1989) increased this data coverage. Four types of acoustic reflection information were collected simultaneously: airgun, Huntec DTS, sidescan sonar, and echo sounding. The ship was positioned by radar (± 25 m accuracy nearshore) and Loran C (± 50 m). The maps are based on a grid of 1765 km of survey lines (Sheet 1). The survey was conducted at speeds of 6-10 km/hr. Filtered air gun seismic reflection profiles (100 to 550 Hz and 300 to 1500 Hz) provide low resolution (3 to 10 m vertical, 4 to 10 m horizontal) penetration at least to the bedrock surface. Filtered Huntec® deep-tow seismic reflection profiles (internal hydrophone: 0.5 to 10 kHz, and external hydrophone array: 0.5 to 3 kHz) provide up to 80 m of high resolution (30 to 50 cm vertical, 1 to 2 m horizontal) subbottom information. Echosounder records were collected using a 12 kHz transducer mounted on the ships' hull.

Sediment thicknesses are reported in metres, calculated using an assumed water velocity of 1.5 km s^{-1} — the thicknesses therefore represent minimum estimates. Details of these field methods can be found in Praeg et al. (1987a,b) and Syvitski (1988).

Seismo-stratigraphic units are defined as successive intervals that can be traced on the basis of distinctive acoustic attributes, bedding styles, and/or unit geometry. Acoustic attributes are the presence and relative strength of both coherent reflections (stratification) and incoherent backscatter (tone), coherency being limited by the resolution of the system. Bedding styles refer to the internal acoustic stratification in relation to the bounding surfaces of the unit. Unit geometry is the nature of the upper bounding reflector and its relation to the basal bounding reflector, and the relation of the interval as a whole to basal topography. Units were established at one or more areas of well-defined or typical section and then traced laterally to establish a regional stratigraphy within which units often display facies variability in their acoustic attributes, bedding style, and geometry.

SEISMO-STRATIGRAPHIC UNITS

On the seismic reflection profiles, the contact between bedrock and the overlying Quaternary succession occurs mainly as an angular unconformity (see sections D-D', I-I', J-J', Sheets 1&2). In the study area, Quaternary cover typically ranges from 25 to 125 m thick, with the thickest deposits located offshore Rivière Ste-Marguerite, Sept-Iles, and Rivière Moisie (Sheet 3).

Bedrock controls, along with the marine, fluvial, and glacial processes of erosion and deposition, have produced a complex subsea geomorphology (Sheet 4). As a consequence of glacioisostatic crustal depression, the post-glacial sea once extended to elevations of 130 m above sea level at Sept-Iles and penetrated up to 50 km inland along glacial and preglacial valleys.

UNIT 5: Offshore, the uppermost acoustic unit 5 (see all seismic sections) forms the seabed almost everywhere and reflects the establishment of modern (post-glacial) sedimentation patterns concomitant with a lowered sea level and ablated Late Wisconsinan ice sheets (Syvitski and Praeg 1989). The unit includes bioturbated pebbly sandy mud, bioturbated sandy silty mud, and rare crossbedded sand (Hein et al., 1992). The sedimentary features and stratigraphic context of this acoustic facies indicate changing oceanographic conditions and decreasing sediment supply. Unit 5 remains thin throughout most of the northwestern gulf (Sheet 5). The basinal mud facies grades laterally into coarser modern deltaic sediments exceeding 20 m in thickness off the mouths of the Moisie and Ste-Marguerite rivers (Sheets 5 & 6). The mud is typically characterized by low tone, weak reflectors (some of which are gas horizons) and a basinal geometry that smooths or masks basinal relief. These acoustic attributes together with core information indicate a muddy organic-rich deposit.

Acoustic unit 5 marks the period when glacial meltwater no longer drained into the gulf, when terrestrial vegetation was established, and mud deposition was confined to deep or protected waters and not subjected to modern tidal or wave action. In shallower water surrounding the basinal muds, the seabed is composed of thin coarse lags developed on older Quaternary units or bedrock. These lags are thought to reflect increased post-glacial current erosion in shallower water levels since the time of the Goldthwait Sea maximum.

UNIT 4: Acoustic unit 4 (Sheets 7 & 8) is characterized by strong and dense acoustic stratification and generally ponded bedding style (see sections A-A', B-B'). The unit commonly contains unstratified lobes representing syndepositional mass flows, as well as buried channels and shear planes related to submarine slides (section C-C'). The lobes may reach 100 m in thickness (Sheet 7) and relate to the position of modern north shore deltas, although deposits of acoustic unit 4 are almost an order of magnitude larger than the post-glacial deposits (acoustic unit 5) related to these deltas (Sheet 5). Paraglacial sediments are coarse grained deposits related to the period of abnormally high rate of sediment transport from a terrestrial ice sheet that was experiencing rapid ablation. Dredge (1983) has mapped the terrestrial equivalent of acoustic unit 4 as part of a marine offlap succession that can be traced as "extensive coalescing deltas where meltwaters emptied into the Goldthwait Sea." Where major subglacial and proglacial meltwater channels once emptied into the sea, such as at Ste-Marguerite, Sept-Iles, and Moisie, thick terrestrial deltaic successions developed.

UNIT 3: Acoustic unit 3 (Sheets 9, 10, 11, 12 & 13) is typically characterized by a distinctive, very low tone, weak stratification, and by conformable bedding, in which basal topography underlying the unit is translated through internal reflectors to the surface (see sections A-A', B-B', F-F', G-G', and I-I'). The unit consists primarily of bioturbated and graded-laminated sand and mud (Hein et al., 1992). The unit can be traced up to, and correlated with, the extensive marine clays mapped along the shore by Dredge (1983) as Goldthwait Sea clays. Acoustic unit 3 represents ice-distal accumulation of glaciomarine sediment from highly turbid glaciofluvial plumes discharged from the rapidly ablating Laurentide Ice Sheet (Syvitski and Praeg 1989). The conformable or draped bedding styles suggest relatively low bottom currents. Regional variations in thickness are interpreted as reflecting distance from the many possible sediment sources, and the general circulation of the buoyant surface plume; locally, acoustic unit 3 can exceed 40 m in thickness (Sheet 9). Two phases of sedimentation have been recognized (Sheets 10 & 12).

UNIT 2: Acoustic unit 2 (Sheets 14 & 15) is characterized by strong, closely spaced reflectors (see sections A-A', D-D', E-E', F-F', G-G', and J-J'). Unit 2 is not ubiquitous and its thickness seldom exceeds 10 m (Sheet 14). It may drape over bedrock or unit 1 (e.g. section G-G'), or may form a wedge-shaped deposit interfingering with morainal deposits (e.g. sections D-D'). Syvitski and Praeg (1989) interpreted acoustic unit 2 as reflecting ice proximal sedimentation associated with high rates of deposition of relatively coarse material close to major discharge outlets issuing from the face of an ice sheet. The closely spaced reflectors, the slump features, and the generation of ponded successions all support the notion of an ice terminal stillstand. The discontinuous distribution of acoustic unit 2 in the northwestern Gulf of St. Lawrence (Sheet 14) may imply large distances between ice-front discharge outlets.

UNIT 1: Outside of the Laurentian Trough, acoustic unit 1 (Sheets 16, 17, 18 & 19) is generally an acoustically unstratified unit (sections D-D' and E-E'), having distinct macro-relief with constructional geometry. Acoustic unit 1 overlies bedrock. The unit is interpreted as ice-contact deposits, including till, eskers, submarine push moraines, grounding-line fans, and submarine frontal-dump and lateral moraines. Three wedge-shaped deposits (10 to 40 m thick, 1 to 4 km wide) can be traced for many tens of kilometres: the most seaward (section E-E') example is 120 km long. Less commonly, these deposits have discontinuous internal reflectors that suggest both an aggradational and a progradational development (section D-D'). The deepest occurrence is in 180 m of water (equivalent water depth of 290 m, ca. 12.5 ka). These deposits occur on the leading edge of bathymetric slopes and correspond onshore to substantial frontal-dump moraines and ice-contact deposits (Sheet 17). Within the Laurentian Trough, unit 1 has a basin fill geometry, is characterized by moderate strong tine and lack of stratification, and has an irregular surface reflector that is smooth on a large scale and independent of basement morphology (section J-J'). Much of these sediments are considered to be glacimarine sediments that have been overridden by the Laurentian Ice Stream of the Late Wisconsinan (Syvitski & Praeg, 1989). A strong reflector within unit 1 was mapped as a separate unit (Sheet (18) and may indicate sediments deposited prior to the Wisconsinan.

The bounding surfaces of acoustic units 1 and 2 both show evidence of scouring by ice-keel turbation (sections H-H', I-I') generated from the Laurentide Ice Sheet (Syvitski and Praeg 1989). These ice scours occurred in paleo water depths of 200 to 400 m.

BEDROCK: The underlying bedrock in the northern Gulf of St. Lawrence consists of Paleozoic strata of limestone and shale (Sandford & Grant, 1990). Acoustic basement is interpreted as an extension of the crystalline Precambrian rocks that outcrop on the north shore (see section A-A'). Airgun acoustic penetration can exceed 50 m in certain locations (sections D-D' and J-J'). The regional bathymetry consists of the fault-bounded Laurentian Trough in the south fed by a number of large bedrock-controlled basins (Sheet 17). Closer inshore are numerous small basins located between cuestas of Ordovician limestone and shale that contain ponded Quaternary deposits (see section B-B').

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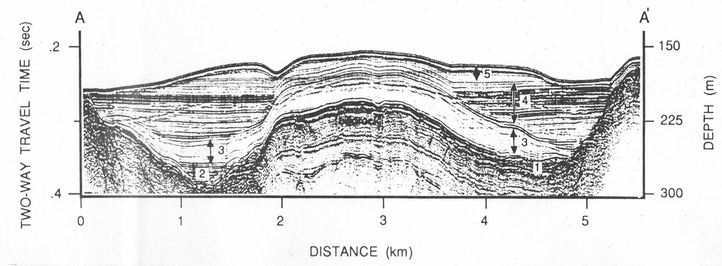
REFERENCES

Dredge, L.A. 1983. Surficial geology of the Sept-Iles area, Quebec north shore. Geological Survey of Canada, Memoir 408, 40 p.
Hein, F.J., Syvitski, J.P.M., Dredge, L.A. and Long, B.F. 1992. Quaternary sedimentation in the north shore area of Sept.-Iles, Quebec: Potential for marine placer. Canadian Journal of Earth Sciences (in press).
Josenhans, H.W., Sanford, B.V., Sparkes, R., Johnston, B.L., Boyce, A., Nielsen, J. and Belliveau, M. 1989. Baffin 89-008 cruise report. Geological Survey of Canada, Open File Report 2115. 68 p.
Praeg, D.B., Syvitski, J.P.M., Asprey, K., Currie, R., Hein, F., Miller, A., Sherin, A. and Standen, G., 1987a, Report of CSS Dawson cruise 87-023 in the Gulf of St. Lawrence. Geological Survey of Canada, Open File Report 1678. 86 p.
Praeg, D.B., Syvitski, J.P.M., Schafer, C.T., Johnston, B.L. and Heckett, D.W., 1987b. CSS Dawson 86-016 cruise report. Geological Survey of Canada, Open File Report 1412, 45 p.
Sandford, B.V., and Grant, A.C. 1990. Bedrock geological mapping and basin studies in the Gulf of St. Lawrence. Geological Survey of Canada, Paper 90-1B, p. 33-42.
Syvitski, J.P.M., and Praeg, D.B., 1989. Quaternary Sedimentation in the St. Lawrence Estuary an Adjoining Areas, Eastern Canada: An overview based on high-resolution seismo-stratigraphy. Géographie physique et Quaternaire 43: 291-310.
Syvitski, J.P.M. 1988. Dawson 88-008 Technical Cruise Summary, May 01 - May 17, 1988. Geological Survey of Canada, Open File 1920. 60 p.
Vilks, G. and Rodrigues, C. 1989. Dawson Cruise 89-007, Gulf of St. Lawrence. Geological Survey of Canada, Open File Report 2119, 113 p.

ENCLOSURES

Sheet 1: Seismic track lines and location of type seismic sections.
Sheet 2: Text and seismic sections.
Sheet 3: Bathymetry.
Sheet 4: Total Quaternary sediment thickness.
Sheet 5: Isopach of unit 5 (Post-glacial) thickness.
Sheet 6: Depth from present sea level to the base of unit 5.
Sheet 7: Isopach of unit 4 (Paraglacial) thickness.
Sheet 8: Depth from present sea level to the base of unit 4.
Sheet 9: Isopach of unit 3 (Ice-distal) thickness.
Sheet 10: Isopach of unit 3B thickness.
Sheet 11: Depth from present sea level to the base of unit 3B.
Sheet 12: Isopach of unit 3A thickness.
Sheet 13: Depth from present sea level to the base of unit 3.
Sheet 14: Isopach of unit 2 (Ice-proximal) thickness.
Sheet 15: Depth from present sea level to base of unit 2.
Sheet 16: Isopach of unit 1B (Ice-contact) thickness.
Sheet 17: Depth from present sea level to the base of unit 1B.
Sheet 18: Isopach of unit 1A (Ice-contact) thickness.
Sheet 19: Depth to bedrock (from present sea level).

AIR GUN



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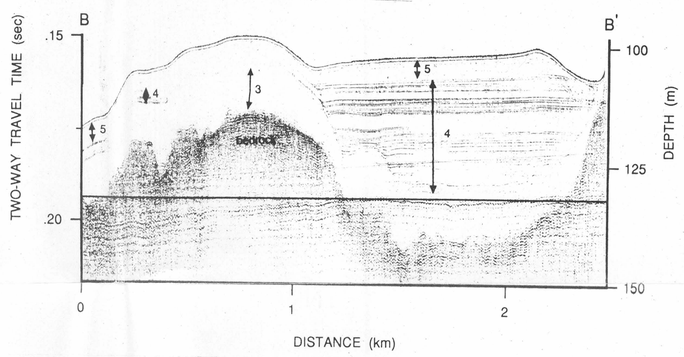

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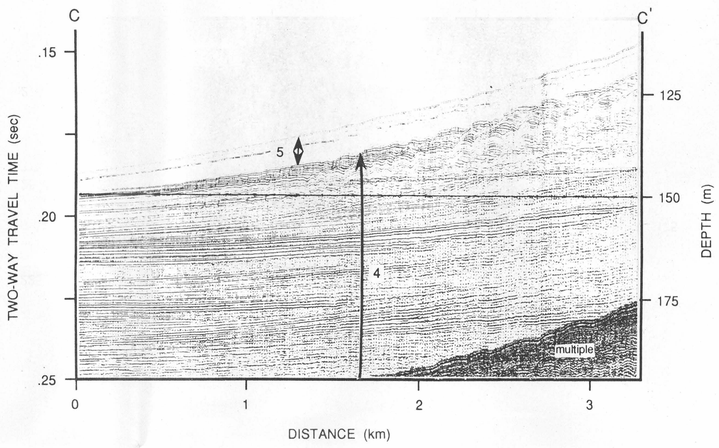

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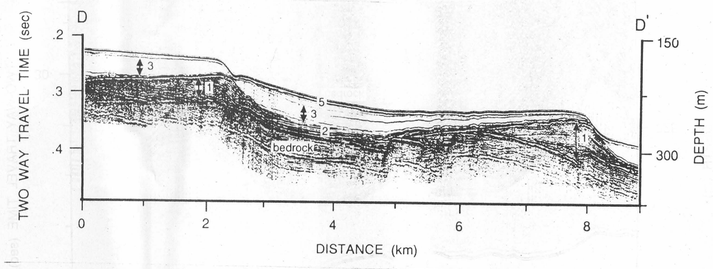

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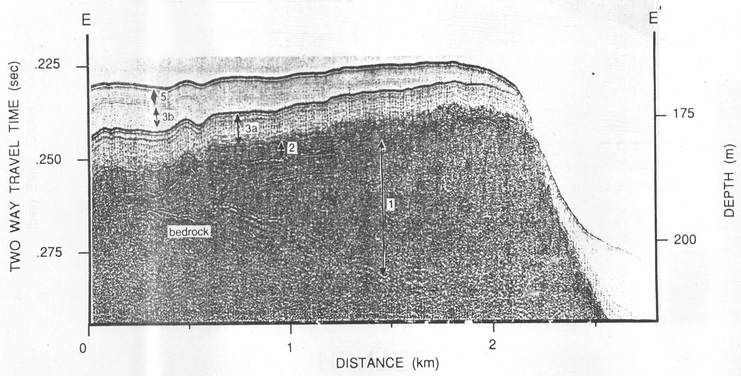

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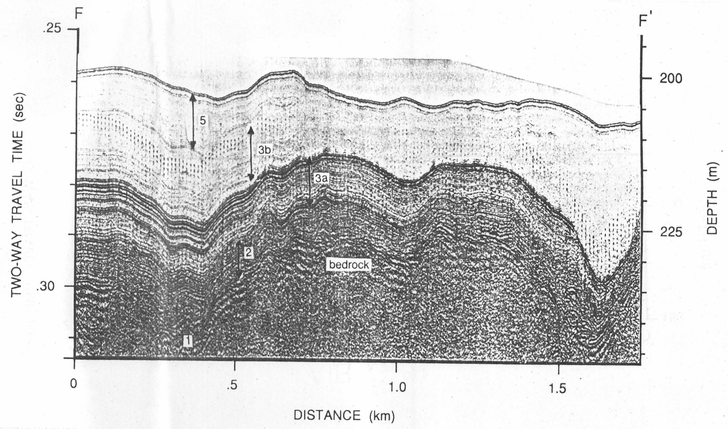

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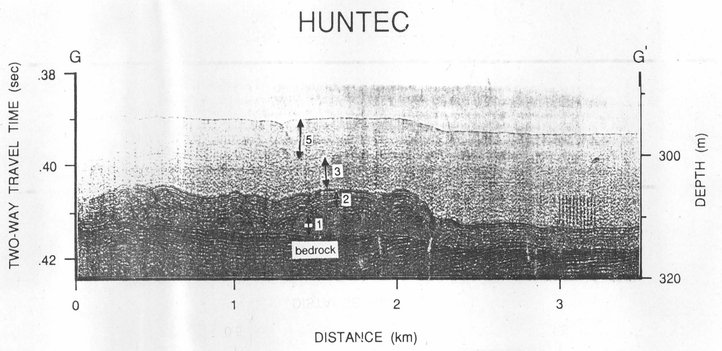

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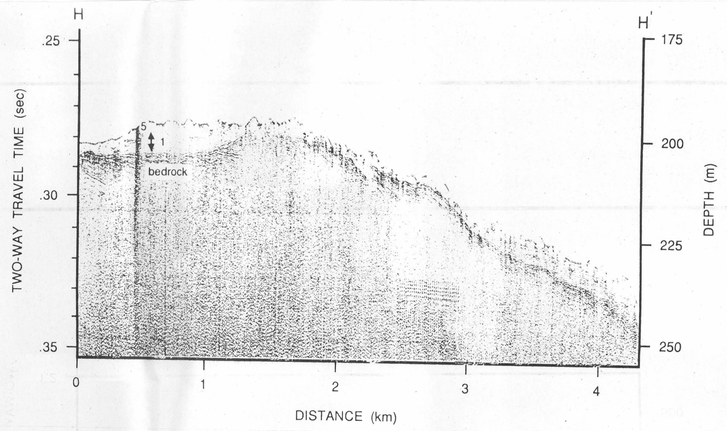

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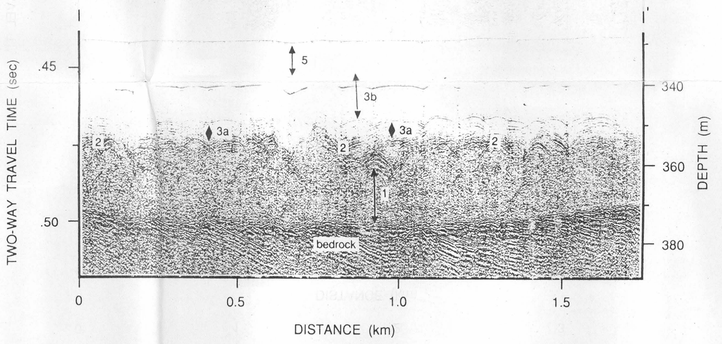

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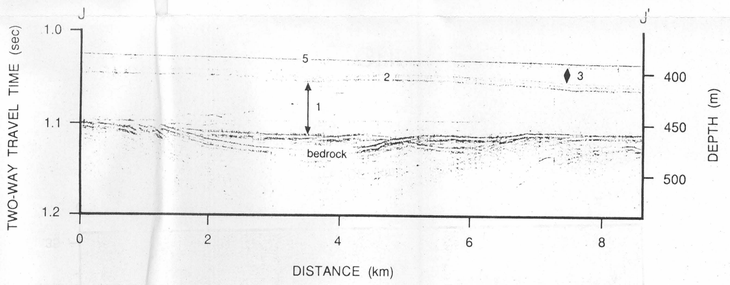

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