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

DESCRIPTIVE NOTES

INTRODUCTION

This map is the first of a map series of Browns Bank, located at the southwestern end of the Scotian Shelf in the entrance to the Gulf of Maine on the Atlantic continental shelf of Nova Scotia. The maps are the products of a 1996–1997 survey that used a multibeam sonar system to map 3054 km² of the seafloor. The survey area is located approximately 200 km southwest of Halifax, Nova Scotia, in water depths of 60–200 m. This map shows the seafloor topography (Fliflemo Band in shaded-relief view with colour-coded seafloor geologic units at a scale of 1:100 000. Topographic contours generated from the multibeam data are superimposed on a base map that shows the geographic features, place names, and bathymetric contours from the multibeam survey area, also presented at a depth interval of 10 m, as from the Natural Resource Map Series (Canadian Hydrographic Service, 1973 a, b). Map 2089A (Todd and Shaw, 2006) shows seafloor topography in shaded-relief view with colour-coded bedform features. Map 2092A (Todd et al., 2006) shows seafloor topography in shaded-relief view with colour-coded benthic habitat units.

GEOLOGICAL HISTORY

The Scotian Shelf is a passive continental shelf characterized by a series of large, shallow banks on the outer shelf, of which Browns Bank is one example. The banks are separated by intervening saddles or troughs. These bathyforms are interpreted as cuestas and juxtaposed lowlands developed on the tectonic platform of the Mesozoic Scotian Basin in response to differential erosion of the basin fill during the Tertiary period (King and MacLean, 1976). The coastal plain was modified by the advance and retreat of North American continental ice sheets during the Pleistocene Epoch (Boulton et al., 1977; Grant, 1977; Stea et al., 2011 BP2; King and Fader, 1986). Further modification took place during the flooding of the continental shelf by the rise of sea level during the Holocene Epoch, transgression across the shelf of rising sea level (Shepard and King, 1973; Fader et al., 1977; Fader, 1993).

Regional mapping of surficial sediments of Quaternary age on the Scotian Shelf has been undertaken by the Geological Survey of Canada (King, 1970; King and Fader, 1986; King, 1986; King, 1987; Fader and King, 1992; Fader et al., 1977, 1989; MacLean et al., 1977). The surficial geological background portrayed by Browns Bank is summarized here and illustrated in Figure 1.

During the last glacial maximum, the Laurentide Ice Sheet advanced onto the continental shelf off Nova Scotia, depositing a thick till veneer. This till is composed of a lower, more compact till and an upper, thick glacial moraine and as linear marginal ridges containing material up to boulder size (>256 mm). The moraine is well developed on Browns Bank (Figure 1; Figure 2; Figure 3; Figure 4; Figure 5) and generally consists of poorly sorted clayey and sandy silt with some gravel. Emerald Silt mainly occurs in shelf basins where it locally outcrops at the seabed, but occurs on some bank areas as well. Following deglaciation, the Laurentide Ice Sheet retreated northward and relative sea level rose to its present level (Fader, 1986), substantially reposing much of the continental shelf. Around the exposed banks during this time, the action of nearshore waves and currents formed the Sandy Sand by erosion of the Emerald Silt and till. Sediment from the Sandy Sand was reworked by the transgressive sea and formed the Sable Island deposit. The banks are covered with Sable Island Sand and Gravel that formed during the subsequent sea-level transgression. These sediments are well sorted sand and gravel and, in places, bedrock outcrops at the seabed. The Sandy Sand and the Sable Island Sand and Gravel are the result of transgressive erosion deposited in the adjacent basins during the Lahave Clay that overlies the Emerald Silt (Figure 2; Figure 3; Figure 4; Figure 5). Sediment from the Sandy Sand was also reworked into Sable Island Sand and Gravel (Drapeau and King, 1972; Fader et al., 1977). Gravel dominated in the east and sand to the west, reflecting the influence of the Scotian Current on the distribution of the lag deposit. The present knowledge of surficial sediment distribution provided by multibeam data provides considerable detail on sediment distribution of the Sable Island Sand and Gravel together with information on bedforms and other seafloor features.

The glacial landforms and deposits of the Browns Bank seafloor provide evidence of the pattern of Late Wisconsinan deglaciation of the Scotian Shelf offshore southern Nova Scotia. In Late Wisconsinan time, the Laurentide Ice Sheet flowed onto the Scotian Shelf from the northeast and formed a series of terminal moraines approximately 30 km to the south of the study area on the upper Scotian Slope (Piper, 2003). Widespread ice-contact sediments (till) were deposited beneath the ice sheet. Subglacial meltwater was released from the ice sheet and flowed southward to the shelf edge. Meltwater channels are an stream flowed southeast out of the Gulf of Maine through Northeast Channel (adjacent to the western edge of Browns Bank) to the continental shelf edge (Schnitker, 1973; Hughes, 1998; Shaw et al., in press).

Following the glacial maximum, the ice front retreated to the north across the Scotian Shelf. The rate of retreat of the ice on eastern Browns Bank may have been more rapid than on western Browns Bank. Two recessional moraines were formed on the bank during the deglaciation of the Scotian Shelf. These are interpreted as delineating the margin of a retreating ice lobe situated on eastern Browns Bank with ice on western Browns Bank. The Lateral Moraine 1 marks a pause in the retreat of the ice lobe on the western ice lobe and lateral moraine 2 marks a younger phase. The Browns Bank Moraine and the Fundian Moraine are ice-contact sediments that were deposited at the ice margin. The Fundian Moraine in deeper water along the northern flank of Browns Bank lies a series of north-south oriented ridges. The ridges may be interbedded moraines largely deposited on bedrock and formed by a readvance of the ice lobe on Browns Bank.

During the retreat of the ice sheet, glaciomarine sediments were deposited. These sediments were probably widespread on Browns Bank, but were subsequently eroded and during the lowstand of relative sea level associated with the Late Wisconsinan glacial maximum and subjected to subaerial weathering and transgression. Under the modern current regime, postglacial sediments on Browns Bank exhibit bedforms (Todd, 2005).

GEOSCIENTIFIC DATA

In order to provide groundtruth for the multibeam data, and to complement the historical geoscientific information in the area, high-resolution geophysical profiles were collected over Browns Bank in 1998 (Todd et al., 2001). These data were collected using a Geoacoustics GeoChirp 3.5/15 kHz Chirp Sonar (CHS) towed, a single-channel sleeve-gun seismic-reflection system, and a Simrad MS992 sidescan sonar (Todd et al., 2001). The geophysical profiles provided information on the surficial sediments identified using the multibeam bathymetry and backscatter data (Todd and Shaw, 2006; Todd et al., 2006a, b). In total, 2132 km of geophysical profiles were used in the interpretation of the Browns Bank surficial geology.

Using an 8.75 m² Ivanhoe de Kombinatsiya/Industrial Combinat (IKI) grab, 18 seafloor sediment samples were collected at strategic sites interpreted from geophysical profiles. The sites were chosen to ground-truth the surficial geology interpretation and to provide information on the surficial sediments on Map 2089A. Todd and Shaw, 2006) and acoustic backscatter response (based on Map 2089A. Todd et al., 2006b). Also the selected sites were located along geophysical profiles to provide detailed geological information. The grab sampling operation recovered the seafloor up to 0.5 m and preserved the integrity of the layering within the surficial sediments.

With locations chosen from the multibeam bathymetric data and the geophysical profiles, 38 seafloor photographs were taken (Todd et al., 2001). The camera was a Benthos 372 (35 mm film, underwater photographic and 8 mm camcorder). The 1998 set of seafloor photographs was augmented by 610 single and stereophotographs collected at 80 stations on Browns Bank by the Departments of Fisheries and Oceans Canada's (DFO) and DFO's (Wilson et al., 1998).

SURFICIAL GEOLOGY

Surficial geology includes all complete Geological sequence consists of some or all of the following: ice-contact sediments, ice-proximal sediments, ice-distal sediments, paraglacial coastal sediments, and postglacial sediments. The Quaternary stratigraphy described here follows this classification. The equivalent formation names are noted here and in the legend.

ICE-CONTACT SEDIMENTS

Ice-contact sediments (till; unit Gm) equivalent to the Scotian Shelf Drift (Drapeau and King, 1972; Fader et al., 1977), are widespread on Browns Bank. A gravel lag developed from the till which was reworked during transgression of sea level across the Scotian Shelf after about 18 000 BP (Drapeau and King, 1972; Fader et al., 1977; Fader, 1993). The surficial till is a compact, poorly sorted, clayey silt containing combined grain sizes up to 1000 mm, and photographs and sidescan sonar records imaged abundant cobbles (64–256 mm) and boulders (>256 mm). Sand (0.062–2 mm) was present in every grained lag deposit (Todd et al., 2001). Sediment from the lag deposit was reworked by the transgressive sea and fine-grained sediment covering the gravel lag. The till grab samples from the eastern bank reflect this observation with silt (0.0039–0.062 mm) constituting up to 4% of individual sediment samples.

The till has been interpreted from seismic-reflection profiles as a hummocky to smooth reflector on the modern regime of oceanic currents and sediment transport and deposition. In spite of this modification, some features remain conspicuous at the seafloor.

Fundian Moraine

A prominent feature on the Browns Bank topography map (Map 2089A, Todd and Shaw, 2006) is a west-east trending ridge located on the northern flank of Browns Bank. This ridge is a distinct, irregular surface in comparison with the surrounding terrain. On the backscatter strength map (Map 2089A, Todd et al., 2006), the ridge is apparent as a band exhibiting variable backscatter intensity along its crest. The ridge is composed of interconnected lobes, approximately 1 km wide, 3–5 km long, and consists of stacked acoustic units of incoherent reflections separated by discontinuous, coherent, high-amplitude reflections. This feature is interpreted as being composed of till (unit Ice) overlying bedrock (unit Ibd) and is a moraine that was deposited at the ice margin. The ridge is located seaward of the Browns Bank Moraine (unit Ice) (Figure 6). The ridge is identified as the Fundian Moraine, part of the Scotian Shelf and Grand Banks Moraine System (Piper, 2003; Piper et al., 2005; Shaw et al., in press). The topography of the Fundian Moraine is a complex feature composed of interconnected, lobate morainal segments, breached by meltwater channels (Figure 6). The Fundian Moraine is well defined on Browns Bank by the multibeam bathymetry and geophysical profiles, combined with the prevalence of boulders where the moraine is exposed, suggest that the Fundian Moraine was subjected to erosion in the surf zone during sea-level fall and has since Browns Bank.

Browns Bank Moraine

The Browns Bank topographic map (Map 2089A, Todd and Shaw, 2006) and, to a lesser degree, the backscatter strength map (Map 2089A, Todd et al., 2006b), indicate a region of shallow, irregular bathymetry to the south (seaward) of the Fundian Moraine. Interpretation of a seismic-reflection profile (Figure 7; Figure 8) shows that this area is characterized by a series of discontinuous, hummocky (unit Ice) ridges named here the Browns Bank Moraine. To the northeast, it connects to the Fundian Moraine, suggesting that the Browns Bank Moraine is evidence of a glacial position farther seaward, and at a lower elevation than the Fundian Moraine. The ridges of the Browns Bank Moraine on Browns Bank Member probably reflects erosion in the surf zone during sea-level transgression or that the moraine was composed of fine-grained till.

Till (unit Ice) interbedded with glacial sediments are outlined by Figures 2, 3, 11, and 15 and are best illustrated using large-scale portions of the seafloor topography (Map 2089A, Todd and Shaw, 2006). Note that for these examples, the colour-coded topographic scales are optimized for each map area.

GLACIOMARINE SEDIMENTS

Glaciomarine silt (unit Gm) is equivalent to the Emerald Silt (Drapeau and King, 1972; Fader et al., 1977) and is present in the subsurface on Browns Bank.

POSTGLACIAL SEDIMENTS

Postglacial sediments are derived from current and wave reworking of glaciogenic deposits and are equivalent to the Sable Island Sand and Gravel (Drapeau and King, 1972; Fader et al., 1977).

Sandy Sand (unit PGsds) is a veneer of well sorted sand and gravel on the seafloor that covers the banks. The morphology and extent of the sand deposits are interpreted from the topographic map (Map 2089A, Todd and Shaw, 2006) and the backscatter strength map (Map 2089A, Todd et al., 2006b), on Browns Bank. Sandy Sand is thicker than 2 m on the bank crests, and grab sediment samples and sidescan sonograms confirm this interpretation (Todd et al., 1999).

Browns Bank is flanked to the south and north by lobes of spillover deposits (unit PGsspp) forming lateral extensions of the bank surface. The spillover deposits (unit PGsspp) are well developed on the south (seaward) side and are characterized by a series of discontinuous reflectors. The sand deposits are discontinuous on the north side of Browns Bank and are thinner than on the south side. The spillover deposits are composed of sand (Figure 3) and are generally active and have developed in response to the mechanical redistribution of water by the bank. The spillover deposits are interpreted as being a result of the interaction of water with the bank surface (Naim, 2004; Shaw et al., 2010). The spillover deposits are characterized by a series of discontinuous reflectors