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CONTENTS

ILLUSTRATIONS

SURFICIAL GEOLOGY OF CANSO BANK AND ADJACENT AREAS

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ABSTRACT

Chart 4013-G delineates the distribution pattern of the unconsolidated sediments on the seafloor across Canso Bank and adjacent areas.

Five sedimentary units comprising Scotian Shelf drift, Emerald silt, Sambro sand, LaHave clay, and Sable Island sand and gravel, which are common to other parts of the Scotian Shelf, occur with local modification within the map-area. Delineation of the areal sediment distribution and stratigraphic relationships are based on textural data from bottom samples and acoustic data from echograms and continuous seismic reflection profiles.

The sediment distribution for the most part is related to the Pleistocene low stand of eustatic sea level 15 000 19 000 years BP and its subsequent rise, together with some modification which is still taking place in some nearshore and other shallow areas.

RÉSUMÉ

La carte 4013-G montre les modalités de la distribution des sédiments non consolidés au fond de l'océan dans le banc Canso et les endroits contigus.

Cinq unités sédimentaires comprenant les dépôts du plateau de la Nouvelle-Écosse, le limon Emerald, le sable de Sambro, l'argile de LaHave et le sable et le gravier de l'île de Sable, communs à d'autres parties dudit plateau, se retrouvent dans la région de la carte, avec quelques modifications locales. Le tracé de la distribution des sédiments dans la région et l'établissement des relations stratigraphiques sont fondés sur les données relatives à la texture, obtenues des échantillons du fond, et de données acoustiques provenant d'échogrammes et de profils continus de sismique-réflexion.

La distribution des sédiments est surtout reliée au bas niveau eustatique de la mer du Pléistocène, il y a 15 000 à 19 000 ans et à sa montée subséquente, et à une certaine modification toujours en cours dans certaines régions littorales ou peu profondes.

INTRODUCTION

Chart 4013-G, Surficial Geology of Canso Bank and Adjacent Areas, is the fifth in a series delineating the distribution of surficial sediments on the Scotian Shelf. This chart is adjoined to the south by Chart 4040-G, Surficial Geology of the Halifax–Sable Island Map-Area, and to the east by Chart 4041-G, Surficial Geology of the Banquereau and Misaine Bank Map-Area. The study area includes Chedabucto Bay and the Strait of Canso south of the Canso Causeway.

Canadian Hydrographic Service charts 4013, Halifax to Sydney, and 4335, Strait of Canso and Approaches, have been utilized as base maps for Chart 4013-G and as sources of bathymetric data.

The surficial geology of the shelf areas that adjoin the present study area to the south and east has been investigated by King (1967a, b, 1970) and MacLean and King (1971), who reported in detail the distribution and history of the surficial sediments in the Halifax-Sable Island and Banquereau and Misaine Bank map-areas respectively, and by Cok (1970), who studied the morphology and surficial sediments of the eastern part of the Scotian Shelf. In the study area Loring (1970) and Kranck and Sheldon (1970) investigated sediments in areas of Chedabucto Bay as part of the studies undertaken during Project Oil following the oil spill that resulted from the sinking of the tanker *Arrow* in February 1970, Owens (1971) mapped the sediment types and coastal features along the shoreline of Chedabucto Bay, and Owens and Drapeau (1973) reported on changes in beach profiles following large-scale removal of sediment. Grant (1971) reported on the surficial geology of southwestern Cape Breton Island, and Buckley et al. (1974) investigated environmental aspects of Canso Strait and Chedabucto Bay. A report by the Canada–Nova Scotia Strait of Canso Environment Committee (1975) was prepared on the geological resources of the Strait of Canso area as part of an inventory of the natural environment of the region. The principal studies related to movements of the water mass include those by Fothergill (1954, 1955) and Lawrence et al. (1973) on the Strait of Canso, and Neu (1970) on the hydrodynamics of Chedabucto Bay.

MAPPING METHODS

Geological sample data utilized in this study were collected principally on cruises aboard CSS *Kapuskasing* in 1969 and CSS *Dawson* in 1973. These data were supplemented in parts of Chedabucto Bay and Canso Strait with data from samples collected in 1970 by D. H. Loring, K. Kranck, and R. W. Sheldon, and in 1973 by D. E. Buckley, B. R. Pelletier, and G. Vilks.

Echograms were used extensively in the identification of the sedimentary units and in the determination of their lateral extent, thickness, and stratigraphic relationships. Echograms obtained by the Canadian Hydrographic Service for charting purposes were utilized together with additional echogram control obtained during geological cruises.

The mapping procedure followed in this study was the same as that utilized by King (1967a, b, 1970) to delineate the surficial geology of the Halifax–Sable Island map-area. A preliminary geological map was compiled using data interpreted from the available Hydrographic Service echograms. A geological sampling program was then carried out to verify the sediment pattern established from the acoustic data and additional acoustic information was also obtained. The acoustic and bottom sampling controls within the map-area are shown in Fig. 1.

The sounding records obtained by the Canadian Hydrographic Service were run mainly along north–south tracks with a line spacing of approximately 0.9 km (0.5 mile)* in the area west of 60°50′W longitude. The inner end of these lines terminated approximately 15 km (8 miles) from shore. East of 60°50′W lines were spaced at approximately 2-km (1-mile) intervals as far north as southern Canso Bank where a 3.7-km (2-mile) spacing was commenced. This track pattern extended nothward to approximately 45°23′N latitude where most of the available hydrographic echogram coverage ceased. In Chedabucto Bay the available hydrographic echogram coverage was limited to Canso Strait and approaches southward to near the center line of the bay. Tracks were spaced at 76-m (250-ft) intervals.

The hydrographic echograms across the main shelf part of the map-area were obtained with a Kelvin Hughes 26J echo sounder, whereas those in the Strait of Canso and approaches were obtained with a Kelvin Hughes 26B unit. Additional acoustic data were obtained during geological sampling cruises with Kelvin Hughes 26B and MS32 echo sounders. The geological echogram data in Chedabucto Bay were obtained along mainly north–south tracks spaced at approximately 2-km (1-mile) intervals. Where Hydrographic Service echograms were not available for the main shelf portion of the map-area, acoustic information was obtained along tracks spaced at 9-km (5-mile) intervals. In this area samples were collected at approximately 5.5-km (3-mile) intervals or where changes in the bathymetry indicated a change in sediment type was likely to occur. Ice prevented the collection of samples at several localities in Chedabucto Bay, particularly in the area east of Isle Madame. Data from samples collected previously in some of these areas and other parts of the study by D. H. Loring, K. Kranck, B. R. Pelletier, D. E. Buckley, and G. Vilks have been incorporated in the map.

Continuous seismic reflection profiles provided additional acoustic data on the thickness and subsurface extent of the unconsolidated sediments and on the underlying bedrock. These data were obtained with a Bolt Associates Marine Profiler Model 600A fitted with a 16.4-cm^3 (1 cubic inch) chamber, a Huntec Mark 2A Hydrosonde profiler, and an Alpine sparker system. Use of the latter two systems was hindered and record quality impaired by the presence of ice in Chedabucto Bay at the time of the survey.

PHYSIOGRAPHY

Two of the main Scotian Shelf physiographic subdivisions are represented within the map-area. These are the inner shelf bordering the coast, and the central shelf, which contains an inner trough and an area seaward of the trough characterized by isolated banks and depressions. King (1967b, 1970) and MacLean and King (1971) described these features on the adjoining shelf areas to the south and east.

The inner shelf within the map-area ranges in width from a maximum of about 20 km (11 miles) at the western boundary of the map to a minimum of about 5.5 km (3 miles) near Michaud Point on the south coast of Cape Breton Island. The outer boundary of the inner shelf follows the general trend of the present coastline. The seafloor within the inner shelf area commonly is rough due mainly to the irregular surface of the underlying bedrock and to the thin cover of surficial sediments. This roughness is most pronounced in the area south and immediately east of mainland Nova Scotia, where metasediments of the Cambro-Ordovician Meguma Group and Devonian granite form the bedrock. In areas adjacent to southwestern Cape Breton Island where Carboniferous strata occur, the seafloor is generally smoother. Locally, irregularities are due to the pronounced mounds of partly modified glacial debris. A smooth bottom composed of soft sediment occurs across much of Chedabucto Bay and parts of Canso Strait.

* Mileages in this report refer to nautical miles.

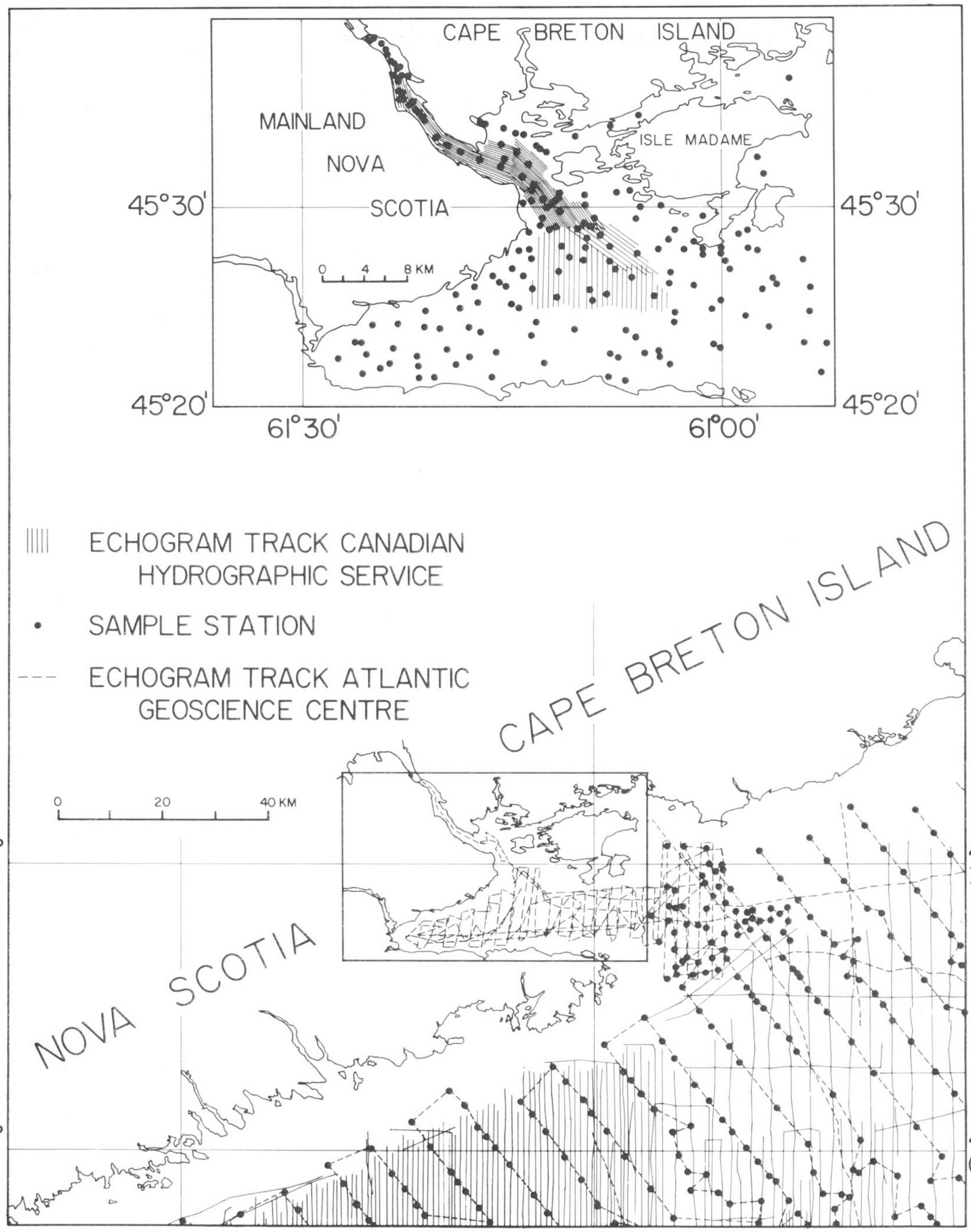

FIG. 1. The acoustic and bottom sampling control across the study area. Due to close spacing of echogram profiles in the Strait of Canso and approaches, only every second hydrographic track is shown on the inset map.

Chedabucto Bay is one of the largest coastal inlets along the southern coast of Nova Scotia. It is 43 km (23 miles) long, attains a maximum width of 23 km (12.5 miles) and narrows to 13 km (7 miles) south of Isle Madame and Petit-de-Grat Island. Water depths in the approaches to Chedabucto Bay mainly are in the 100–160 m (55–87 fath) range and in the central part of the bay are, for the most part, in the 30–100 m (16–55 fath) range and gradually shallow to the head of the bay. Near the southern side of the bay, however, depths to 190 m (104 fath) occur in a trough adjacent to a pronounced east–west trending escarpment that represents a seaward continuation of the Cobequid–Chedabucto segment of the Glooscap fault system (King and MacLean 1970, 1976). A less pronounced but abrupt shallowing also occurs on the north side of the bay close to the south coast of Isle Madame and extends seaward 5 km (3 miles) to the south of Michaud Point, where it approximately coincides with the Pleistocene terrace at a depth of 110–120 m (60–66 fath). Gradual shallowing occurs shoreward from this feature. A sill with 7–8 m (25 ft) relief occurs at a depth of 30 m (16 fath) in the general area between Cerberus Rock and Cape Argos (approximately 45°29′N, 61°09′W) in the approaches to the Strait of Canso in the northwestern part of the bay. Echogram and continuous seismic reflection data across this feature indicate that it occupies a bedrock channel and that it is composed of unconsolidated sediment.

The Strait of Canso extends northwestward from Chedabucto Bay to St. Georges Bay on Northumberland Strait and separates Cape Breton Island from mainland Nova Scotia. It is 26 km (14 miles) long and ranges from 0.9 to 1.9 km (0.5 to 1 mile) wide. Water depths of 30 m (16 fath) are continuous along the strait with depths to 50 m (27 fath) in isolated depressions. The Strait of Canso is thought to represent a drowned remnant of an old river valley (Goldthwait 1924). There is no evidence to suggest that the origin of the feature was fault controlled. In 1954 the Canso Causeway and lock were constructed at Auld Cove, completely altering the tidal current regime in the strait. Prior to the construction of this barrier, current velocities as great as 9.6 km/h (5.2 kn) southbound and 7.6 km/h (4.1 kn) northbound were recorded (Fothergill 1954). Since the installation of the causeway these strong currents have been reduced to nearly negligible amplitudes (Lawrence et al. 1973). Construction of the causeway converted the strait into two deep water harbors and by preventing the passage of ice from Northumberland Strait into Chedabucto Bay made the southern harbour virtually ice-free.

The inner trough of the central shelf physiographic subdivision generally is a broad feature up to 46 km (25 miles) wide that extends for the length of the shelf. Within the map-area, however, it narrows to 13 km (7 miles) north of Canso Bank. The northern margin of the trough extends around the eastward projection of the inner shelf north of Canso Bank and underlies the approaches to Chedabucto Bay westward to the vicinity of Isle Madame. Water depths generally extend to about 190 m (104 fath) except in a few isolated depressions, where depths as great as 230 m (126 fath) occur.

Canso Bank, the largest bank within the map-area, is 46 km (25 miles) long, 30 km (16 miles) wide, and has a smooth surface that lies at depths ranging from 60 to 90 m (33 to 49 fath).

Adjacent to the south side of Canso Bank is a highly dissected area that forms the western end of a major system of partly disconnected valleys with relief to 230 m (126 fath). The valleys are incised in the underlying bedrock and, because of partial mantling by unconsolidated material, the features are deeper and more continuous than the bathymetry indicates. These valleys appear to represent a former drainage system that has been modified by glaciation and subsequent deposition.

Investigation of the Scotian Shelf by continuous seismic reflection techniques has revealed that the bedrock surface is mantled with a veneer of Pleistocene and Recent sediments, which varies in thickness from less than 1 m to more than 100 m (330 ft). In general the shape of the present seafloor closely reflects the erosional surface developed across the underlying bedrock. The origin of this erosional surface and the resulting configuration of the landscape is complex. From a study of continuous seismic reflection data and correlation with information from exploratory wells King et al. (1974) recognized four erosional intervals within Mesozoic–Cenozoic strata on the Scotian Shelf. These occurred during the Early Cretaceous, Late Cretaceous, Early Tertiary, and Late Tertiary–Early Pleistocene. The regional extent of the Cretaceous erosional episodes has not been established, but those in the Early Tertiary and Late Tertiary–Early Pleistocene appear to have been shelf-wide events.

Many of the present major shelf physiographic features such as cuestas, mesas, and lowlands have been inherited from former Tertiary landscapes. Some remodelling of the present seafloor occurred during the Pleistocene and Recent, but these changes for the most part appear to have been superficial.

BEDROCK GEOLOGY

The bedrock geology of the Canso Bank map-area has been reported by King and MacLean (1970) in connection with seismic reflection investigations of the Orpheus gravity anomaly, and by the same authors (1976) in a regional description of the geology of the Scotian Shelf and adjacent areas. A brief outline of the bedrock geology within the map-area is included here to supplement the data presented on the geological section.

The bedrock geology is based mainly on the interpretation of continuous seismic reflection data obtained by the authors in conjunction with data from exploratory wells, geology of adjacent land areas (Weeks 1954, 1965; Cormier 1972), and gravity, magnetic, and seismic refraction and reflection data of several authors, including Bower (1962), Garland (1964), Loncarevic (1965), Manchester (1965), Ewing and Hobson (1966), Hood (1966), and Loncarevic and Ewing (1967). McIver (1972), on the basis of well data, proposed the framework and terminology for the Mesozoic–Cenozoic section on the Scotian Shelf.

Map-unit 1 represents acoustic basement. It occurs along the southern coast of Cape Breton Island and may comprise Precambrian and Cambrian sediments, metasediments, and volcanics, Precambrian–Cambrian granite, Silurian or Lower Devonian sediments, local Devonian granitic intrusions, and Mississippian sediments.

South of mainland Nova Scotia the Cambro-Ordovician Meguma Group of quartzites and slates and Devonian intrusives form the bedrock surface for about 40 km (22 miles) offshore where they are onlapped by Mesozoic and Cenozoic strata. These basement rocks also extend easterly along the southern margin of the Orpheus basin beneath a cover of

Table of Formations

Era	Period or epoch	Map-unit	Lithology	Thickness (m)
Cenozoic	Quaternary	Sable Island sand and gravel (11)	Dark grayish brown, fine- to coarse-grained, well-sorted sand, grading laterally to coarse subangular-to-rounded glacial lag gravels; in the Strait of Canso includes a nearshore facies consisting of a highly variable mixture of gravel, sand, silt, and clay. Time equivalent of map-unit 10.	0–15 (generally thin)
		LaHave clay (10)	Very dark grayish brown, locally black, clayey silt, grading locally to silty clay and sandy silt with minor gravel. May in part be time equivalent of upper portions of map-units 8 and 9, mostly younger.	0–30
		Sambro sand (9)	Very dark grayish brown, fine- to coarse-grained, moderately to well-sorted sublittoral sand, grading to sandy gravel or modified till. Time equivalent of map-unit 8.	0–40 (generally thin)
		Emerald silt (8)	Very dark grayish brown, poorly sorted, clayey and sandy silt, grading to silty sand with some gravel; proglacial. In part a time equivalent of the late drift (map-unit 7); otherwise younger.	0–130
		Scotian Shelf drift (7)	Dark grayish brown, cohesive, sandy till in ground and end moraines; may include some modified till and stratified drift.	0–80
			Disconformity	
	Tertiary and latest Cretaceous	Banquereau Formation (6)	Semicompacted bedrock; mainly mudstone with lesser quantities of siltstone and argillaceous sandstone.	—
			Angular unconformity	
Mesozoic	Cretaceous	(5)	Semicompacted to well-compacted bedrock; mainly sandstone and shale, with lesser quantities of chalk.	—
			Angular unconformity	
Paleozoic–Mesozoic	Pennsylvanian–Jurassic	(4)	Undifferentiated sedimentary rocks of probable Pennsylvanian–Jurassic age; interpretation based on adjacent land geology, well information, and continuous seismic reflection data.	—
			Angular unconformity	
Paleozoic	Mississippian	(3)	Undifferentiated sedimentary rocks of Mississippian age; interpretation based on adjacent land geology and continuous seismic reflection data; probably mainly composed of sandstone, siltstone, shale, conglomerate, and possibly some limestone.	—
			Angular unconformity	
	Cambrian to Devonian	(2)	Undifferentiated metasedimentary rocks of the Meguma Group and Devonian granite; interpretation based on adjacent land geology and continuous seismic reflection data; probably composed of folded Cambrian and Ordovician quartzite and slate, cut by Devonian granite.	—
			Angular unconformity	
Paleozoic and older	Pre-Pennsylvanian	(1)	Undifferentiated sediments, metasediments, volcanics and intrusives of the Precambrian and Cambrian and possibly some sediments of Silurian–Lower Devonian and Mississippian age and Devonian granite; interpretation based on adjacent land geology and continuous seismic reflection data.	—

Mesozoic–Cenozoic strata. To the north the basement sequence is terminated by the Glooscap fault, a major feature that appears to extend from the Gulf of Maine across the Bay of Fundy and Nova Scotia to the Grand Banks and possibly beyond (King and MacLean 1976).

The Orpheus basin is a graben that extends eastward from Chedabucto Bay and gives rise to the Orpheus negative gravity anomaly. Exploratory drilling (Shell Argo F-38 [Shell Canada Ltd. 1971a] and Shell Eurydice P-36 [Shell Canada Ltd. 1971b]) revealed the presence of a thick sequence of Mesozoic strata including a substantial thickness of salt in the Orpheus basin. This confirmed the earlier postulation of Loncarevic (1965), Ewing and Hobson (1966), and Loncarevic and Ewing (1967) that the negative gravity anomaly results from the presence of a thick sequence of low density sedimentary rocks.

Mississippian strata occur along southern Cape Breton Island westward from Red Point (60°45'W longitude) to St. Peters, and underlie most of Isle Madame, Janvrin Island, part of the islands in Inhabitants Bay, an area on the north shore of Inhabitants Bay, and the Nova Scotia mainland shores of Canso Strait and Chedabucto Bay north of the Glooscap fault. Also, Mississippian strata are believed to underlie Chedabucto Bay north of the fault westward from about 61°15'W longitude.

Pennsylvanian strata underlie the shore north of Lennox Passage and most of the eastern shore of Canso Strait northward to about the midpoint between Port Hawkesbury and Port Hastings.

Triassic strata occur on shore at three localities around the inner part of Chedabucto Bay.

Because Pennsylvanian and Triassic strata occur nearby on the shores of Chedabucto Bay, and Jurassic strata are present in the Orpheus basin (Shell Argo F-38 and Shell Eurydice P-36), pre-Cretaceous strata recognized on seismic reflection profiles beneath the central and outer parts and approaches of Chedabucto Bay (section AB) are considered to be Pennsylvanian to Jurassic in age.

Cretaceous strata lap on the Cambro-Ordovician Meguma Group rocks and Devonian granitic intrusions about 40 km (22 miles) south of mainland Nova Scotia. In the Orpheus basin south of Cape Breton Island these strata overlie Pennsylvanian–Jurassic rocks eastward from 60°22'W longitude and lap on pre-Pennsylvanian rocks along the basin's northern margin. Cretaceous strata on the Scotian Shelf for the most part have a gentle seaward dip of one degree or less and prograde near the edge of the shelf, but in the Orpheus basin they have been mildly folded as a result of halokinetic movements and tectonic adjustments (King and MacLean 1970, 1976).

The Banquereau Formation (McIver 1972), which includes Tertiary and latest Cretaceous strata, forms a thin unconformable veneer over the underlying Cretaceous strata on the inner and central parts of the shelf and thickens to approximately 2 km (1 mile) at the shelf edge. Within the map-area these strata form a thin layer over the irregular, eroded surface of the Cretaceous rocks across Canso Bank (section BC) and extend northward into the Orpheus basin where they overstep the zero edge of the Cretaceous strata to lie directly on Pennsylvanian–Jurassic and pre-Pennsylvanian rocks. It is probable that across much of the map-area only the uppermost part of the Tertiary sequence is represented. Locally, some early Pleistocene material may be included.

SURFICIAL GEOLOGY

The Quaternary history of the Scotian Shelf has been discussed by King (1967a, b, 1970) as interpreted from studies of the Halifax–Sable Island area. The surficial geology of the Banquereau and Misaine Bank area has been reported by MacLean and King (1971). The present study area adjoins these two map-areas, and the same sedimentary units are common to the three areas.

King related the occurrence of a 115–120 m (63–65 fath) terrace that is well developed at many localities within the Halifax–Sable Island area to an old shoreline developed during a late Pleistocene lowering of sea level about 15 000 (Milliman and Emery 1968) to 19 000 (Curray 1960) years ago, and established the relationship between this feature and the sediment distribution pattern. This terrace is recognizable on echogram profiles at several localities within the Canso Bank map-area (e.g. along the north and south sides of Canso Bank). The sediment distribution pattern relative to the depth of the terrace is in accordance with relationships established for other parts of the shelf.

During the low stand of sea level represented by the 115–120 m (63–65 fath) terrace, large areas of the shelf were subaerially exposed. Areas adjacent to the coast formed part of the mainland and the isolated banks (e.g. Canso and Middle banks) and the outer shelf banks (e.g. Sable Island Bank and Banquereau) were islands with arms and embayments of the sea largely enclosed within them. Exchange of water between these areas and the open sea probably was considerably restricted. This condition together with the influx of cold meltwater from the nearby ice sheet led to the development of a cold brackish water environment over large areas of the shelf (King 1970).

The presence of subbottom deposits of glacial material and reworked glacial debris on the seafloor indicates that the ice extended seaward to the outer margin of the shelf. However, it cannot be established from the present data whether this glacial material was the product of one or more ice sheets. An end moraine complex extends in a discontinuous manner along the entire Scotian Shelf about 30–40 km (16–22 miles) seaward from and approximately parallel to the present coastline (King 1969; King et al. 1972). The moraine system presumably is a Wisconsin feature, but it has not been established whether it marks the farthest point of advance of Wisconsin ice or is a recessional feature formed during the general retreat of a more extensive Wisconsin ice sheet.

Following the events that occurred during the low stand of the sea, sediments on the banks and other shallow areas of the shelf above the 115–120 m (63–65 fath) terrace were subjected to reworking and redistribution as sea level rose during the Holocene transgression. This accounted for much of the present shelf sediment distribution in which lag deposits of reworked glacial material remained on the banks and other shallow areas, and the finer sediments were deposited in deeper water.

King (1967b, 1970) recognized five sedimentary units in the Quaternary deposits of the Halifax–Sable Island area and subsequent studies (Drapeau and King 1972; MacLean and King 1971; Fader et al. 1977) have indicated that these units are shelf-wide. The succession comprises glacial drift, silt, sand, clay, and sand and gravel units, some of which are contemporaneous. The silt and sand units are in part proglacial deposits. The sand and gravel unit, derived from reworking of glacial debris during the Holocene, is confined to the banks and other shallow areas above the elevation of the Pleistocene terrace. Some modification of the sediment distribution, particularly the sand and gravel unit, has occurred through the action of storm waves and bottom currents, and ice rafting in some areas of the eastern part of the shelf. However, except perhaps for local modification in shallow areas these processes do not seem to have significantly altered the earlier distribution pattern of the five relict sedimentary units.

Scotian Shelf Drift

The Scotian Shelf drift is an informal term proposed by King (1970) for deposits of glacial material. It is a dark grayish brown cohesive and poorly sorted sediment. Composed of abundant sand, silt, and clay it commonly contains angular fragments in the pebble-to-boulder size range, which mainly consist of quartzite, granite, and some sandstone fragments.

Acoustic data indicate that the glacial material characteristically has a rough and undulating surface and a chaotic internal structure, and that it generally conforms to the surface of the bedrock, except where the till thickens as in the case of channel filling or moraine development. Usually a reasonably good contrast between the undulating surface of the till and the smooth, hard bottom of the Sambro sand is evident on the echograms. The till–sand boundary commonly is gradational and thus there is a problem in distinguishing till from modified till.

Glacial till exposures within the map-area occur along the longitudinal trough north and west of Canso Bank, in Chedabucto Bay south and southeast of Isle Madame, and in the approaches to Chedabucto Bay south of Cape Breton Island. Glacial till occurs at the seafloor in water depths as shallow as 70 m (38 fath) south and southeast of Isle Madame in Chedabucto Bay. It may also form the subbottom ridges evident on echograms across much of the central and inner parts of Chedabucto Bay. In the Strait of Canso, drill cores for engineering data east of Melford Point have indicated the presence of at least 29 m (96 ft) of till in the subbottom at a depth of 27 m (15 fath) below present sea level (extracted from data made available by Canso Superport Limited). Preservation of glacial deposits at these shallow depths is dissimilar to their history in other shallow areas of the shelf and this suggests that the material at these localities was not subjected to marine erosion during the Holocene transgression. There is no evidence to indicate this was due to tectonic or isostatic adjustments. Therefore, preservation was probably due to the presence of a lobe of late ice which protected this material from erosive forces during the transgression.

Interpretation of the immediate subbottom across the banks and other shallow areas is uncertain because of lack of penetration of the hard bottom by the echo sounder and the nonresolution within the bubble pulse of the seismic reflection profiling system. Although a thin subsurface layer of the Scotian Shelf drift has been inferred across these areas on Section ABC its presence there has not been established. If the original glacial debris in these shallow areas was completely reworked during the transgression, the lag deposits would lie directly on the bedrock. The presence of glacial till is evident on seismic profiles across depressions and other areas where its thickness is sufficient to permit resolution by the seismic equipment.

The Scotian Shelf end moraine system is represented within the Canso Bank map-area by the western part of the Gabarus moraine along the eastern edge of the study area about 30 km (16 miles) south of Cape Breton Island. The end moraine system along the Scotian Shelf occurs as a series of discontinuous lobes and has been traced from the Laurentian Channel to the Gulf of Maine (King et al. 1972).

Emerald Silt

Emerald silt is an informal term proposed by King (1970) for a proglacial silt unit that mainly lies on the Scotian Shelf drift (map-unit 7) and in many areas is overlain by the LaHave clay (map-unit 10). The Emerald silt within the map-area is mainly a very dark grayish brown, poorly sorted sediment composed of clayey and sandy silt (unit 8a), and silty sand with some gravel (unit 8b). The boundary between units 8a and 8b is gradational and cannot be defined on the basis of the present sample control.

The Emerald silt within the Canso Bank map-area principally underlies the LaHave clay and is exposed along the northern margin of the depression that lies west of Canso Bank and northwest of Middle Bank. It also occurs as isolated deposits along the inner trough north of Canso Bank, as well as in the valleys between Canso Bank and Misaine and Sable Island banks. Within the map-area and on the adjacent shelf areas the Emerald silt appears stratified on the echograms, in contrast to other areas of the shelf, where stratification within the unit is not so apparent. The Emerald silt has not been recognized within the sedimentary sequence on the floor of Chedabucto Bay or Canso Strait.

Where the Emerald silt is overlain by the LaHave clay (map-unit 10) the boundary between the two units is distinct because of the acoustic transparency of the clay. The smooth, relatively soft bottom characteristic of the silt also contrasts with the rough, undulating and somewhat harder bottom presented by the till. These units are readily distinguished on continuous seismic reflection profiles because of the well-stratified appearance of the silt in contrast to the irregular surface and lack of orderly or regular events in the till. The contrast between the Emerald silt and Sambro sand generally is provided by an acoustically hard smooth bottom for the sand as opposed to a soft bottom for the silt. The boundary between these two units, however, is usually gradational.

King (1969, 1970) found that the Emerald silt interfingers with the glacial debris of the end moraines, which indicates that these sediments are in part contemporaneous. He concluded that the silt was a proglacial unit deposited from floating ice in front of the ice sheet. Variations in the texture of the unit were ascribed to several factors, notably proximity to the ice front, littoral, and sublittoral environments with respect to the Pleistocene shoreline, tidal currents, and bottom topography.

In isolated areas of soft sediment where the Emerald silt and the LaHave clay are not both represented, a measure of stratigraphic control is lacking and correlation without the support of paleontological data becomes uncertain. Where either the Emerald silt or LaHave clay has been mapped in such areas the interpretation was based on textural and acoustical characteristics of the sediment consistent with regional stratigraphic relationships.

Sambro Sand

The Sambro sand is an informal term introduced by King (1970) for a sand formation that occurs below the elevation of the Pleistocene terrace and that overlies in part the Scotian Shelf drift. It is in part a lateral equivalent of the Emerald silt. King (1967a, b, 1970) related the Sambro sand to the development of the submarine terrace at a depth of 115–120 m (63–65 fath) during the Pleistocene low stand of sea level, and he concluded that the Sambro sand was deposited in, as well as adjacent to, the littoral zone of this old shoreline. This feature marks the boundary between the Sambro sand and the Sable Island sand and gravel unit. Both units appear as hard bottoms on echograms and differentiation is on the basis of textural parameters from samples.

The Sambro sand is a very dark grayish brown, silty and clayey sand with some gravel. The unit is designated 9a where the gravel content of the samples is $< 10\%$, and 9b where the gravel content is $> 10\%$. Silt and clay are present usually in amounts up to 10% but may occasionally reach 30%. The presence of the finer fractions is one of the main criteria in distinguishing the sands of map-unit 9 from those of the Sable Island sand and gravel (map-unit 11).

Within the map-area the Sambro sand occurs adjacent to the Pleistocene 115–120 m (63–65 fath) terrace along the flanks of the inner trough and Canso Bank and across parts of the adjacent seafloor below the elevation of the terrace. The unit occurs usually as a thin veneer, only a few metres thick, overlying glacial till. The Sambro sand has not been recognized in Chedabucto Bay west of approximately 60°50′W longitude. Its absence there could be due to the presence of a lobe of late glacial ice, which would have delayed the onset of marine sediment deposition in the area. However, the surface of the glacial till in Chadabucto Bay may have been partly modified, as indicated by the presence of a somewhat higher than normal gravel content. This modification may have occurred during a late stage of the Holocene transgression or more recently through the action of storm waves or bottom currents.

LaHave Clay

The LaHave clay is an informal name proposed by King (1970) for a formation mainly consisting of silty clay (unit 10a) and clayey silt (unit 10b) that overlies the Scotian Shelf drift and Emerald silt, and is an equivalent of the Sable Island sand and gravel. Additional textural variations in the LaHave clay occur within the study area.

The LaHave clay on the main shelf part of the map-area and beneath much of Chedabucto Bay consists predominantly of clayey silt (unit 10b) with some minor sand. An increase in sand content occurs locally southeast of Isle Madame and around the head of Chedabucto Bay. The increase in sand becomes most marked north of 45°25′N in the approaches to the Strait of Canso where it constitutes 40% of some samples. In this area the unit consists of clayey and sandy silt with some minor amounts of gravel (unit 10c). Sediments of unit 10c together with those of unit 10d, which comprise silty and clayey sand with minor gravel, are the main components of the LaHave clay in the Strait of Canso westward from Eddy Point. Data from cores in the latter area collected by G. Vilks indicate that the LaHave clay forms a generally very thin layer on the seafloor. The fine surface sediment may have been deposited as a thin and somewhat discontinuous veneer over the coarser material of the more rigorous environment that prevailed prior to the construction of the causeway. The extent of the LaHave clay unit delineated in Canso Strait is based largely on the distribution of smooth bottoms from echo sounder profiles together with data from bottom samples.

The LaHave clay characteristically is portrayed on echograms by a smooth surface and a high degree of acoustic transparency. The latter characteristic diminishes with increasing silt or sand content. Where the coarser fraction occurs in isolated depressions, a problem arises in distinguishing the LaHave clay from the Emerald silt on the basis of textural data alone.

For the most part the LaHave clay was derived from the winnowing of silt and clay from glacial debris on the banks during the Holocene transgression, and the finer material was deposited in the basins and other depressions. Deposition of clay has probably continued at a slow rate in most of these basinal areas through the winnowing action of storm waves and bottom currents on the shallow parts of the shelf, or from coastline erosion in nearshore areas such as the Strait of Canso and Chedabucto Bay. In parts of both these areas the LaHave clay laps upon and appears to partly cover deposits of Sable Island sand and gravel. A few pockets of LaHave clay occur above the elevation of the Pleistocene terrace on the inner shelf south of mainland Nova Scotia, for example, seaward from the Tor Bay–Whitehaven Harbour area (45°08′N, 61°05′W). These LaHave clay occurrences may arise as a consequence of fine sediment transport from the adjacent land and deposition in small local accumulations on the coarser sediments derived during the Holocene transgression.

Acoustic masking of subbottom events has been recognized on shallow seismic profiles and echograms across several areas in Chedabucto Bay where the LaHave clay forms the sea bottom. These localities are mainly in the east central part of the bay 4–7 km (2–4 miles) northwest of Durell Island and 2–4 km (1–2 miles) northwest of Fogherty Head. The masking is considered to be a result of the generation and entrapment of gas within the soft sediments, which effectively blanks out all acoustic events beneath it.

Sable Island Sand and Gravel

The Sable Island sand and gravel is an informal name introduced by King (1970) for a sand and gravel formation overlying the Scotian Shelf drift. It occurs across the bank areas and on the inner shelf at depths above that of the Pleistocene terrace (115–120 m [63–65 fath]). The Sable Island sand and gravel is a time equivalent of the LaHave clay.

The Sable Island sand and gravel unit primarily consists of clean, dark grayish brown, fine- to coarse-grained sand, which grades laterally to gravel. The unit is subdivided into four categories on the basis of textural analyses of bottom samples as follows: unit 11a is sand with $< 50\%$ gravel; unit 11b is gravel with $< 50\%$ sand; unit 11c is a highly variable mixture of gravel, sand, silt, and clay that occurs in the Strait of Canso and its approaches and represents a nearshore facies of the typical Sable Island sand and gravel unit of the Scotian Shelf; and unit 11d is undifferentiated sand and gravel. Unit 11d refers to areas for which textural data are not available but which have been included in map-unit 11 because of their acoustically hard bottom and occurrence at depths shallower than that of the submarine terrace. This classification is substantiated by data from adjacent areas where the presence of fine fractions below the terrace and their general absence or very low concentrations above it distinguish the Sable Island sand and gravel from the Sambro sand.

Within the present study area sediments of unit 11a are confined mainly to the central and southwestern parts of Canso Bank. Sediments of unit 11b ($> 50\%$ gravel) are present on most of the northern and southeastern parts of Canso Bank and across the inner shelf above the elevation of the Pleistocene terrace adjacent to mainland Nova Scotia and Cape Breton Island. On the inner shelf, unit 11b locally may also include bedrock outcrops. At a few localities on the inner shelf, as for example in the vicinity of the pocket of LaHave clay seaward from the Tor Bay–Whitehaven Harbour area (45°08′N, 61°05′W), the sediments of unit 11 contain higher than normal amounts of silt and clay. This appears to result from fine sediment transport from the adjacent land and local deposition as a veneer or in small pockets on the coarser sediments that accumulated during the Holocene transgression. Sediments of unit 11c occur south and west of Isle Madame in Chedabucto Bay and in the Strait of Canso. In the latter area, definition of unit 11 conforms to areas of irregular bottom and is based primarily on acoustic data from echograms. It probably includes some exposures of bedrock or glacial till and locally may be overlain by thin patches of LaHave clay.

The gravel fraction of sediments on Canso Bank principally consists of subrounded to rounded pebbles and cobbles of quartzite and granite with some particles of red and buff sandstone and shell fragments. On the inner shelf south of mainland Nova Scotia, the gravel fraction mainly comprises subrounded to rounded particles of quartzite with lesser amounts of granite, sandstone, and slate in the pebble and cobble size ranges. Samples from several localities along the western part of this zone were coated with red or white calcareous algae (*Lithothamnium*). Shell fragments are abundant on the eastern extremity of the mainland part of the inner shelf near Carousse Bank east of Cape Canso. Gravel on the inner shelf south of Cape Breton Island near the eastern edge of the map-area consists mainly of subangular to subrounded particles of granite together with some metamorphic and volcanic fragments. In Chedabucto Bay the gravel fraction in the western part of the bay consists principally of cobbles and pebbles of quartzite and granite with some sandstone and volcanic particles. South of Isle Madame the gravel fraction consists predominantly of small subangular to well-rounded pebbles and granules of quartzite, granite, and red and buff sandstone. *Lithothamnium* covers the gravel at most of the localities where samples of the Sable Island sand and gravel unit were obtained in Chedabucto Bay. In the Strait of Canso the gravel fraction consists principally of pebbles of sandstone, granite, and quartzite together with a few fragments of coal. Shell fragments are particularly numerous near the southern end of the strait. Wood fibers constituted virtually all the gravel fraction at one locality midway along the strait.

The geology of the immediate subsurface across the banks and other shallow parts of the shelf above the Pleistocene terrace is not well established. Such areas of hard bottom are not penetrated by the acoustic energy of the echo sounder, and events in the immediate subbottom generally are not within the resolution capabilities of the continuous seismic profiling equipment employed primarily to obtain bedrock data. In these areas the Sable Island sand and gravel unit may be underlain by deposits of glacial till or outwash, or it may lie directly on bedrock where the glacial material has been completely reworked.

The Sable Island sand and gravel represents a transgressive basal deposit, which in some shallow areas is still being subjected to modification through reworking and sediment deposition.

APPLICATIONS

Mineral Potential

The chart delineates the distribution of sand and gravel deposits within the map-area. These constitute a potential source of material for use as aggregate.

Examination of the heavy mineral assemblage of the sediments on the eastern part of the Scotian Shelf by Cok (1970) did not reveal the presence of mineral occurrences of apparent economic significance. However, the samples available for study have been essentially surface samples. It is probable that placer deposits, if present, would be more likely to occur in fluvial sediments in the bottoms of old river channels that extended onto the shelf. Because of the thickness of overlying sediment, sampling of this material would require specialized equipment.

Industrial and Scientific Applications

Data on the nature and areal distribution of the various types of unconsolidated sediments on the seafloor provided by this chart and report have a number of engineering applications related to route selection and burial of submarine cables and pipelines, anchoring of platforms and other floating structures, foundation studies for design and installation of structures on the seafloor, and dredging operations.

The chart also provides a basis for further geological, environmental, and bottom-related biological investigations in the area. Early data interpreted for this study has already served as a basis for environmental investigations in Chedabucto Bay by Loring (1970) at the time of the *Arrow* disaster, and more recently by Buckley et al. (1974) in the Strait of Canso, for studies of sediment hydrodynamics by B. R. Pelletier, and for engineering studies by consultants concerned with the development of port facilities by the Nova Scotia government. The studies carried out by these individuals and groups have in turn contributed data which were utilized in the preparation of the chart and the report.

The following section indicates the degree of roughness of the seafloor across the various sedimentary units on the chart and is included to aid those involved in fishing operations.

Mud bottoms represented by map units 8 (Emerald silt) and 10 (LaHave clay) are usually smooth and relatively flat. Locally, the Emerald silt has an undulating surface where it forms a thin cover over the underlying till (map-unit 7).

Sand bottoms represented by map-unit 11a (sandy facies of the Sable Island sand and gravel) are generally flat and smooth, whereas bottoms represented by map-unit 9a (the sandy facies of the Sambro sand) range from smooth to undulating and hummocky. Boulders and rock outcrops may occur on the steeply sloping sides of valleys.

Gravel bottoms represented by map-units 11b and 11c (gravelly facies of the Sable Island sand and gravel) are rough due to the coarse nature of the sediment particles, but may be flat and topographically smooth as across Canso Bank. On the inner part of the shelf they are hummocky to jagged and may include areas of bedrock exposure. Gravel also occurs on the upper surface of the Sambro sand (map unit 9b), in which case the bottoms generally consist of sand with scattered pebbles and cobbles. Glacial till (Scotian Shelf drift, map-unit 7) is a mixture of mud, sand, and gravel. It has a rough, hummocky surface and would be unsuitable for most fishing operations.

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