Natural Resources Canada / Ressources naturelles Canada
Fisheries and Oceans Canada / Pêches et Océans Canada
GEOLOGICAL SURVEY OF CANADA / COMMISSION GÉOLOGIQUE DU CANADA

Figure 1. This photograph was taken in a deep basin at the head of St. Patricks Channel, near Iron Mines, at 45°56.66'N, 61°07.42'W. The backscatter intensity (*see* map) has a featureless light tone, indicating a soft seafloor. The grab sample from this location contained mud. The photograph shows a soft bottom, consisting of black anoxic mud. Cruise 2003068 (CCGS *Navicula*), station 30f, depth 45 m. Photograph by K. Asprey, 21 October 2003. GSC 2006-099

Figure 2. This image was made by gridding the sidescan signal from an interferometric sidescan-sonar system at 2.5 m resolution. The bright streaks are the nadir of survey lines that were spaced at 25 m. The location is near Black Island, in the southwest part of Denys Basin. This area was not surveyed by the multibeam-sonar launch, hence no backscatter information appears on the main map. The purpose of showing this image is to demonstrate that as data resolution increases, so the complexity of the seafloor increases also.

The seafloor here has a generally light tone, which is interpreted as mud; however, circular to oval areas of very high reflectivity (dark tone on the sidescan imagery) occur. These are interpreted as oyster beds. They are commonly 5 m in diameter, but some are smaller, and others are about 10 m across. One oval patch is 20 m long. Knudsen 3.5 kHz subbottom profiler records show that the oyster beds are the exposed tops of bioherms up to 4 m tall that extend downwards to a hard substrate that is up to 10 m below sea level on some lines. In some areas the bioherms could not keep pace with sedimentation, and are now buried below mud. The oyster species is probably the American Oyster, *Crassostrea virginica* (Gmelin).

Figure 3. Photograph taken on an underwater ridge southeast of McKinnons Point, in Bras d'Or Lake, at 45°54.34'N, 60°52.82'W. The backscatter intensity in this area has a dark tone, indicating a hard seafloor. The grab sample from this location contained muddy gravel. The photograph shows subrounded to subangular pebble gravel, with a few small green sea urchins (*Strongylocentrotus droebachiensis*). The ridge is probably composed of glacial diamict (till). Cruise 2003068 (CCGS *Navicula*), station 18e, depth 10 m. Photograph by K. Asprey, 20 October 2003. GSC 2006-100

Figure 4. This photograph was taken on the flat seafloor northeast of Malagawatch Point, in Bras d'Or Lake, at 45°53.47'N, 60°52.89'W. The backscatter intensity (*see* map) has a featureless light tone, indicating a soft seafloor. The grab sample from this location contained mud. The photograph shows a soft, muddy bottom, bioturbated and heavily imprinted with animal tracks, possibly a green crab. The mud is thin (<1 m) and overlies the deposits of an early Holocene delta graded to about -24 m. Cruise 2003068 (CCGS *Navicula*), station 19a, depth 23 m. Photograph by K. Asprey, 20 October 2003. GSC 2006-101

Figure 5. This photograph was taken on an underwater ridge east of Malagawatch Point, in Bras d'Or Lake, at 45°52.64'N, 60°52.72'W. The backscatter intensity (*see* map) has a dark tone, indicating a hard seafloor. The grab sample from this location contained muddy gravel. The photograph shows a densely packed pavement of large and small subrounded and subangular pebbles. Larger clasts are heavily encrusted with *Lithothamnion* sp., indicating immobility. The only other life forms visible are dozens of small green sea urchins (*Strongylocentrotus droebachiensis*) and a starfish (*Asterias* sp.). The gravel forms a veneer on the surface of a submarine ridge that is the visible portion of a large arcuate moraine, formed by a glacier that emanated from the northwest. The underlying material is undoubtedly glacial diamict (till). Cruise 2003068 (CCGS *Navicula*), station 26e, depth 15 m. Photograph by K. Asprey, 20 October 2003. GSC 2006-102

Figure 6. This photograph was taken on a large underwater ridge that extends south from Benacadie Point, reaching almost to the south shore of East Bay, at 45°52.27'N, 60°42.20'W. The backscatter intensity has a dark tone, indicating a hard seafloor. The grab sample from this location contained muddy gravel. The photograph shows subrounded pebble gravel, with a few small green sea urchins (*Strongylocentrotus droebachiensis*), a sponge, a fanworm, and several dead bivalves, including propeller clam shells. Siphonal openings of infaunal bivalves can also be seen. The ridge is interpreted as a gravel tombolo that formed during the early Holocene low lake level (approximately -24 m) and was subsequently submerged by rising sea level. Cruise 2003015 (CCGS *Matthew*), station 33a, depth 21 m. Photograph by T. Atkinson, 17 May 2003. GSC 2006-103

Figure 7. This photograph was taken in the middle of East Bay, at 45°52.78'N, 60°39.85'W. The backscatter intensity (*see* map) has a light tone, indicating a 'soft' seafloor. The grab sample from this location contained reddish brown, clayey mud with dark grey mottles. The photograph shows a muddy seafloor with numerous worm tubes (perhaps *sabellid polychaetes*) extending into the water column, and several animal tracks at the surface, including perhaps tracks of a hermit crab. The mud is about 5 m thick here, and overlies a similar thickness of glaciomarine and/or lacustrine mud that is draped over glacial ridges (drumlins). Cruise 2003015 (CCGS *Matthew*), station 29b, depth 31 m. Photograph by T. Atkinson, 17 May 2003. GSC 2006-104

DESCRIPTIVE NOTES

INTRODUCTION

Multibeam bathymetric systems record mean energy and a time series of amplitudes returned in each beam. The mean energy is commonly called the backscatter amplitude. While it is tempting to use this as a direct proxy for surficial sediment type, consideration of the physics of the problem presents a more convoluted picture (Courtney and Shaw, 2000), and there exists no direct relationship between backscatter amplitude and surficial sediment type. For angles of incidence greater than roughly 20° there is a general correspondence between backscatter amplitudes and surficial sediment roughness that can be used for cursory mapping and sediment identification. Coarse gravel and cobble units tend to be locally rough and return high-amplitude, wide-angle backscatter signals, whereas sand and fine-grained materials can be locally smooth with a much lower backscatter.

METHODOLOGY

Data were collected using Canadian Coast Guard vessels. The majority of surveys were performed by the Canadian Hydrographic Service (CHS), but some were conducted by the Geological Survey of Canada (GSC). The *Frederick G. Creed* is a SWATH vessel equipped with a Simrad EM1000 multibeam-bathymetric survey system, with the transducer mounted in the starboard pontoon. The hydrographic launch *Plover* deployed a hull-mounted Simrad EM3000 multibeam-sonar system. The hydrographic launch *Penguin* deployed a Submetrix™ interferometric sidescan-sonar system. A differential Global Positioning System was used for navigation, providing positional accuracy of about 3 m. Survey speeds averaged 10 knots. Data were adjusted for tidal variation using output from a tide gauge installed at Iona Narrows.

Backscatter is depicted using a colour scale ranging from almost white (low backscatter) to indigo (high backscatter). The coloured backscatter is draped over a grey digital elevation model of the bathymetry. The distribution of backscatter values in the map area is strongly bimodal, with a primary peak at 38 dB (low backscatter) and secondary peak at 25 dB (high backscatter). The floor of the lake is extremely patchy, with juxtaposed areas of high and low backscatter. Backscatter distributions for the adjoining area to the north are shown on GSC Map 2099A (Shaw and Potter, 2007).

INTERPRETATION OF BACKSCATTER DATA

The interpretations of backscatter are based on the following GSC marine seismic and sampling surveys: Dawson 85-036, Hart 96-165, and Matthew 2003-015. The authors had access to the unpublished results of coring in 1996 by Kathy Ellis of the Department of Fisheries and Oceans.

Some high-backscatter areas comprise gravel and bouldery gravel (1) that forms a surficial lag over subcropping glacial diamict. Boulders visible on sidescan sonograms are diagnostic of this material. Seabed photographs (Fig. 3, 5) show gravel on a muddy substrate. In some areas the outcrops of gravel are commonly circular to elliptical, and mark the portions of drumlins that have been trimmed by wave erosion during the period of lowered lake level. The drumlin fields are best developed in West Bay, southern Bras d'Or Lake, and East Bay, and drumlins show differing orientations in each area. On Cod Shoals, bouldery gravel overlies glacial diamict organized into a large arcuate moraine.

Other areas of high backscatter (2) consist of subangular to subrounded gravel (Fig. 6). This material occurs in linear ridges that resemble modern coastal spits, tombolos, and barrier beaches in their proportions and morphology. This material is interpreted as beach gravel, reworked from glacial deposits during the period of lowered lake level.

The predominant seafloor sediment in the map area (3) is mud that ranges from clayey silt in the deepest areas to sandy silty clay in much of the lake, and to sandy silt or silty sand in shallows (Fig. 1, 4, 7). This unit has low backscatter, and appears almost white in tone on the map.

Undifferentiated gravel (4) has high backscatter, and may have several origins, including winnowing of glaciolacustrine muds, or low rates of deposition of postglacial mud over topographic highs, such as bedrock ridges. While there are many areas of the lakes where bedrock ridges can be seen on the multibeam imagery, bare rock is seldom exposed at the seafloor. Areas mapped as bedrock on GSC Map 2115A (Shaw and Potter, in press) actually have a veneer of undifferentiated gravel. Bedrock (5) occurs only in one area. A series of narrow bedrock ridges are separated by muddy depressions.

The bathymetry of Denys Basin was obtained using the interferometric sidescan-sonar system. The backscatter intensity data from that system was not judged to be comparable to that obtained with the Simrad multibeam systems, and is not shown. Rather, the authors show backscatter intensity derived from a less extensive Simrad survey in the basin. Parts of the basin for which only bathymetry is shown have a greyscale tone — difficult to distinguish from land — whereas areas of backscatter intensity range from indigo to pale greenish grey. At high resolution, the interferometric data show dark-toned, circular to oval oyster beds on the seafloor, surrounded by mud (Fig. 2).

ACKNOWLEDGMENTS

The Master and crew of the CCGS *Frederick G. Creed* were instrumental in the multibeam bathymetric surveys carried out by the GSC. The Canadian Hydrographic Service (CHS) organized most of the surveys and provided tidal stations. Cartographic support was provided by G. Grant with assistance from Phil O'Regan, Scott Hayward, and Sheila Hynes, Natural Resources Canada. The map was reviewed by R.C. Courtney and R.B Taylor. The work was part of GSC project X-29 (J. Shaw, leader) in the Geoscience for Ocean Management Program.

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2007: Backscatter strength and sun-illuminated seafloor topography, Great Bras d'Or, Cape Breton Island, Nova Scotia; Geological Survey of Canada, Map 2099A, scale 1:50 000.
in press: Surficial geology and sun-illuminated seafloor topography, Bras d'Or Lake, Cape Breton Island, Nova Scotia; Geological Survey of Canada, Map 2115A, scale 1:50 000.

SYMBOLS

Grab sample . . . . (yellow circle)
Gravity core . . . . (red circle)
Seafloor photograph . . . . (red triangle)

SEABED TEXTURE (INTERPRETED)
Bouldery gravel (glacial diamict) 1
Littoral gravel (submerged beach deposits) 2
Mud: clayey silt to sandy silty clay 3
Undifferentiated gravel 4
Bedrock 5

-128 Low | -80 | -40 | -30 | -20 | -10 | 0 High
Approximate backscatter strengeh (dB)


LOCATION MAP

Authors: J. Shaw and D.P. Potter

Backscatter data compiled by D.P. Potter, 2005

Digital cartography by G. Grant and S. Hayward, GSC (Atlantic)

Any revisions or additional information known to the user would be welcomed by the Geological Survey of Canada

MAP 2100A
BACKSCATTER STRENGTH AND SUN-ILLUMINATED SEAFLOOR TOPOGRAPHY

BRAS D'OR LAKE

CAPE BRETON ISLAND, NOVA SCOTIA

Scale 1:50 000/Échelle 1/50 000
kilometres 1 0 1 2 3 4 kilometrès

Universal Transverse Mercator Projection
North American Datum 1983
© Her Majesty the Queen in Right of Canada, 2007
This map is not to be used for navigational purposes

Projection transverse universelle de Mercator
Système de référence géodésique nord-américain, 1983
© Sa Majesté la Reine du chef du Canada, 2007
Cette carte ne doit pas être utilisée aux fins de navigation

Digital base map (land area) from data compiled by Geomatics Canada, modified by GSC (Atlantic)

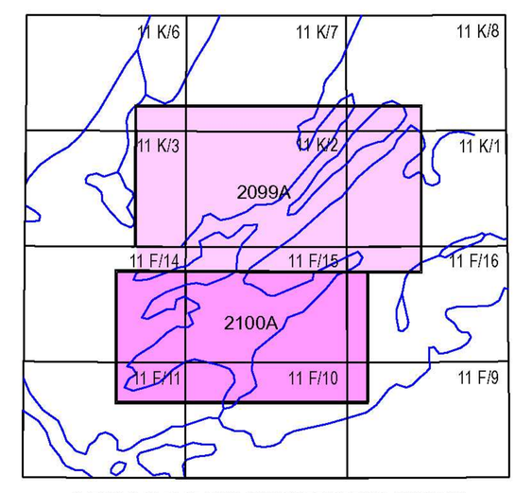
Some geographical names subject to revision

Magnetic declination 2007, 19°40'W, decreasing 9.6' annually

Elevations in metres above mean sea level

Depth in metres below sea level

Published 2007



NATIONAL TOPOGRAPHIC SYSTEM REFERENCE AND INDEX TO ADJOINING GEOLOGICAL SURVEY OF CANADA MAPS

Recommended citation:
Shaw, J. and Potter, D.P.
2007: Backscatter strength and sun-illuminated seafloor topography, Bras d'Or Lake, Cape Breton Island, Nova Scotia; Geological Survey of Canada, Map 2100A, scale 1:50 000.

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